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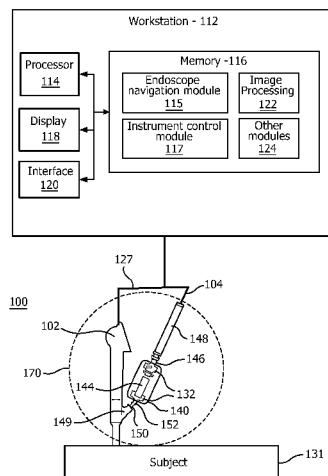


FIG. 1A

(57) Abstract: An instrument driving mechanism includes an instrument drive assembly (140) including a first set of wheels (136) coupled to a first end portion and a second set (138) of wheels coupled to a second end portion opposite the first end portion. The first set of wheels is configured to engage an elongated instrument (104) therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the instrument. The second set of wheels is configured to engage the elongated instrument therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of the instrument wherein motion of the instrument is controlled by controlling rotations of the wheels. The instrument drive assembly mounts to a mounting position (149) of a medical device that permits the instrument to pass therethrough and is configured to fix a position of the instrument drive assembly to enable positioning of the instrument.

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**HANDHELD CATHETER DRIVER WITH ENDOSCOPE MOUNT UTILIZING**  
**FRICTION-DRIVEN WHEEL MECHANISM**

5    **BACKGROUND:**

**Technical Field**

This disclosure relates to medical instruments and more particularly to a medical device driver that provides ergonomic features and improves procedural workflow.

10    **Description of the Related Art**

Catheter-assisted endoscopic interventions can significantly advance the navigation capability of endoscopes. However, endoscope manipulation can be cumbersome and requires multiple operators. This is more evident for catheter-assisted endoscope interventions where an increased number of instruments is needed. In one scenario, one doctor needs to operate 15 the endoscope while the other operator employs a catheter and potentially an interventional tool. The cumbersome nature of endoscope use can also lead to fatigue of the operators.

For catheter-assisted endoscope intervention, at least three instruments are employed and many degrees of freedom (DOF) are required. This necessitates delicate coordination of multiple operators. The instruments and corresponding operation DOFs may include, e.g.: 20 Endoscope: insertion, rotation, steering, holding the distal shaft for immobilization and guide, fluid flush; Catheter: insertion, rotation, deflection; Tool: insertion, rotation, deployment.

One of the major limitations of commercially available catheter drivers for endoscope-catheter-tool systems is that the systems completely change the workflow of traditional catheter operation. Another limitation includes the bulky design that usually utilizes more 25 than 1-2 meters in length of space, is heavy and only allows ground mounting and control

through teleoperation.

## **SUMMARY**

In accordance with the present principles, an instrument driving mechanism includes an instrument drive assembly including a first set of wheels coupled to a first end portion and a second set of wheels coupled to a second end portion opposite the first end portion. The first set of wheels is configured to engage an elongated instrument therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the instrument. The second set of wheels is configured to engage the elongated instrument therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of the instrument wherein motion of the instrument is controlled by controlling rotations of the wheels. The instrument drive assembly mounts to a mounting position of a medical device that permits the instrument to pass therethrough and is configured to fix a position of the instrument drive assembly to enable positioning of the instrument.

Another instrument driving mechanism includes an instrument drive assembly including a first set of wheels coupled to a first end portion and a second set of wheels coupled to a second end portion opposite the first end portion. The first set of wheels is configured to engage an elongated instrument therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the instrument, and the second set of wheels is configured to engage the elongated instrument therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of the instrument wherein motion of the instrument is controlled by controlling rotations of the wheels. A joint is configured to mount the instrument drive assembly to a mounting position and permit the instrument to pass through the joint. The joint is configured to fix a position of the instrument drive assembly to

enable positioning of the instrument.

Yet another instrument driving mechanism includes an instrument drive assembly including a first set of wheels coupled to a first end portion and a second set of wheels coupled to a second end portion opposite the first end portion. The first set of wheels is configured to engage a catheter therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the catheter. The second set of wheels is configured to engage the catheter therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of the catheter wherein fixation and motion of the catheter is controlled by controlling rotations of the wheels. A joint is configured to mount the instrument drive assembly to an endoscope and permit the catheter to pass through the joint into a working channel of the endoscope, the joint being configured to fix a position of the instrument drive assembly to enable positioning of the catheter. A telescopic stabilizer is configured to connect a handle of the catheter to the instrument drive assembly on an opposite side of for the joint. A user interface is configured to control the instrument drive assembly.

A method for driving an instrument includes positioning an instrument drive assembly on a mounting position on another device to mount the instrument drive assembly and permit an elongated instrument to pass through the other device; controlling motion of the instrument using the instrument drive assembly including a first set of wheels coupled to a first end portion and a second set of wheels coupled to a second end portion opposite the first end portion, the first set of wheels being configured to engage the instrument therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the instrument, the second set of wheels being configured to engage the elongated instrument therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of the instrument wherein fixation and motion of the instrument is controlled by controlling

rotations of the wheels; and navigating the instrument using the first and second sets of wheels, which cooperate to provide a specific motion of the instrument.

These and other objects, features and advantages of the present disclosure will become apparent from the following detailed description of illustrative embodiments thereof, which is to be read in connection with the accompanying drawings.

### **BRIEF DESCRIPTION OF DRAWINGS**

This disclosure will present in detail the following description of preferred embodiments with reference to the following figures wherein:

10 FIG. 1A is a block/flow diagram showing a system having an assembly for providing a catheter-assisted endoscopic intervention in accordance with one embodiment of the present principles;

FIG. 1B is a diagram showing the catheter-assisted endoscopic intervention assembly in greater detail in accordance with the present principles;

15 FIG. 2A is a diagram showing an instrument drive mechanism with its housing removed in accordance with one embodiment;

FIG. 2B is a diagram showing the instrument drive mechanism of FIG. 2A with bushing housings and assembly body housing removed to show internal parts in accordance with one embodiment;

20 FIGS. 3A-3C show a spherical joint in different positions for adjusting a position of an instrument drive mechanism in accordance with the present principles;

FIG. 4A is a diagram showing a user interface that includes control buttons on an endoscope in accordance with one embodiment;

FIG. 4B is a diagram showing a user interface that includes a strap with control

buttons in accordance with one embodiment;

FIG. 4C is a diagram showing a user interface that includes an articulated haptic device in accordance with one embodiment; and

FIG. 5 is a flow diagram showing a method for driving an instrument in accordance

5 with illustrative embodiments.

## **DETAILED DESCRIPTION OF EMBODIMENTS**

In accordance with the present principles, systems and methods are described that overcome the shortcomings of conventional catheter-assisted endoscopic systems.

10 Embodiments in accordance with the present principles provide lightweight friction drives and permit mounting to an endoscope with handheld operation of both the endoscope and a catheter driver. Precision motorized control of catheter insertion and rotation with closed-loop position feedback is also provided. In one embodiment, a compact endoscope-mount mechanism utilizes a friction wheel drive to control the catheter insertion and rotation motion.

15 The catheter driver mechanism simplifies workflow, reduces operational personnel and enhances controllability of the catheter.

The present principles employ a differentially driven mechanism that has multiple friction wheels to cooperatively control catheter insertion and rotation. Since this mechanism is compact and lightweight, it can also be mounted on an endoscope working channel to aid 20 with catheter manipulation. The mechanism may employ intelligent feedback from a multitude of sources to supply useful and precise actuation. Feedback sources may include, but are not limited to, force and position sensors, imaging information, motor driving torque, etc. The present embodiments streamline workflow, which has the potential to increase an adoption rate of the present procedures, and reduce the required personnel during an

endoscopy/bronchoscopy procedure. The device can be used with an endoscope and employ quick attachment or detachment. The driver mechanism in accordance with the present principles can be configured to be directly operated by push buttons in combination with the endoscope, or it may be used as a slave driver mechanism to perform catheter navigation by 5 remote control. These techniques can significantly simplify the workflow and can be used for a number of catheter-assisted endoscope procedures. Such procedures have increased in popularity as catheter access to smaller anatomy is being employed to aid in early diagnosis and therapy.

The present principles may be employed in combination with catheters or other 10 instruments and endoscopes or the like to drive the motion of catheters through a joint connection to mount a catheter driver to the endoscope. The present principles also permit use of the endoscope to directly drive the motion of catheters by a single user. The catheter drive mechanism may be configured as slave drive mechanism to remotely control the catheter motion.

15 It should be understood that the present invention will be described in terms of catheter-based medical instruments; however, the teachings of the present invention are much broader and are applicable to any flexible, elongated instruments. In some embodiments, the present principles are employed in tracking or analyzing complex biological or mechanical systems. The elements depicted in the FIGS. may be implemented in various combinations of 20 hardware and software and provide functions which may be combined in a single element or multiple elements.

The functions of the various elements shown in the FIGS. can be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions can be provided by a

single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which can be shared. Moreover, explicit use of the term “processor” or “controller” should not be construed to refer exclusively to hardware capable of executing software, and can implicitly include, without limitation, digital signal processor (“DSP”) hardware, read-only memory (“ROM”) for storing software, random access memory (“RAM”), non-volatile storage, etc.

5 Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both 10 currently known equivalents as well as equivalents developed in the future (i.e., any elements developed that perform the same function, regardless of structure). Thus, for example, it will be appreciated by those skilled in the art that the block diagrams presented herein represent conceptual views of illustrative system components and/or circuitry embodying the principles 15 of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams and the like represent various processes which may be substantially represented in computer readable storage media and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

Furthermore, embodiments of the present invention can take the form of a computer 20 program product accessible from a computer-readable storage medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-readable storage medium can be any apparatus that may include, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The medium can be an electronic, magnetic, optical,

electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk and an optical disk. Current examples of 5 optical disks include compact disk – read only memory (CD-ROM), compact disk – read/write (CD-R/W), Blu-Ray™ and DVD.

Referring now to the drawings in which like numerals represent the same or similar elements and initially to FIG. 1A, a system 100 for performing a procedure, which employs an endoscope mount utilizing a friction-driven wheel mechanism for instrument control is 10 illustratively shown in accordance with one embodiment. System 100 may include a workstation or console 112 from which a procedure is supervised, controlled and/or managed.

Workstation 112 preferably includes one or more processors 114 and memory 116 for storing programs and applications. Memory 116 may store an endoscope navigation module 115 configured to interpret feedback signals and provide navigation directions for the placement 15 and operation of a mounting device 102, such as an endoscope. The endoscope 102 may be manually controlled, although robotically controlled endoscopes may also be employed. The present principles provide the mounting device 102 with a mounting position 149 for securing another instrument 104.

Memory 116 may also store an instrument control module 117 configured to interpret 20 feedback signals and control the placement and operation of the instrument 104. It should be understood that the endoscope 102 and the instrument 104 may include software and hardware (e.g., manual) controls and settings. In addition, although referred to as an endoscope 102 and instrument 104, these devices may include any instruments or devices that are employed in conjunction and should not be construed as limited to the examples given.

Modules 115 and 117 are configured to use the signal feedback (and any other available feedback) to position, reposition or perform other tasks with the endoscope 102 and the instrument 104, respectively. The instrument 104 may include a catheter, a guidewire, a probe, another endoscope, an electrode, a filter device, a balloon device, another medical component, etc.

5 The endoscope 102 and instrument 104 can communicate with their respective modules 115 and 117 through cabling 127 or wireless communications. The cabling 127 may include fiber optics, electrical connections, other instrumentation, etc., as needed.

In useful embodiments, workstation 112 includes modules to perform different tasks 10 during a procedure. These modules may include an image processing module 122 to process images collected by the endoscope 102 or instrument 104. Other modules 124 may include application specific controls and measurements systems to control power, measure parameters, etc.

Workstation 112 preferably includes a display 118 for viewing internal images of a 15 subject (patient) or volume 131. Display 118 may also permit a user to interact with the workstation 112 and its components and functions, or any other element within the system 100. This is further facilitated by an interface 120 which may include a keyboard, mouse, a joystick, a haptic device, or any other peripheral or control to permit user feedback from and interaction with the workstation 112. For example, the user interface 120 allows the user to 20 control the motion of the catheter 104. In one embodiment, the user interface 120 may include a strap with control buttons that wraps around the endoscope 102. Other examples of the user interface 120 are described herein.

In accordance with the present principles, a compact endoscope-mounted instrument drive mechanism or assembly 140 includes a friction wheel drive 132 to control

insertion/retraction and rotation motion of instrument 104. In a particularly useful embodiment, the instrument 104 includes a catheter that is positioned within a working channel of the endoscope 102. The friction wheel drive 132 includes friction wheel sets (136, 138, FIG. 2B) that are operated as a differential friction drive. The friction wheel drive sets 5 include a first set (136) of friction wheels with a rotation plane coplanar with an insertion axis of the catheter 104. Note that the wheels themselves of the first set 136 have a rotation plane that is coplanar to the insertion axis of the catheter 104. A second set (138) of friction wheels includes an oblique angle to the insertion axis of the catheter 104.

Motion of the catheter 104 is determined by the coupled motion of the two wheel sets 10 136 and 138 in the instrument drive mechanism or assembly 140. When the oblique set 138 is driven, it imparts both a rotation force and a translational force on the catheter 104. If the coplanar set 136 is driven in the same direction, the catheter is advanced or retracted accordingly. If the set 136 is held fixed, the catheter 104 is prevented from moving along its 15 axis. Encoders or other sensors (not shown) may be provided in motors 144 or with the wheel sets 136 and 138 to sense rotation and insertion motion of the catheter 104, and assist in closed-loop control of the catheter 104 to compensate for potential slippage of the wheels.

A telescopic stabilizer 146 (also known as a telescopic arm) may be employed to 20 connect the catheter driver assembly 140 to a catheter handle 148, which protects a catheter shaft for the prevention of kinking. In addition, the use of the telescopic stabilizer 146 avoids the need for an extra person to operate the catheter 104.

The mounting position 149 may include or form a joint 150, e.g., a spherical joint, that may be employed to connect the endoscope 102 and the catheter driver assembly 140. An attachment mechanism 152 (e.g., a Luer lock) permits positioning of the catheter driver assembly 140 in different orientations while also permitting easy and quick detachment and

attachment to the endoscope 102.

The catheter 104 preferably runs through the handle 148, through the telescopic stabilizer 146 and through the joint 150 into a base or mounting position (149) (e.g., on the endoscope 102, although other base mounts or positions may be employed). If the base 5 position includes an endoscope 102, the catheter 104 (or other instrument) may run through a working channel of the endoscope 102.

In another embodiment, the catheter drive mechanism or assembly 140 can be employed independently of the endoscope 102 to directly control the motion of the catheter 104. For example, in a catheter-only navigation scenario, the friction-driven catheter drive 10 mechanism 140 could operate independently to control an insertion and rotation motion of the catheter 104. The catheter 104 may be mounted, using the joint 150, to a port or other base. In one embodiment, the active catheter driver (140) mounts to the endoscope 102 and the instruments are employed together during a procedure.

The friction-driven catheter drive mechanism 140 can also be employed as a remotely 15 controlled slave manipulator/mechanism, and the drive mechanism 140 could be table-mounted or ground-mounted and freestanding. In a particularly useful embodiment, the drive mechanism 140 is handheld and includes a light weight and smaller size to permit single user control and use of the device. In one embodiment, the drive mechanism 140 has a largest dimension of under about 4 inches, and preferably less.

20 A handheld assembly 170 may include the endoscope 102, the instrument drive mechanism 140, the instrument 104 and attachment devices (e.g., joint 150, lock 152, telescopic stabilizer 148, etc.). The assembly 170 is shown in greater detail in FIG. 1B.

Referring to FIGS. 2A and 2B, the catheter drive mechanism 140 is shown in greater detail with its housing removed. The mechanism 140 includes two rotary motors 144 to

control the insertion and rotation of catheter 104 by friction. FIG. 2A shows external bushings 202 and 204. FIG. 2B shows wheels 206 and 208 in internal portions of the bushings 202 and 204. The catheter drive mechanism 140 includes a friction drive system used to control the catheter insertion and rotation. The catheter drive mechanism 140

5 includes the set 136 of friction wheels 206 with a rotation plane that is coplanar with the axis of the catheter 102. These wheels 206 (also known as straight wheels) are used to control the linear insertion motion of the catheter 104. In this configuration, three wheels (the minimum number of wheels) are employed to generate the friction, but multiple wheels (more than three) are also capable of driving the mechanism 140 with increased friction. The set 138 of friction

10 wheels 208 has a rotation plane that is at an angle (oblique) with respect to the axis of the catheter 104. These wheels 208 (also referred to as oblique wheels) are employed to control the rotation motion of the catheter 104. In this configuration, three wheels 208 (the minimum number of wheels) are employed to generate the friction, but multiple wheels (more than three) are also capable of driving the mechanism 140 with increased friction.

15 The friction wheels 206, 208 may include different material selections, geometry, texture, mounting angles, etc. In some examples, steel, rubber, plastic or other material with low durameter may be used. The texture of the wheels 206, 208 may be knurled or include a microfinish to increase friction. More than three wheels may be employed to increase the friction as well.

20 Two rotary motors 144 drive the wheel-embedded bushings 202 and 204 through gears 210 for straight and oblique wheels, respectively. Two or more position sensing devices 214 (e.g., linear and rotary optical encoders) may be included to measure the insertion and rotation motion of the catheter 104 through reflected light, in a manner similar to an optical mouse. Other encoder systems may also be employed.

An assembly body 216 includes ball bearings 218 (FIG. 2B) and gears 220 to transfer and support stable motion of the wheels 206 and 208. The assembly body 216 is preferably covered by a housing 222 (FIG. 2A).

Referring to FIGS. 3A-3C, the system could optionally include a joint 150, e.g., a 5 spherical joint that may include the attachment mechanism or lock 152, such as, e.g., a Luer lock. The spherical joint 150 connects a working channel of endoscope 102 and the catheter driver mechanism 140. The spherical joint 150 assists in orienting the friction drive mechanism 140 to any desired position. The spherical joint 150 may be lockable with a rotation knob that presses against the spherical ball in socket mechanism, although other mechanisms may also 10 be employed.

The spherical joint 150 allows positioning the catheter driver mechanism or assembly 140 in different orientations as shown in FIGS. 3A, 3B and 3C. The spherical joint 150 is mounted to the endoscope 102 through the attachment mechanism 152, which aids with quick attachment and detachment. Since the spherical joint 150 can be adjusted to apply an 15 appropriate amount of friction, the joint 150 is positionable in fixed orientations that can hold the catheter driver assembly 140.

Referring to FIGS. 4A-4C, alternative user interface controls 302 are illustratively depicted. The user interface controls 302 are configured to control the catheter drive assembly 140. In FIG. 4A, an endoscope handle 304 includes integrated buttons 306 for 20 controlling the catheter drive assembly 140. Each button may control a direction or type of motion (e.g., translation versus rotation). Control integration with the endoscope handle permits the user to have push buttons on the handle of the endoscope 102 to manually control the catheter 104 driver without coming into physical contact with the catheter 104. One advantage of this would be a single user interface to operate both the endoscope 102 and the

drive mechanism 140.

In FIG. 4B, a strap 308 with control buttons 310 is provided. The strap 308 may be wrapped around the endoscope 102 or be placed over a hand or finger of a user as a ring mouse with touch control. The strap 308 with control buttons 310 mounted on it may be attached to the endoscope handle. The strap 308 permits the user to position the control interface wherever desired. The control buttons 310 may include a joystick, buttons, knobs, a slide or any other physical control. The ring mouse with touch control may be configured to control the catheter driver's insertion and rotation motion, and this may be used in a wireless or wired configuration.

In FIG. 4C, another interface 302 may include an articulated haptic device 314. Device 314 may be employed to control the catheter drive assembly 140 and hence the catheter 104. The articulated haptic device 314 may be based on current sensing within the motors, wheel motion encoding, image feedback, etc. The articulated haptic device 314 may also be used to give a clinician tactile feedback through a handle 316 for the catheter contact force (e.g., against anatomical features). The articulated haptic device 314 includes links 318, which connect to a ball joint 320 on a base 322. Other configurations are also contemplated. This system (314) may or may not be directly connected to the endoscope handle.

Referring to FIG. 5, a method for driving an instrument is shown in accordance with illustrative embodiments. In block 406, a position (e.g., rotation) of an elongated instrument drive assembly is fixed to enable positioning of the instrument using a joint configured to mount the instrument drive assembly to a mounting position and permit the instrument to pass through the joint. The joint may include a spherical joint, and the spherical joint may include a lock. The mounting position may be included on an endoscope and the instrument can be passed through the endoscope. In block 408, the position of the instrument drive assembly

may be locked in a position by locking the joint. In block 409, a telescopic stabilizer may be employed to connect to and support a handle of the instrument, which may include a catheter.

In block 410, the instrument is deployed using first and second sets of wheels, which cooperate to provide a specific motion of the instrument. In block 412, the first set of wheels 5 is controlled by a first motor to control linear motion and provide friction for the instrument, and the second set of wheels is controlled by a second motor to rotate the instrument.

Fixation and/or motion of the instrument, such as a catheter, is controlled using the instrument drive assembly, which includes the first set of wheels coupled to a first end portion and the second set of wheels coupled to a second end portion opposite the first end portion.

10 The first set of wheels is configured to engage the instrument therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the instrument, and the second set of wheels is configured to engage the elongated instrument therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of the instrument wherein fixation and motion of the instrument is controlled by controlling 15 rotations of the wheels.

In block 414, the mounting position which may include an endoscope or other medical device is navigated to a desired location (e.g., within a subject). In block 416, the instrument drive assembly may be controlled with a user interface to navigate the instrument to a desired location. The user interface may include a portable interface device that may be placed at or 20 near the instrument drive assembly or disposed remotely from. The user interface may include an attachment mechanism to attach to an endoscope, to a body part of the user (or other) or any other object. The instrument drive assembly may be controlled through a user interface mounted on the endoscope. The user interface may include a specifically designed interface and may employ acoustic commands, haptic feedback, button or other device inputs, etc.

In interpreting the appended claims, it should be understood that:

- a) the word "comprising" does not exclude the presence of other elements or acts than those listed in a given claim;
- b) the word "a" or "an" preceding an element does not exclude the presence of 5 a plurality of such elements;
- c) any reference signs in the claims do not limit their scope;
- d) several "means" may be represented by the same item or hardware or software implemented structure or function; and
- e) no specific sequence of acts is intended to be required unless specifically 10 indicated.

Having described preferred embodiments for handheld catheter driver with endoscope mount utilizing friction-driven wheel mechanism (which are intended to be illustrative and not limiting), it is noted that modifications and variations can be made by persons skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in 15 the particular embodiments of the disclosure disclosed which are within the scope of the embodiments disclosed herein as outlined by the appended claims. Having thus described the details and particularity required by the patent laws, what is claimed and desired protected by Letters Patent is set forth in the appended claims.

**CLAIMS:**

1. An instrument driving mechanism, comprising:
  - an instrument drive assembly (140) including a first set of wheels (136) coupled to a first end portion and a second set (138) of wheels coupled to a second end portion opposite the first end portion, the first set of wheels being configured to engage an elongated instrument (104) therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the instrument, the second set of wheels being configured to engage the elongated instrument therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of the instrument wherein motion of the instrument is controlled by controlling rotations of the wheels;
  - the instrument drive assembly mounts to a mounting position (149) of a medical device that permits the instrument to pass therethrough and being configured to fix a position of the instrument drive assembly to enable positioning of the instrument.
2. The mechanism as recited in claim 1, wherein the first and second sets of wheels (136, 138) are controlled to cooperate to control motion of the instrument.
3. The mechanism as recited in claim 2, wherein the first set of wheels are controlled by a first motor (144) to control linear motion and provide friction for the instrument.
4. The mechanism as recited in claim 2, wherein the second set of wheels are controlled by a second motor (144) to rotate the instrument.

5. The mechanism as recited in claim 1, wherein the mounting position forms a joint (150) and the joint includes a lock (152) to lock a position of the joint.

6. The mechanism as recited in claim 1, wherein the mounting position (149) is included on the medical device, which includes an endoscope and the instrument is passed through the endoscope.

7. The mechanism as recited in claim 6, wherein the instrument drive assembly is controlled through a user interface (306) mounted on the endoscope.

8. The mechanism as recited in claim 1, further comprising a user interface (302, 314) for controlling the instrument drive assembly.

9. The mechanism as recited in claim 1, wherein the instrument (104) includes a catheter and further comprising a telescopic stabilizer (146) for connecting to and supporting a handle of the catheter.

10. An instrument driving mechanism, comprising:  
an instrument drive assembly (140) including a first set (136) of wheels coupled to a first end portion and a second set (138) of wheels coupled to a second end portion opposite the first end portion, the first set of wheels being configured to engage a catheter therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the catheter, the second set of wheels being configured to engage the catheter therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of

the catheter wherein fixation and motion of the catheter is controlled by controlling rotations of the wheels;

a joint (150) configured to mount the instrument drive assembly to an endoscope and permit the catheter to pass through the joint into a working channel of the endoscope, the joint being configured to fix a position of the instrument drive assembly to enable positioning of the catheter;

a telescopic stabilizer (146) configured to connect a handle of the catheter to the instrument drive assembly on an opposite side of for the joint; and

a user interface (120) configured to control the instrument drive assembly.

11. The mechanism as recited in claim 10, wherein the first and second sets (136, 138) of wheels are controlled to cooperate to control motion of the instrument.

12. The mechanism as recited in claim 11, wherein the first set of wheels are controlled by a first motor (144) to control linear motion and provide friction for the instrument.

13. The mechanism as recited in claim 11, wherein the second set of wheels are controlled by a second motor (144) to rotate the instrument.

14. The mechanism as recited in claim 10, wherein the joint (150) includes a spherical joint and the spherical joint includes a lock (152) to lock a position of the joint.

15. The mechanism as recited in claim 10, wherein the user interface (306) is mounted on the endoscope.

16. The mechanism as recited in claim 10, wherein the user interface (302) includes a handheld portable instrument that is attachable to and detachable from objects.

17. A method for driving an instrument, comprising:  
positioning (406) an instrument drive assembly on a mounting position on another device to mount the instrument drive assembly and permit an elongated instrument to pass through the other device;  
controlling (410) motion of the instrument using the instrument drive assembly including a first set of wheels coupled to a first end portion and a second set of wheels coupled to a second end portion opposite the first end portion, the first set of wheels being configured to engage the instrument therein such that a rotation plane of the first set of wheels is coplanar with a longitudinal axis of the instrument, the second set of wheels being configured to engage the elongated instrument therein such that a rotation plane of the second set of wheels is obliquely oriented with the longitudinal axis of the instrument wherein fixation and motion of the instrument is controlled by controlling rotations of the wheels; and navigating (416) the instrument using the first and second sets of wheels, which cooperate to provide a specific motion of the instrument.

18. The method as recited in claim 17, wherein navigating (416) the instrument includes controlling the first set of wheels by a first motor to control linear motion and provide friction for the instrument, and controlling the second set of wheels by a second motor to rotate the instrument.

19. The method as recited in claim 17, wherein the mounting position includes a joint having a lock and wherein positioning includes locking (408) a position of the joint.

20. The method as recited in claim 17, wherein the mounting position is included on an endoscope and the instrument is passed through the endoscope.

21. The method as recited in claim 20, wherein the instrument drive assembly is navigated (416) using a user interface mounted on the endoscope.

22. The method as recited in claim 17, wherein navigating (416) includes controlling the instrument drive assembly with a user interface remote from the instrument drive assembly.

23. The method as recited in claim 17, wherein the instrument includes a catheter and the method further comprises connecting to and supporting (409) a handle of the catheter with a telescopic stabilizer.

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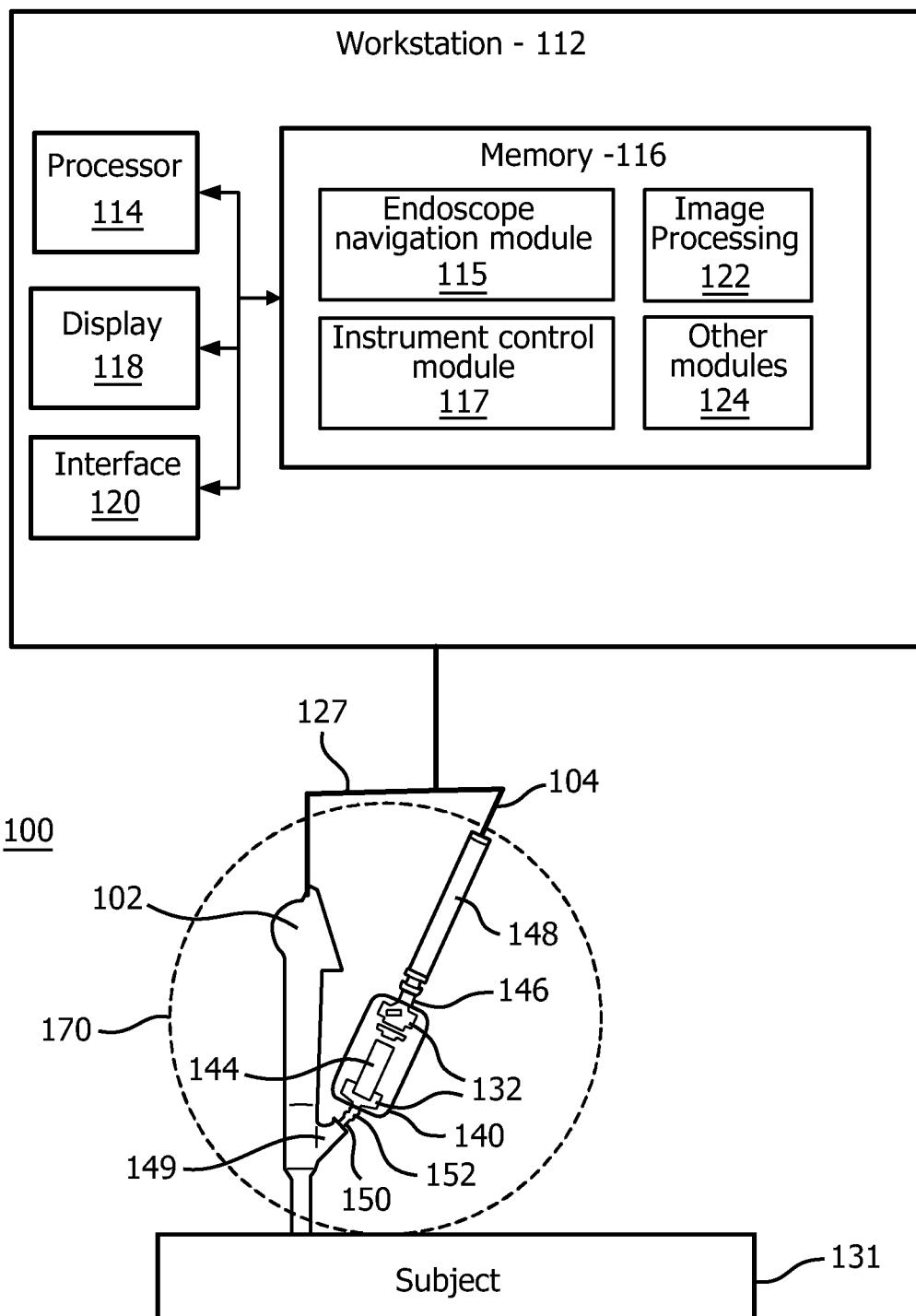


FIG. 1A

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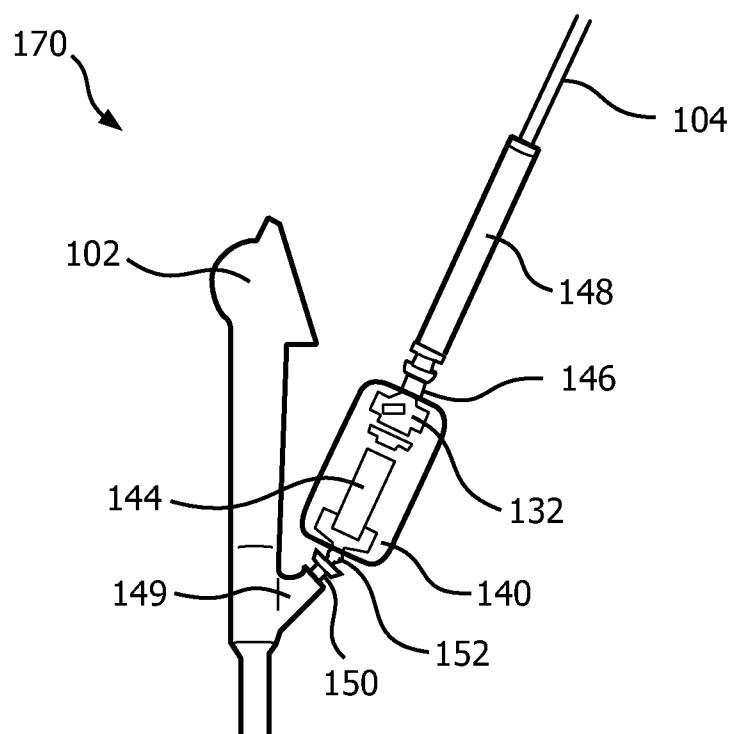


FIG. 1B

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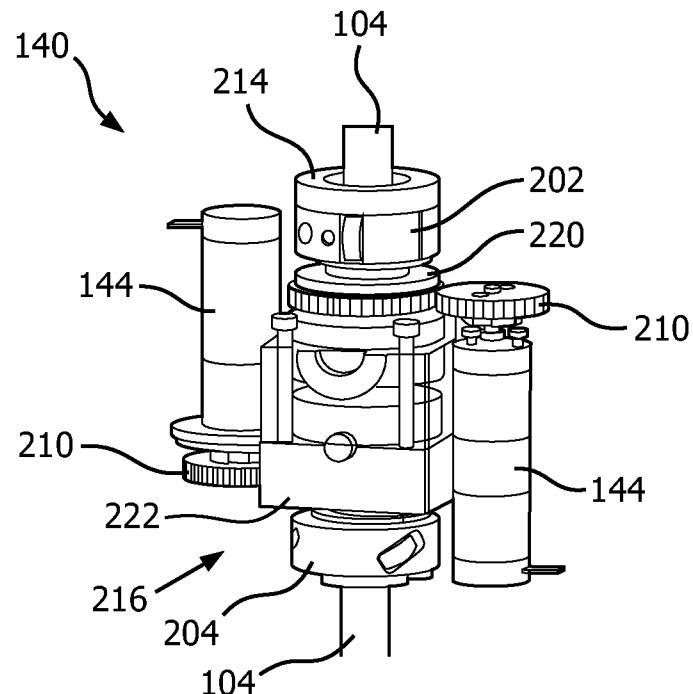


FIG. 2A

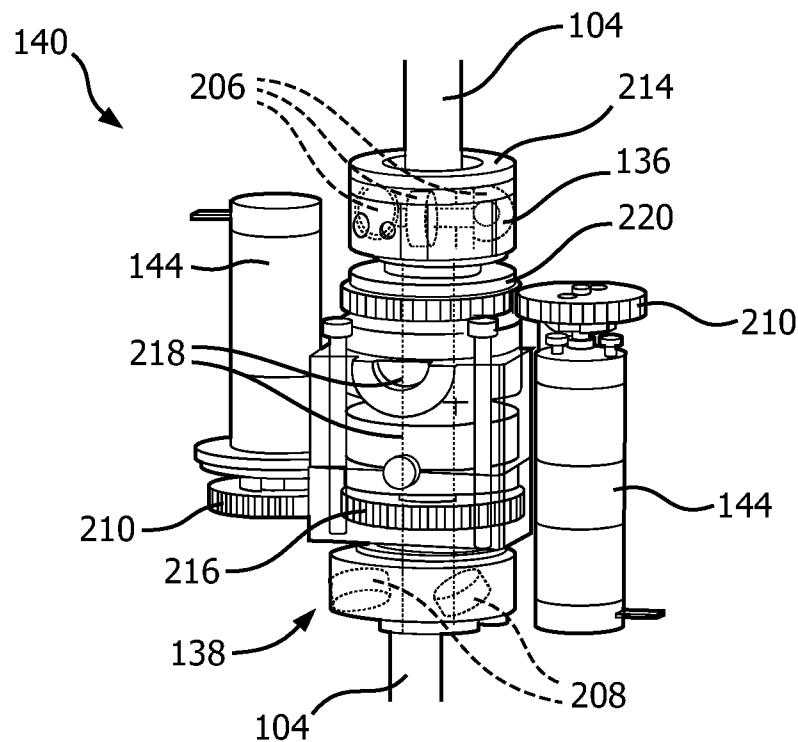


FIG. 2B

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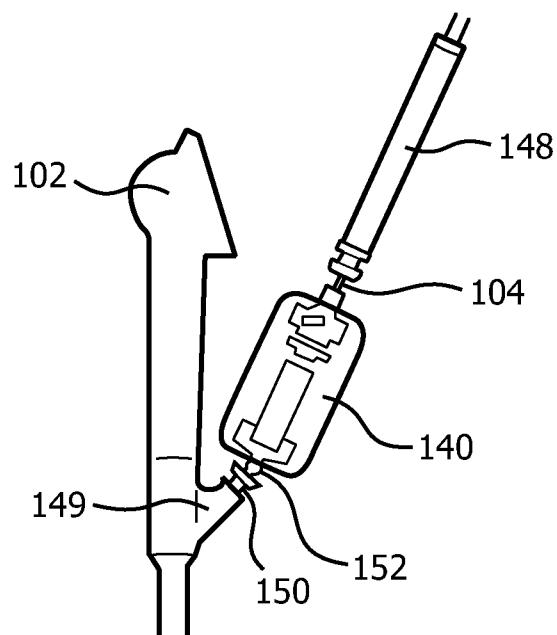


FIG. 3A

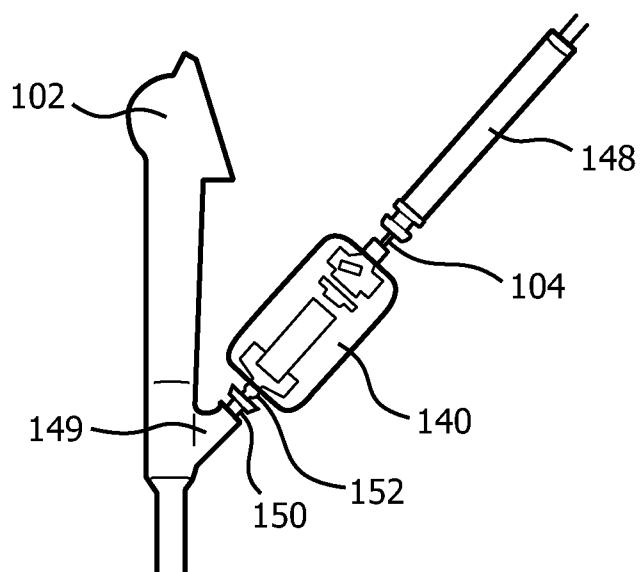


FIG. 3B

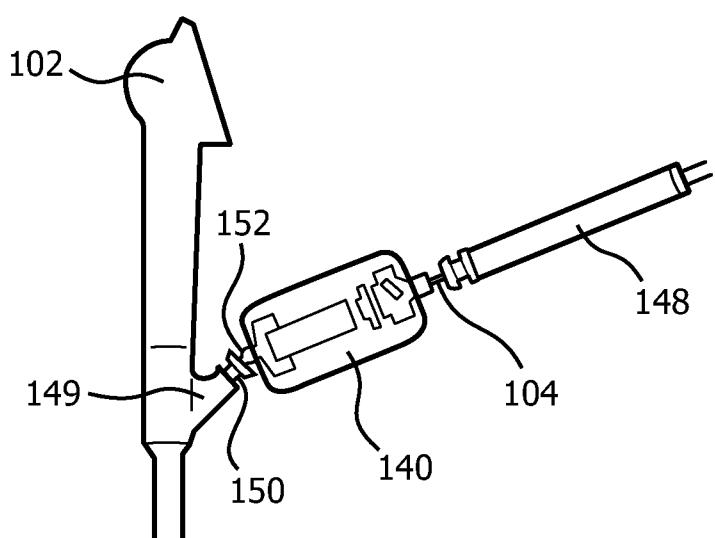
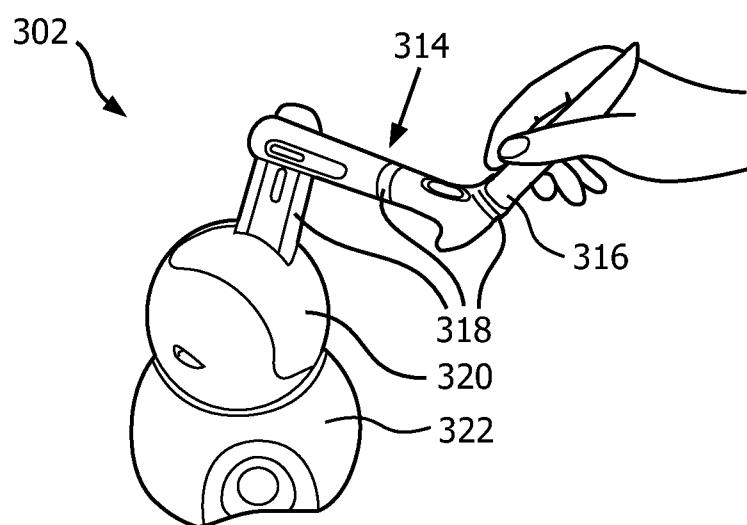
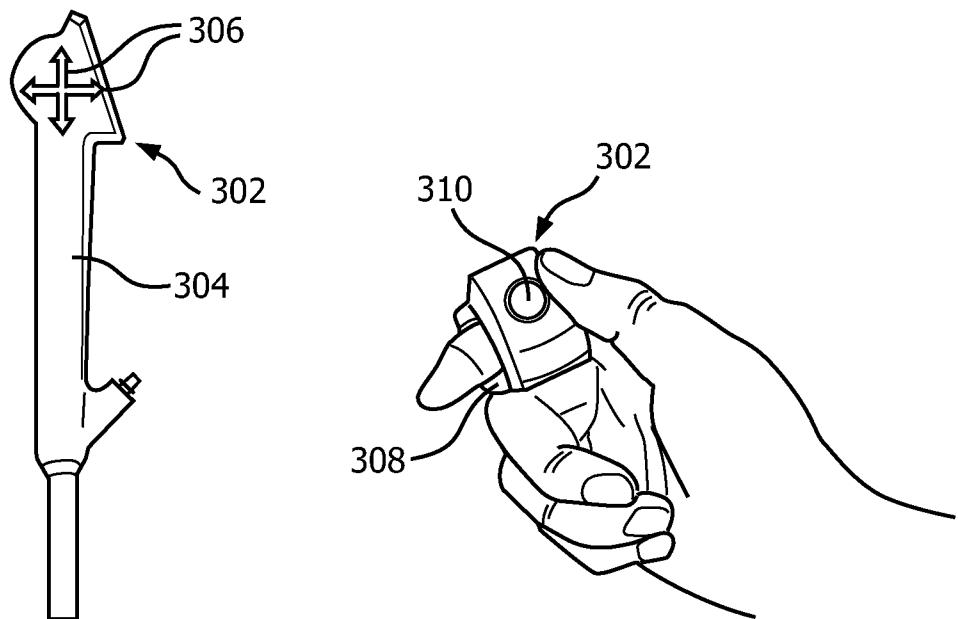


FIG. 3C

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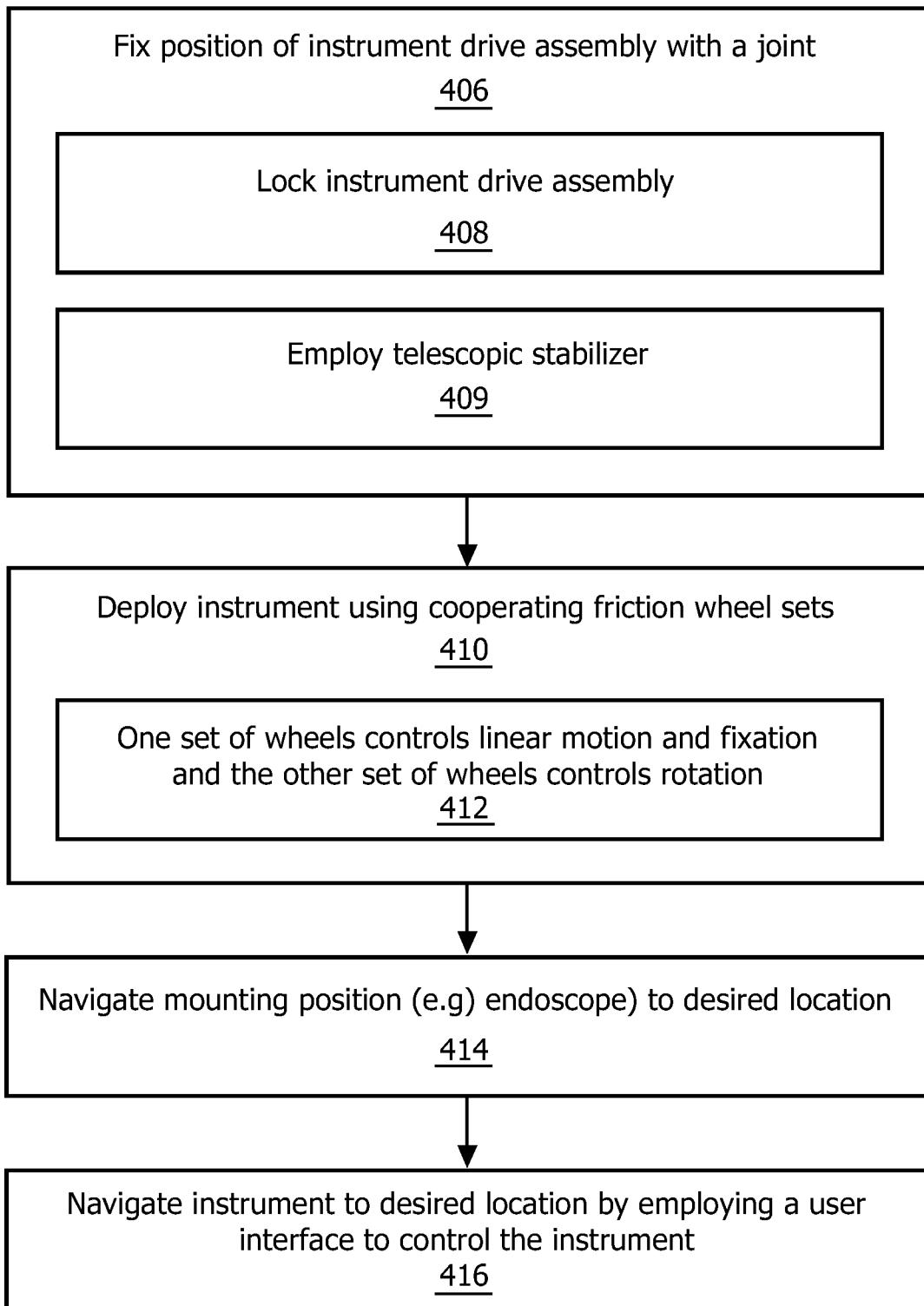


FIG. 5

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2015/057754

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. A61B1/00 A61M25/01 A61B34/30  
ADD.

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
A61B A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2003/040737 A1 (MERRIL GREGORY L [US] ET AL) 27 February 2003 (2003-02-27) paragraphs [0021], [0022], [0035], [0036]; figures 3,4 -----	1-16
Y	US 2006/224162 A1 (SUZUKI KEITA [JP] ET AL) 5 October 2006 (2006-10-05) paragraphs [0049] - [0057]; figures 7-11 -----	1-16
Y	WO 2014/132672 A1 (OLYMPUS MEDICAL SYSTEMS CORP [JP]) 4 September 2014 (2014-09-04) figures 4A,4B & US 2015/045617 A1 (YAMADA TETSUHIRO [JP]) 12 February 2015 (2015-02-12) ----- -/-	5,10-16

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 January 2016	15/01/2016

Name and mailing address of the ISA/  
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NL - 2280 HV Rijswijk  
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Fax: (+31-70) 340-3016

Authorized officer

Mayer-Martenson, E

## INTERNATIONAL SEARCH REPORT

International application No PCT/IB2015/057754
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## C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 2 305 339 A1 (TRE ESSE PROGETTAZIONE BIOMEDICA S R L [IT]) 6 April 2011 (2011-04-06) abstract; figure 2 -----	9-16
Y	EP 1 987 789 A1 (OLYMPUS MEDICAL SYSTEMS CORP [JP]) 5 November 2008 (2008-11-05) figure 1 -----	7,8,15, 16
A	US 2009/209812 A1 (OMOTO KEIJIRO [JP]) 20 August 2009 (2009-08-20) figure 5 -----	1-16
A	US 2012/232476 A1 (BHAT RAVINDRA [NL] ET AL) 13 September 2012 (2012-09-13) abstract; figure 1 -----	1-16

**INTERNATIONAL SEARCH REPORT**International application No.  
PCT/IB2015/057754**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

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

1.  Claims Nos.: 17-23  
because they relate to subject matter not required to be searched by this Authority, namely:  
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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

**Remark on Protest**

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

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

 International application No  
 PCT/IB2015/057754

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