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(54) **EMERGENCY RELEASE AND STERILE BARRIERS FOR ROBOTIC SURGERY SYSTEMS**

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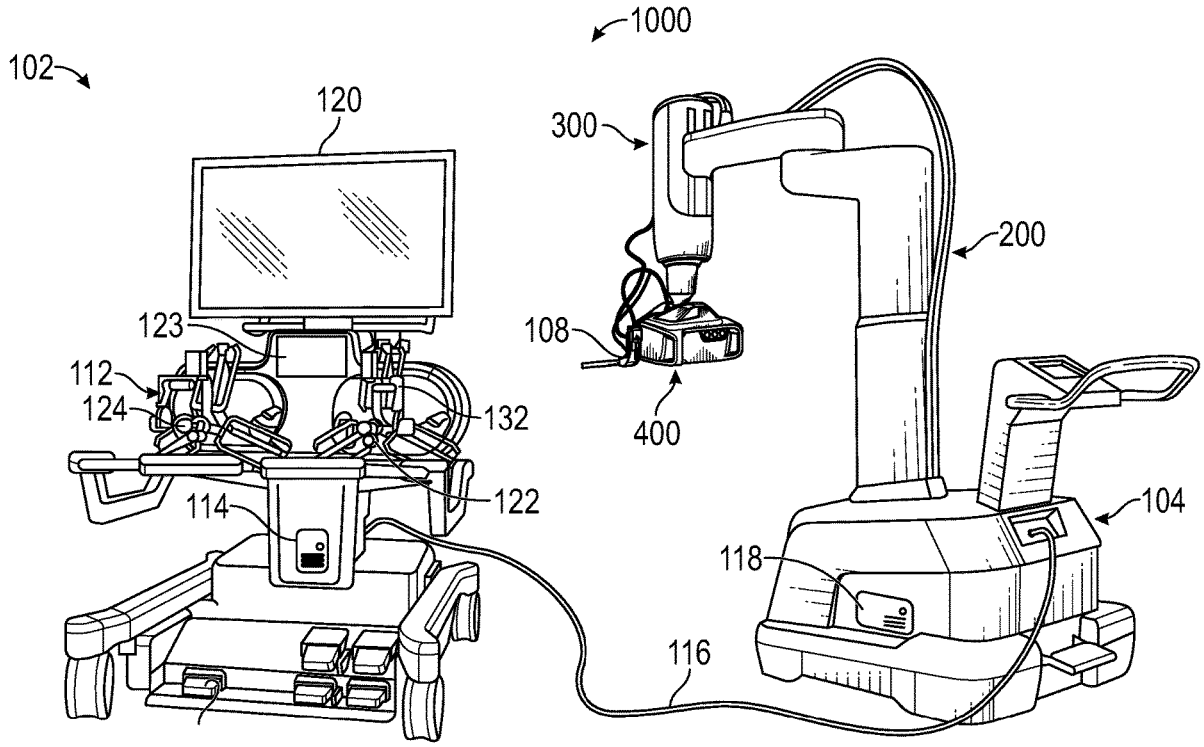
(52) **U.S. Cl.**
CPC ..... ***A61B 34/74*** (2016.02); *A61B 2034/743* (2016.02)

(57) **ABSTRACT**

An instrument manipulator for a robotic surgery system can include a housing configured to support a surgical instrument. The instrument manipulator can include an actuator configured to move the housing forward and backward. The instrument manipulator can include a release connected to the housing and configured to engage with the actuator in a first configuration to allow the housing and the at least one surgical instrument to move forward responsive to activation of the actuator. The release can be configured to disengage from the actuator in a second configuration to allow a user to manually retract the housing and the at least one surgical instrument. The instrument manipulator can include a user interface positioned at least partially on an exterior surface of the housing and configured to permit the user to transition the release from the first configuration to the second configuration.



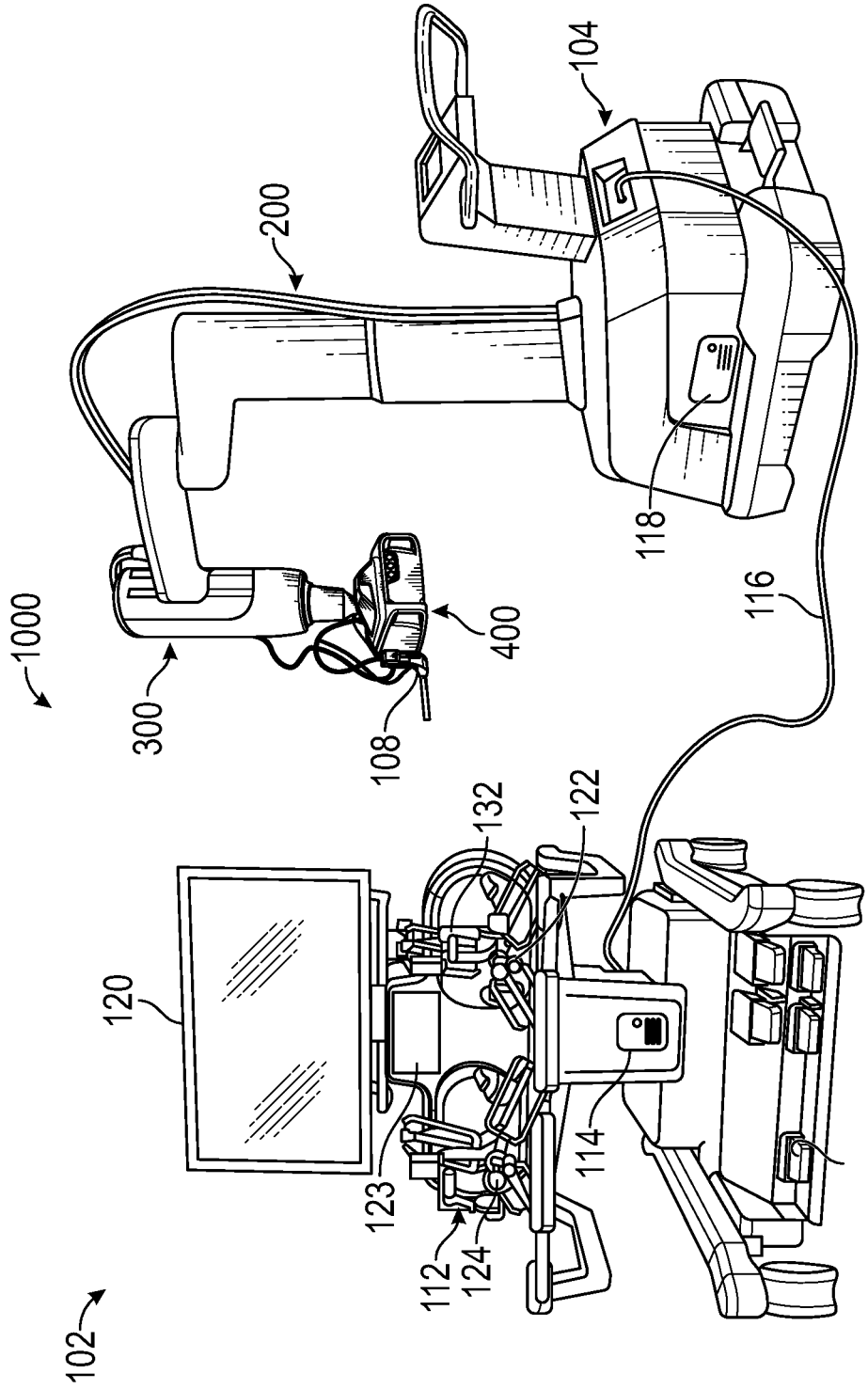



FIG. 1A

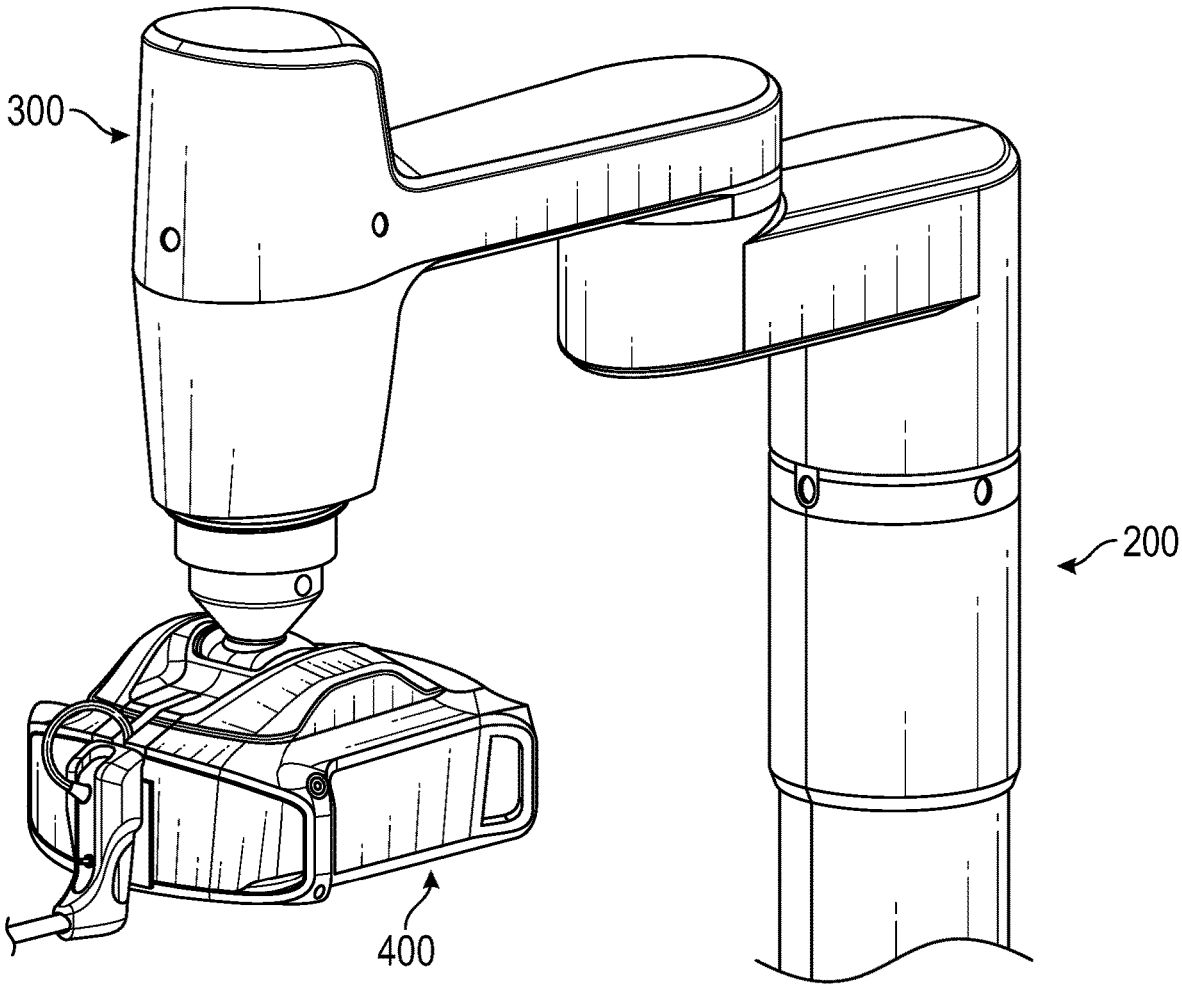



FIG. 1B

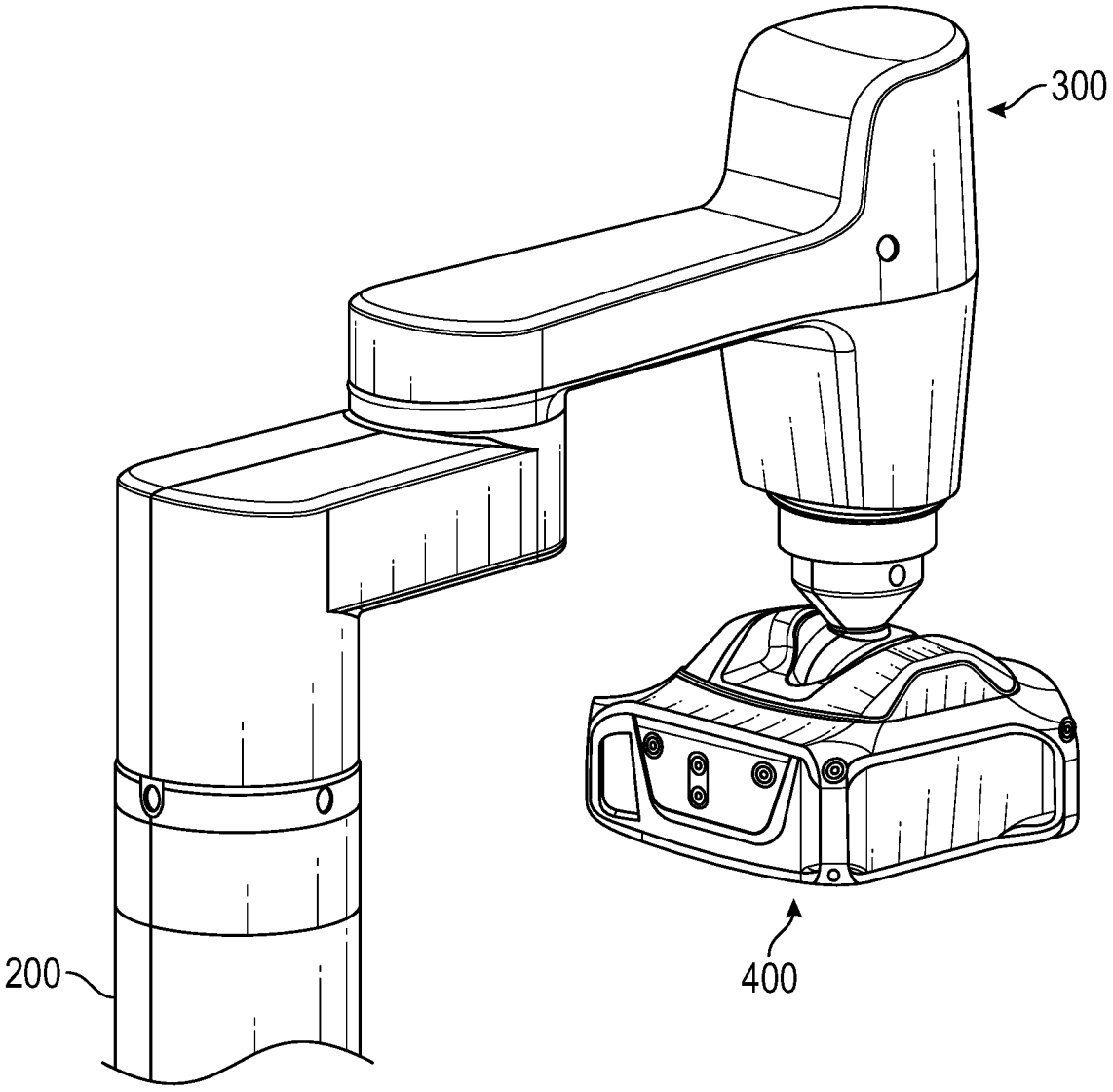



FIG. 1C

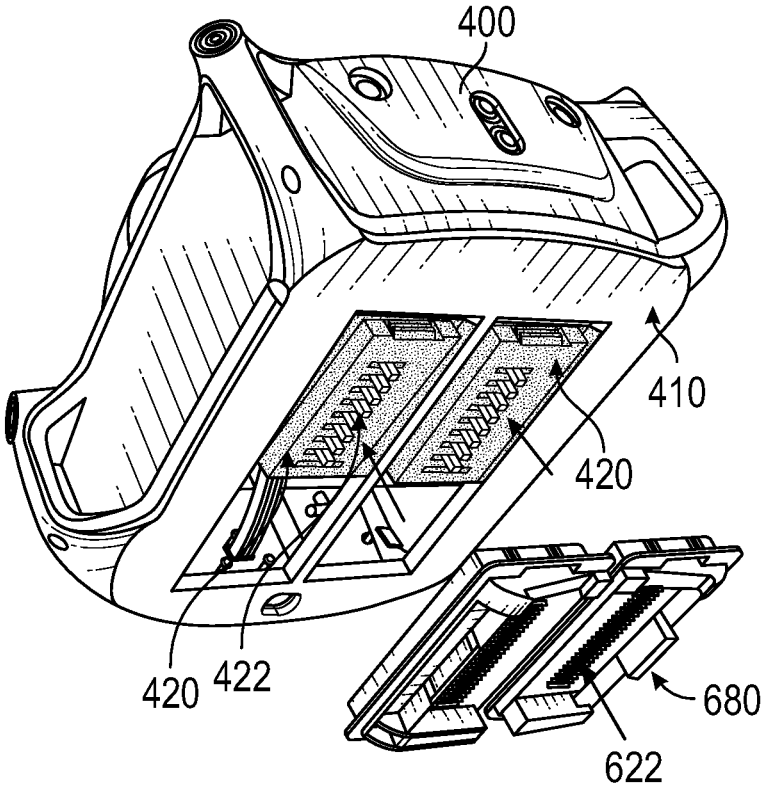



FIG. 2A

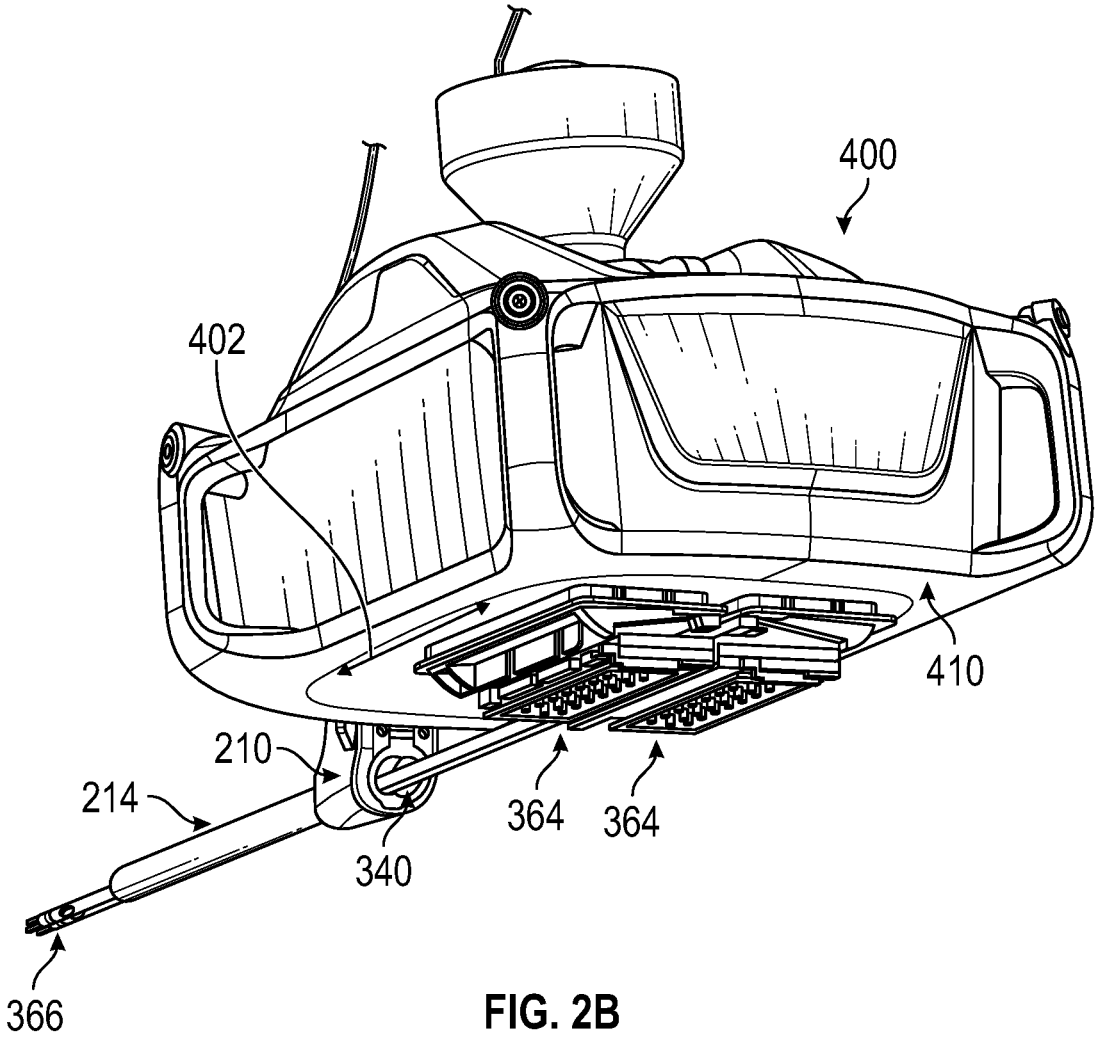



FIG. 2B

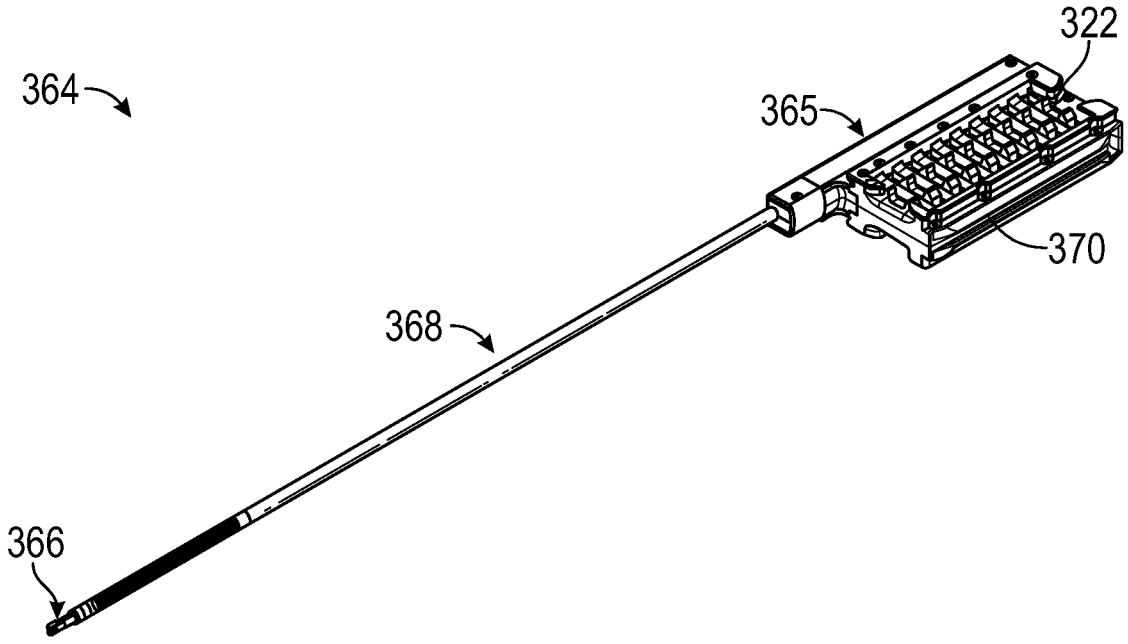



FIG. 2C

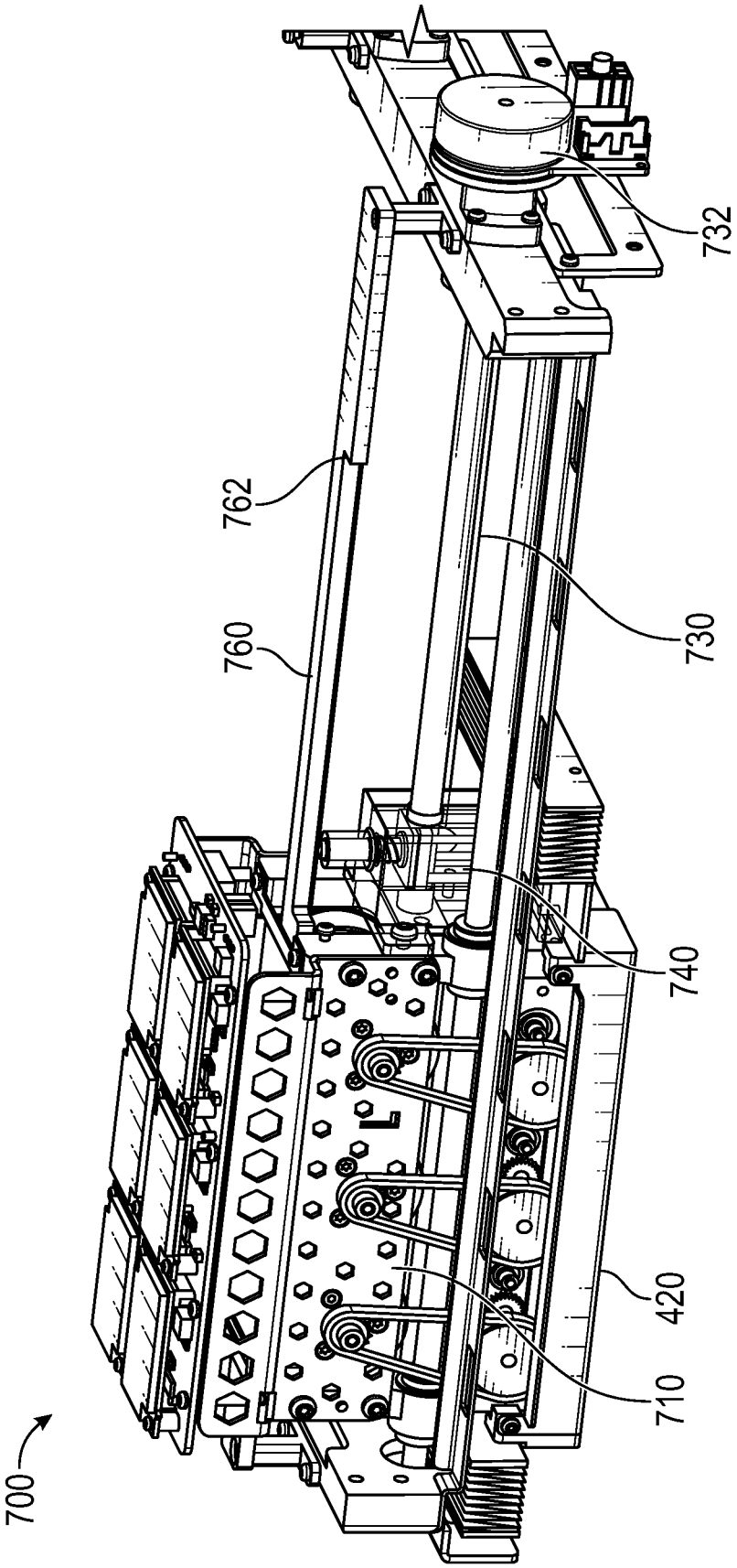



FIG. 3A

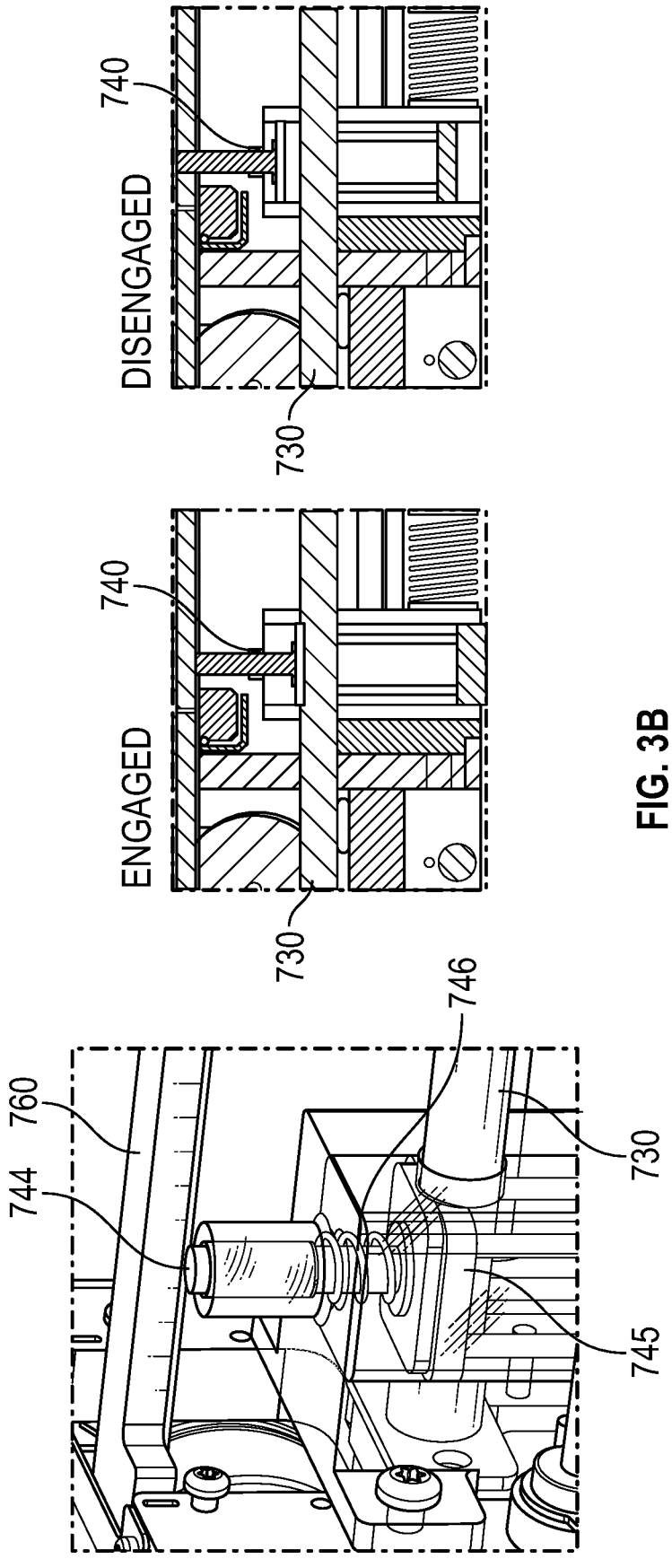



FIG. 3B

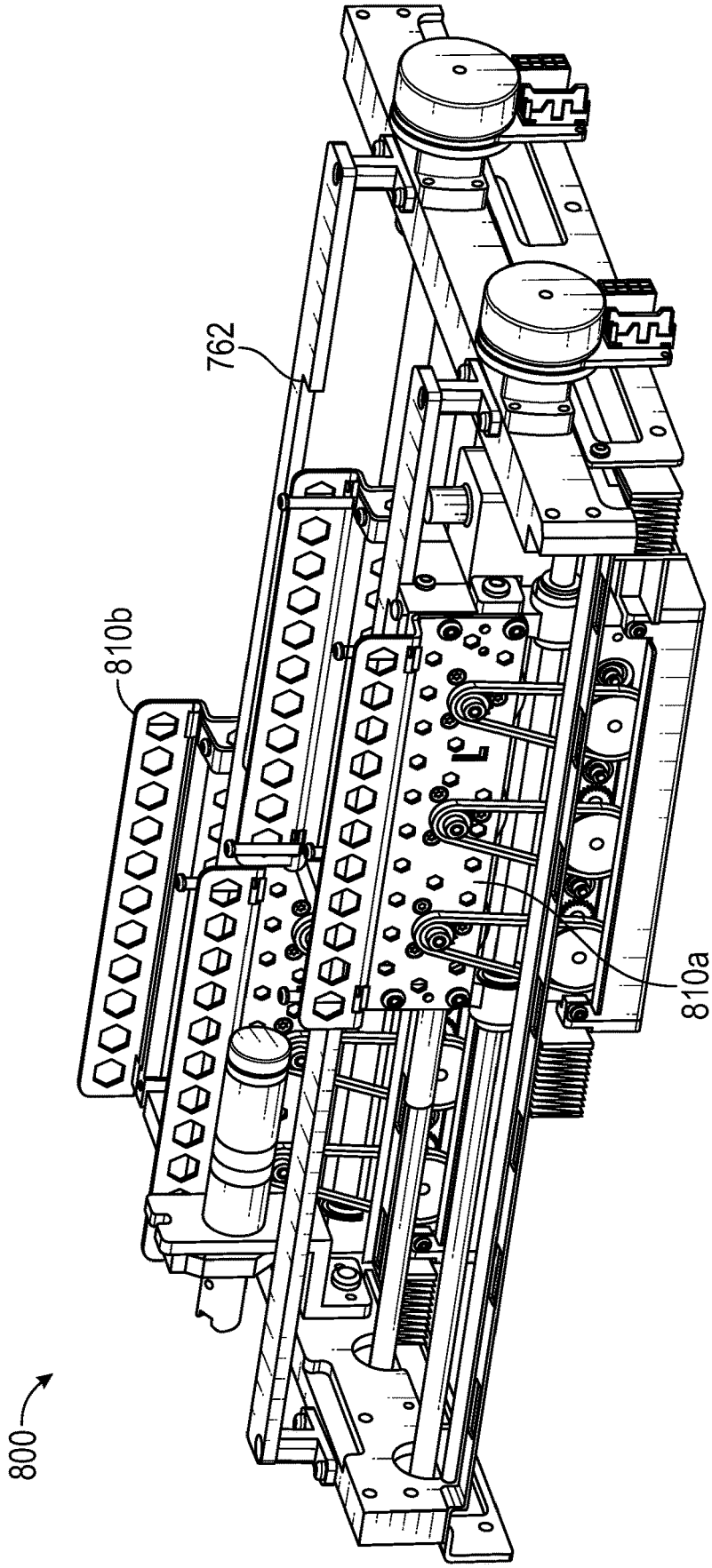



FIG. 3C

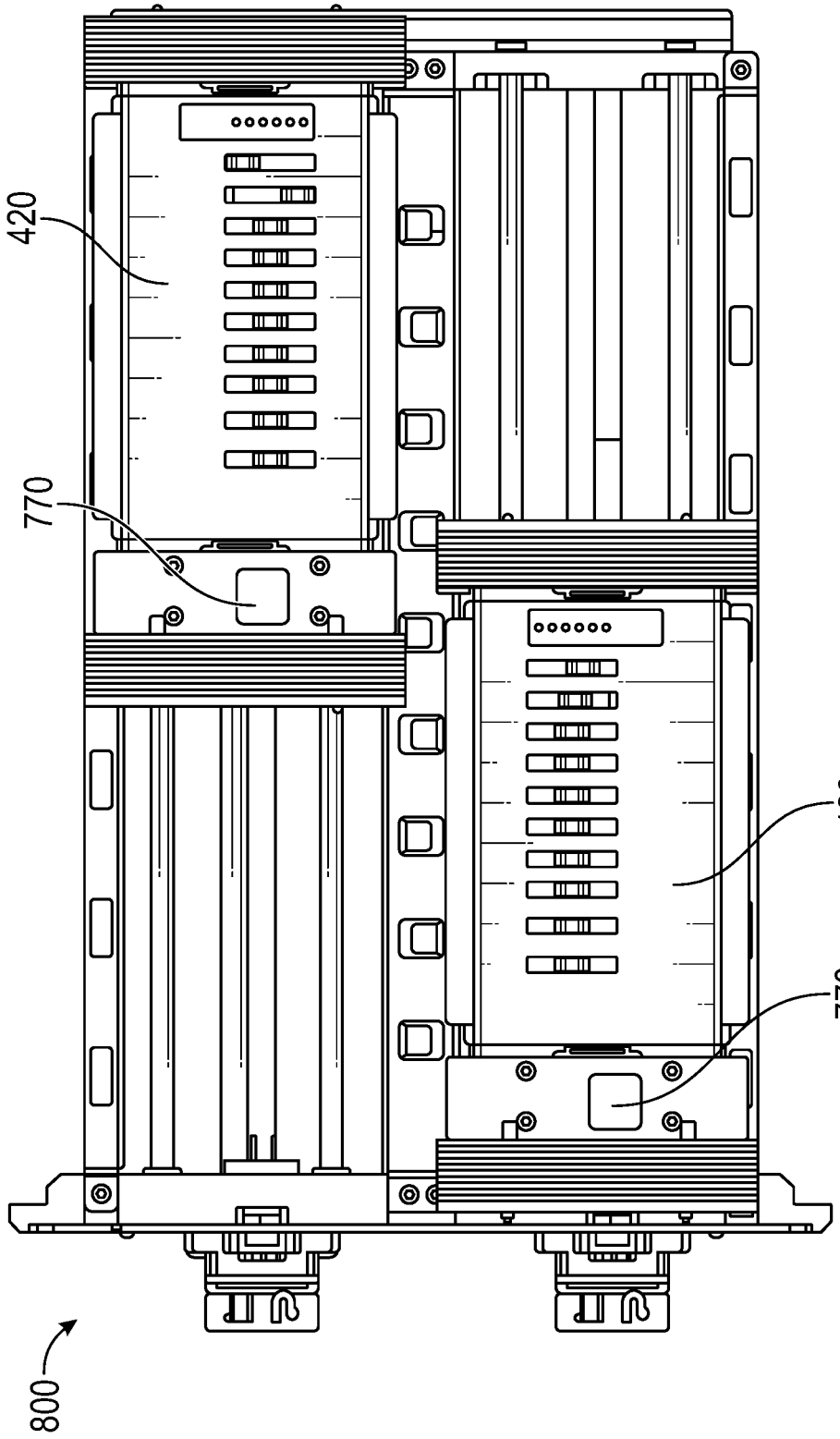



FIG. 3D

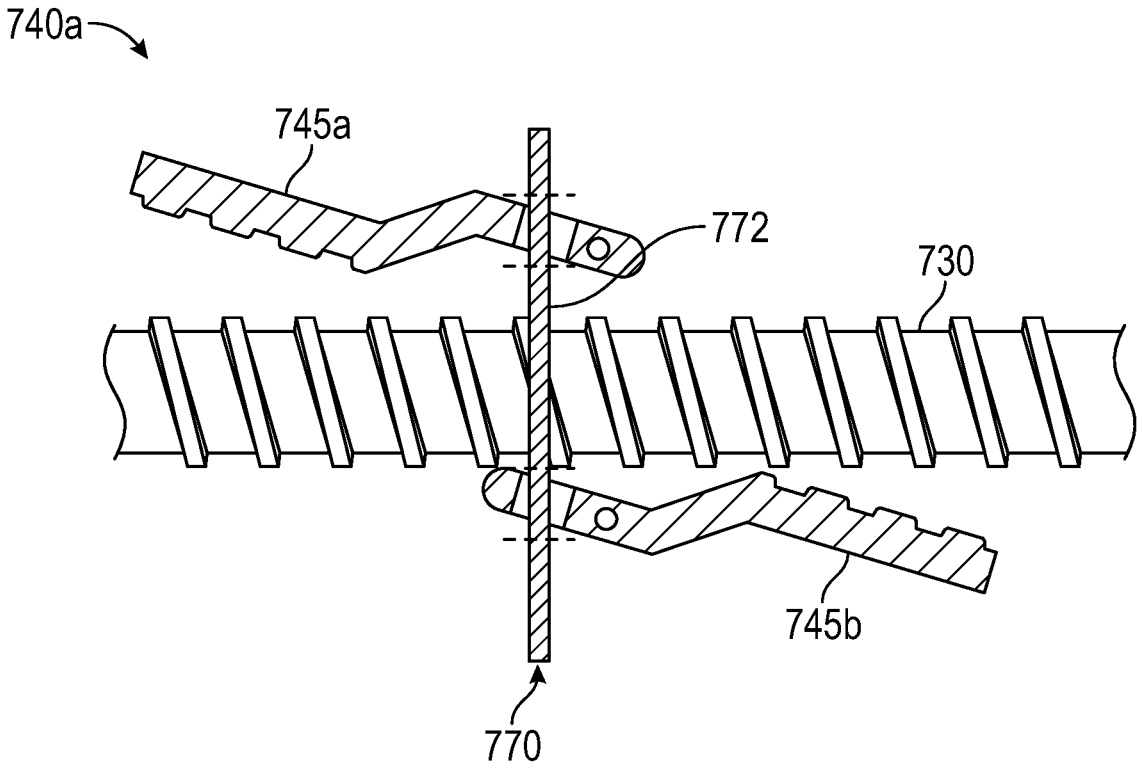



FIG. 3E

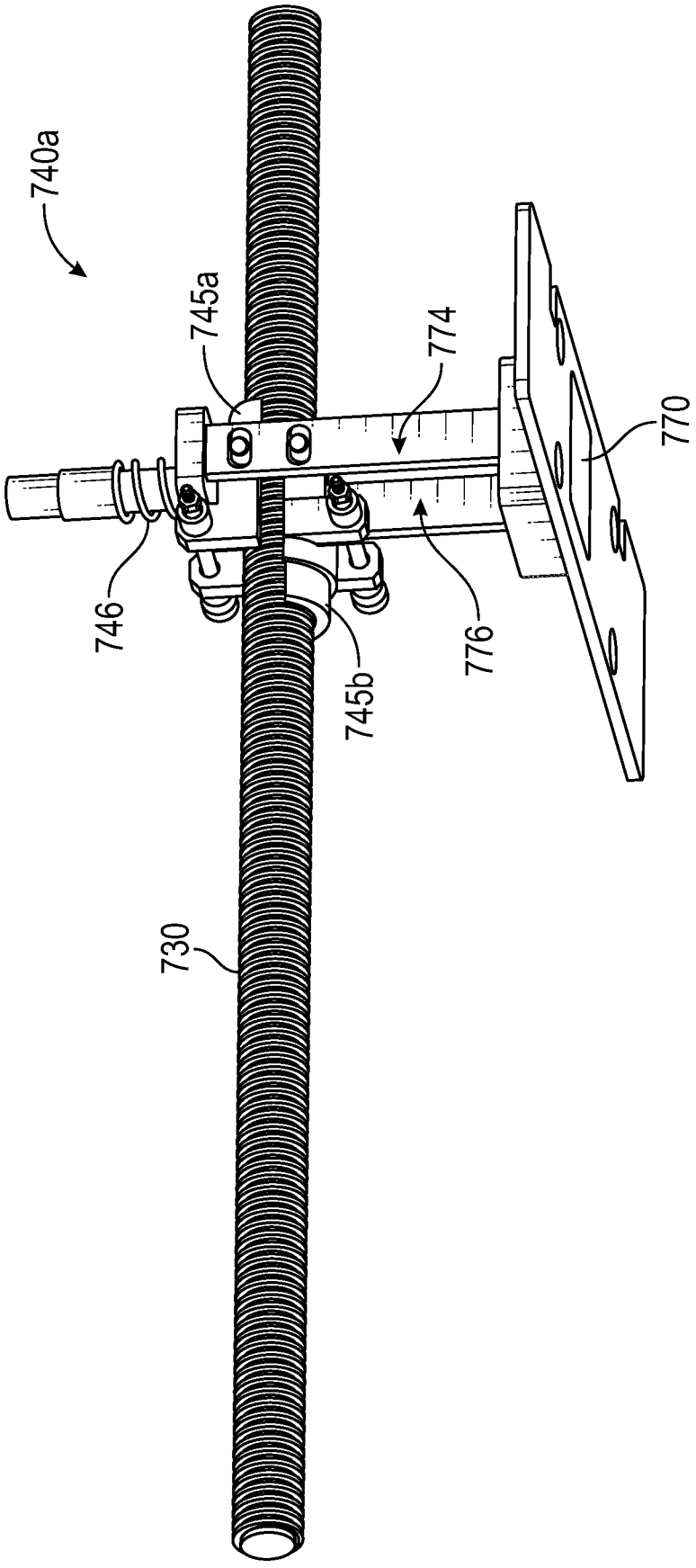



FIG. 3F

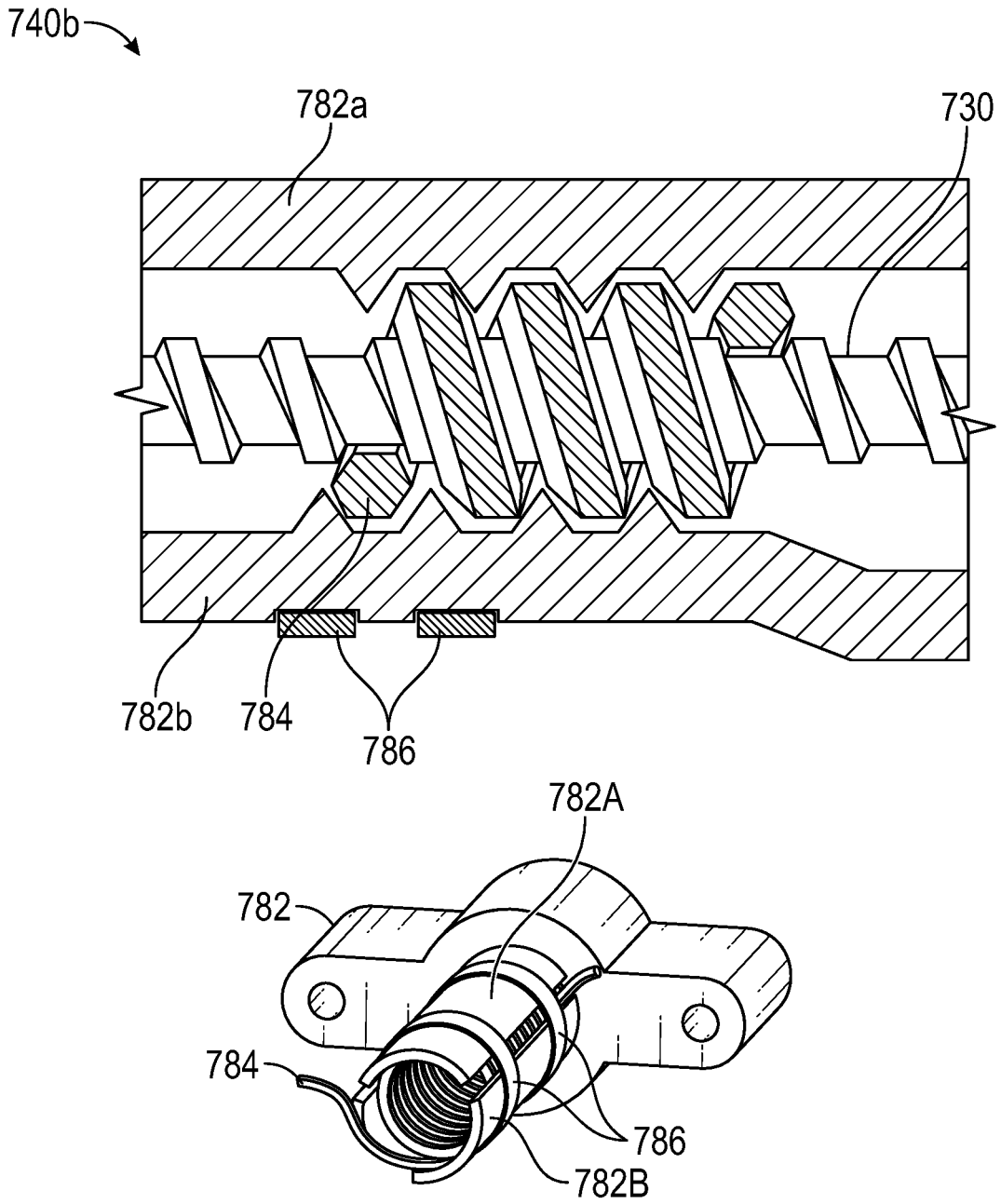



FIG. 3G

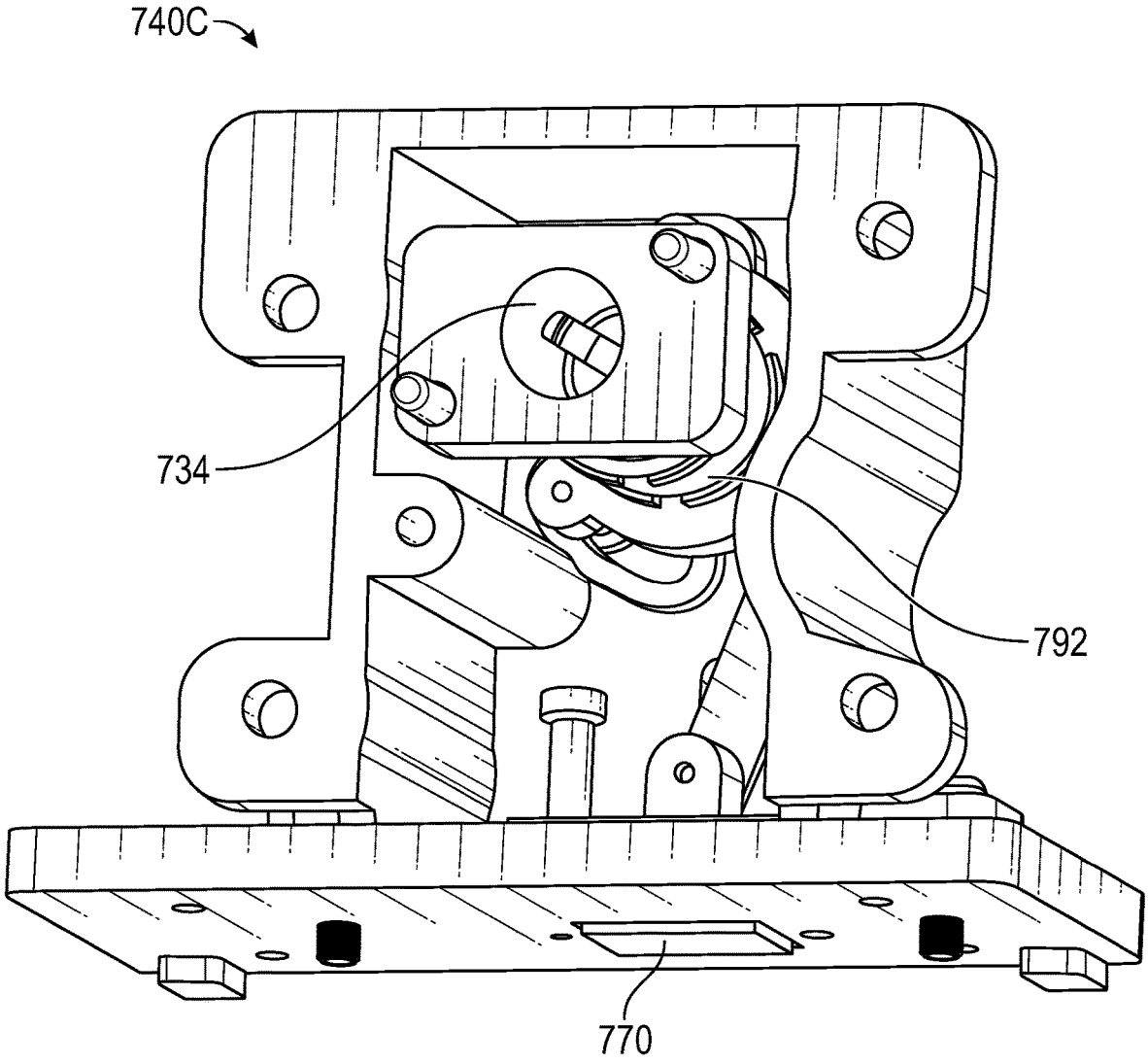



FIG. 3H

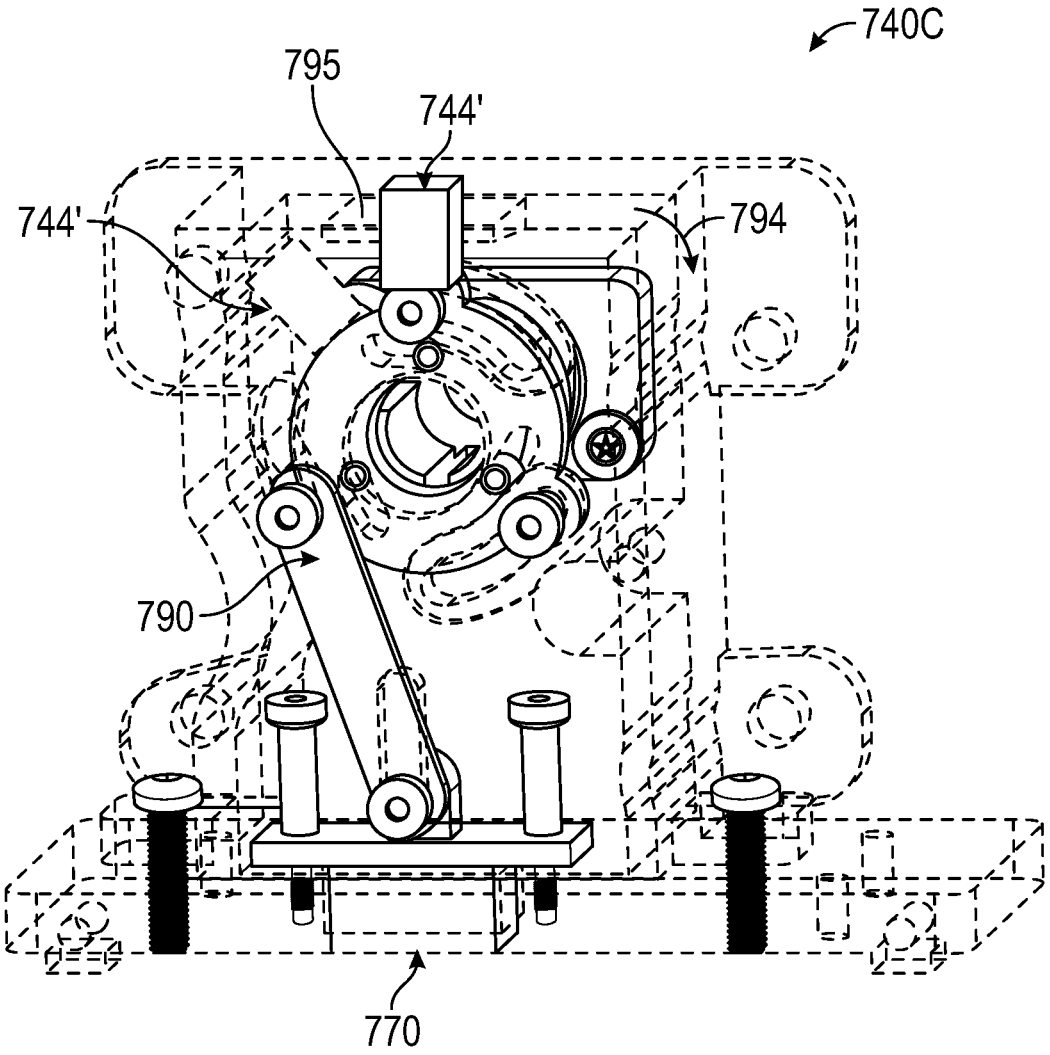



FIG. 3I

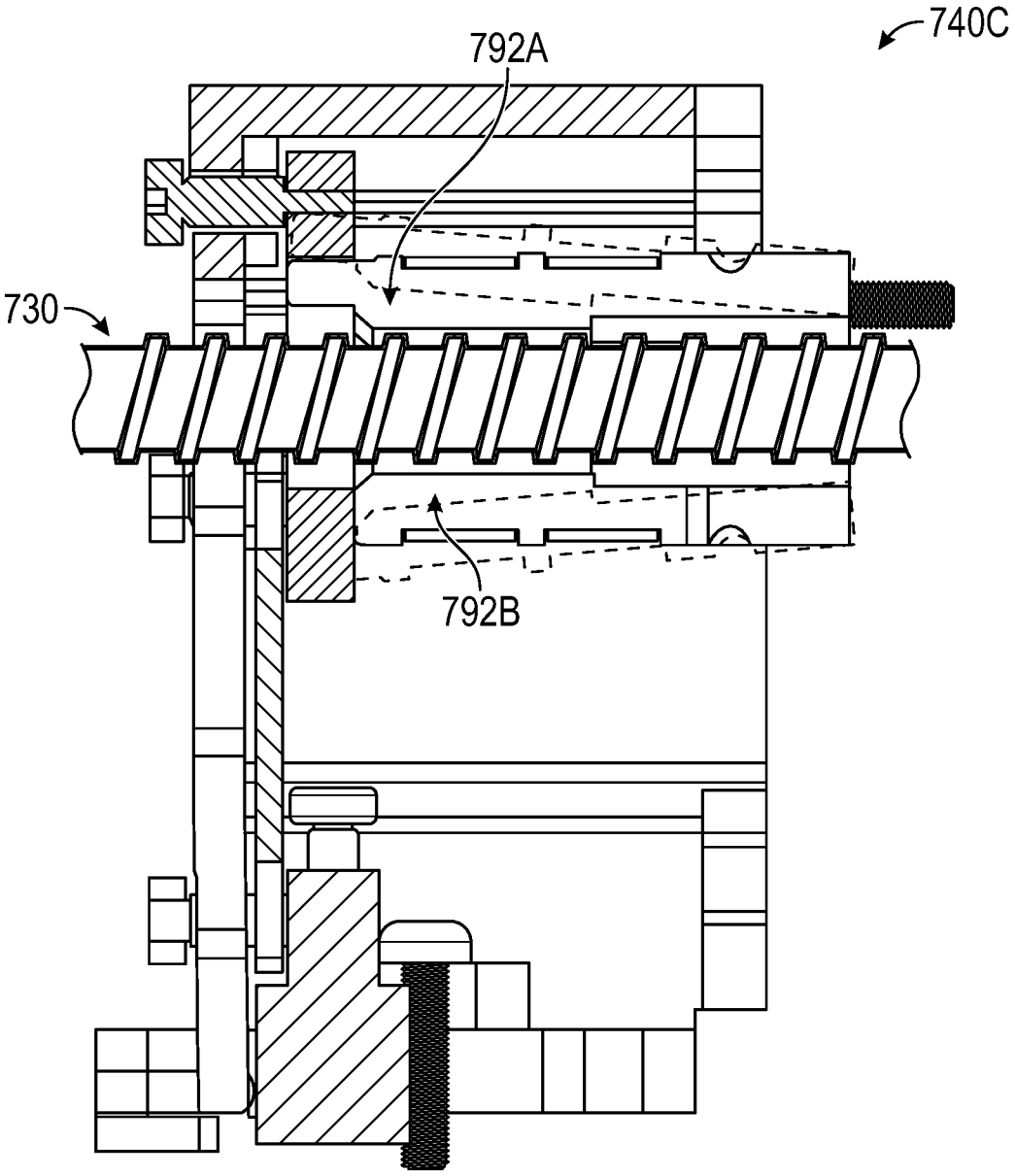



FIG. 3J

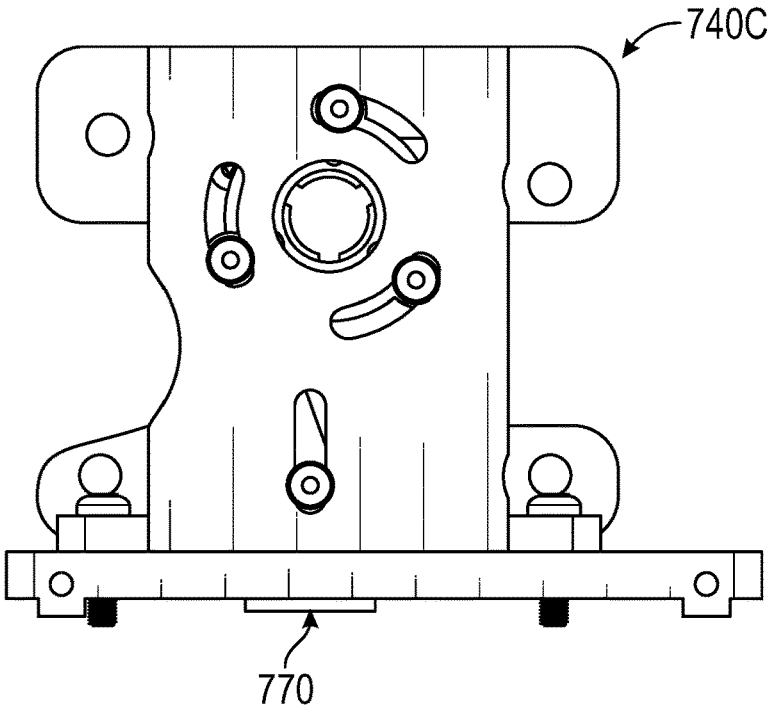



FIG. 3K

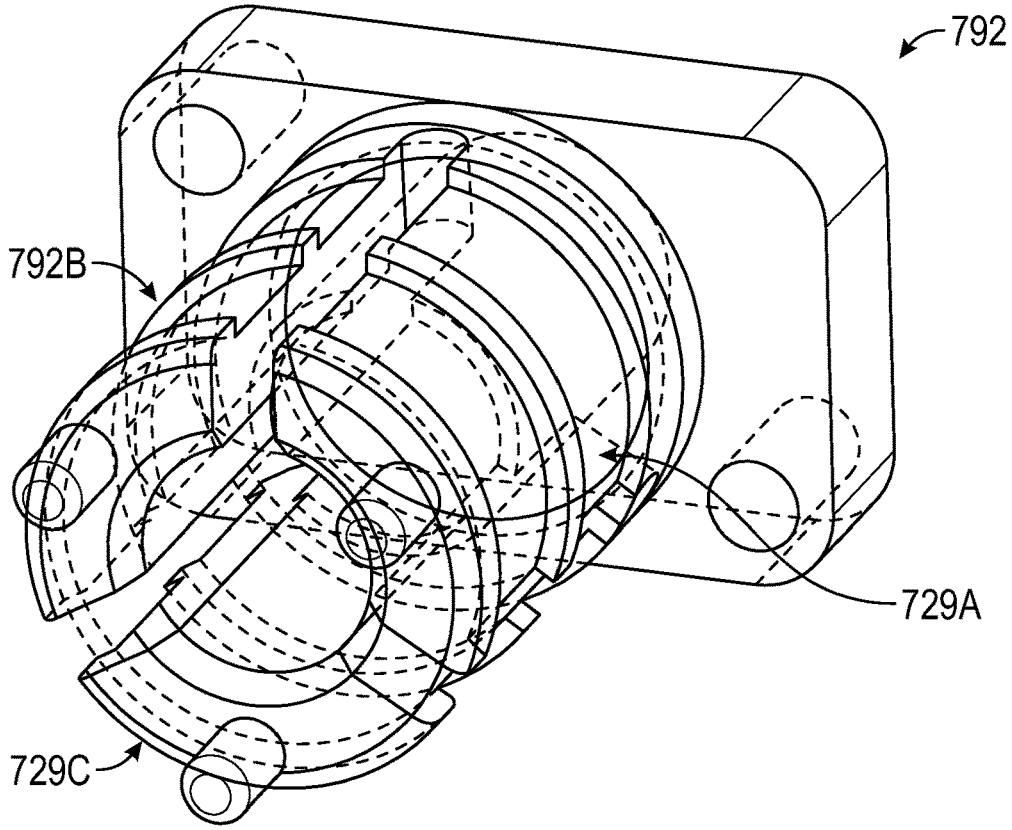



FIG. 3L

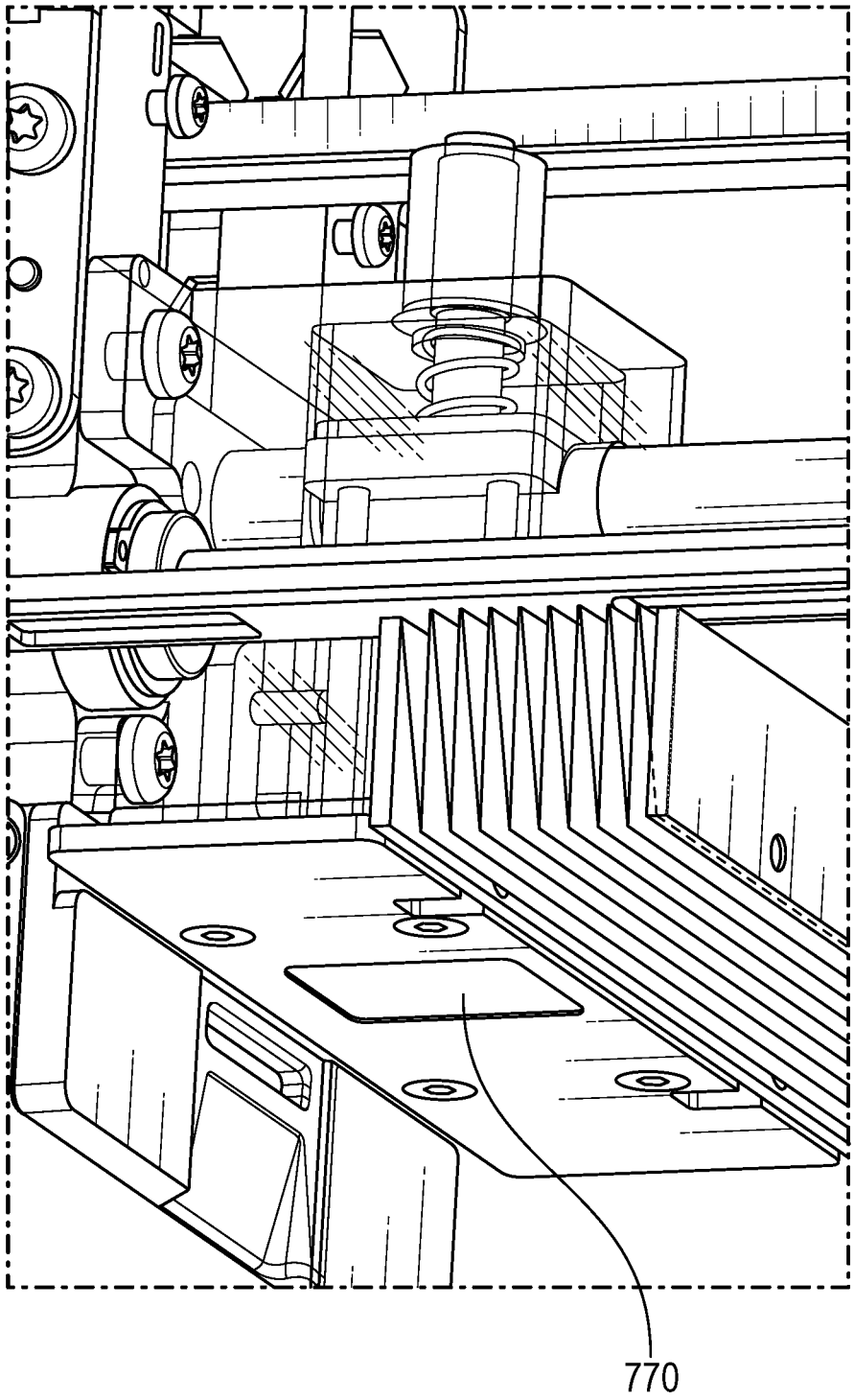



FIG. 4A

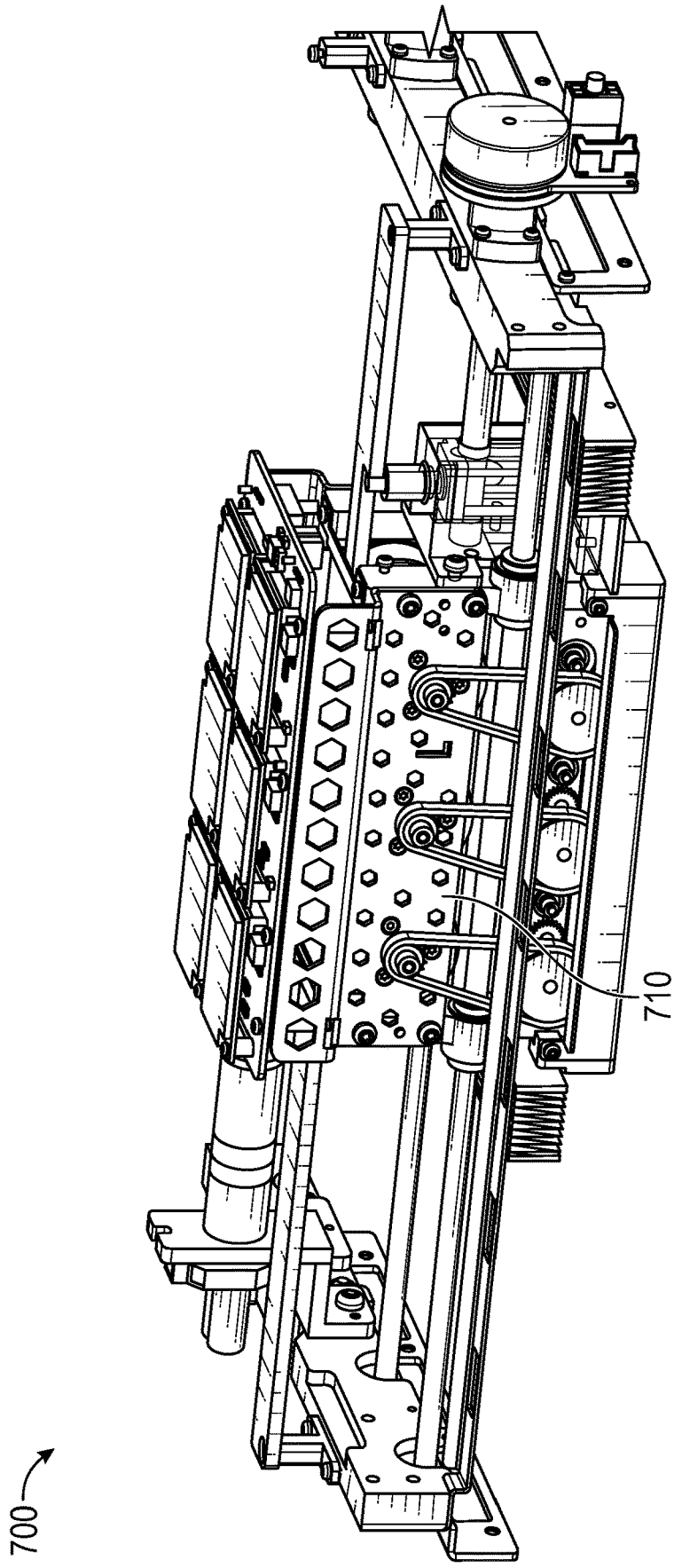



FIG. 4B

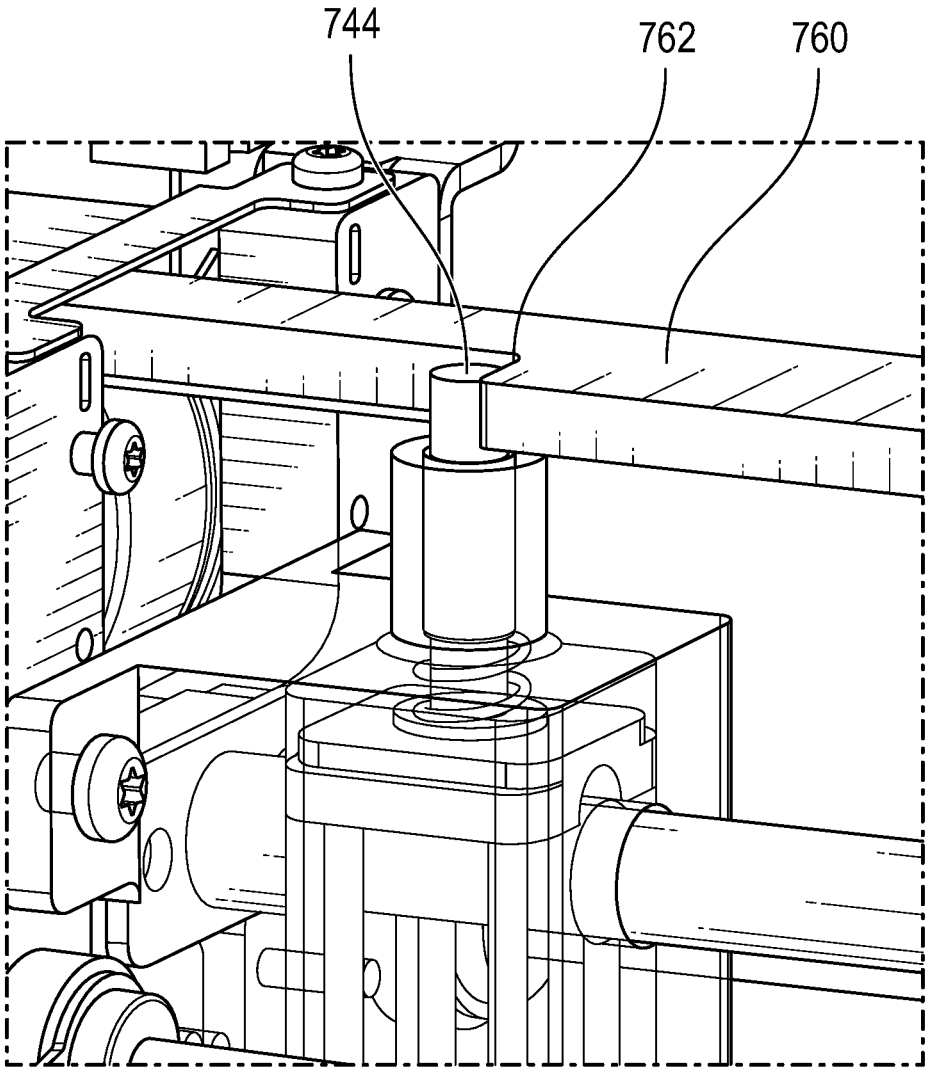



FIG. 4C

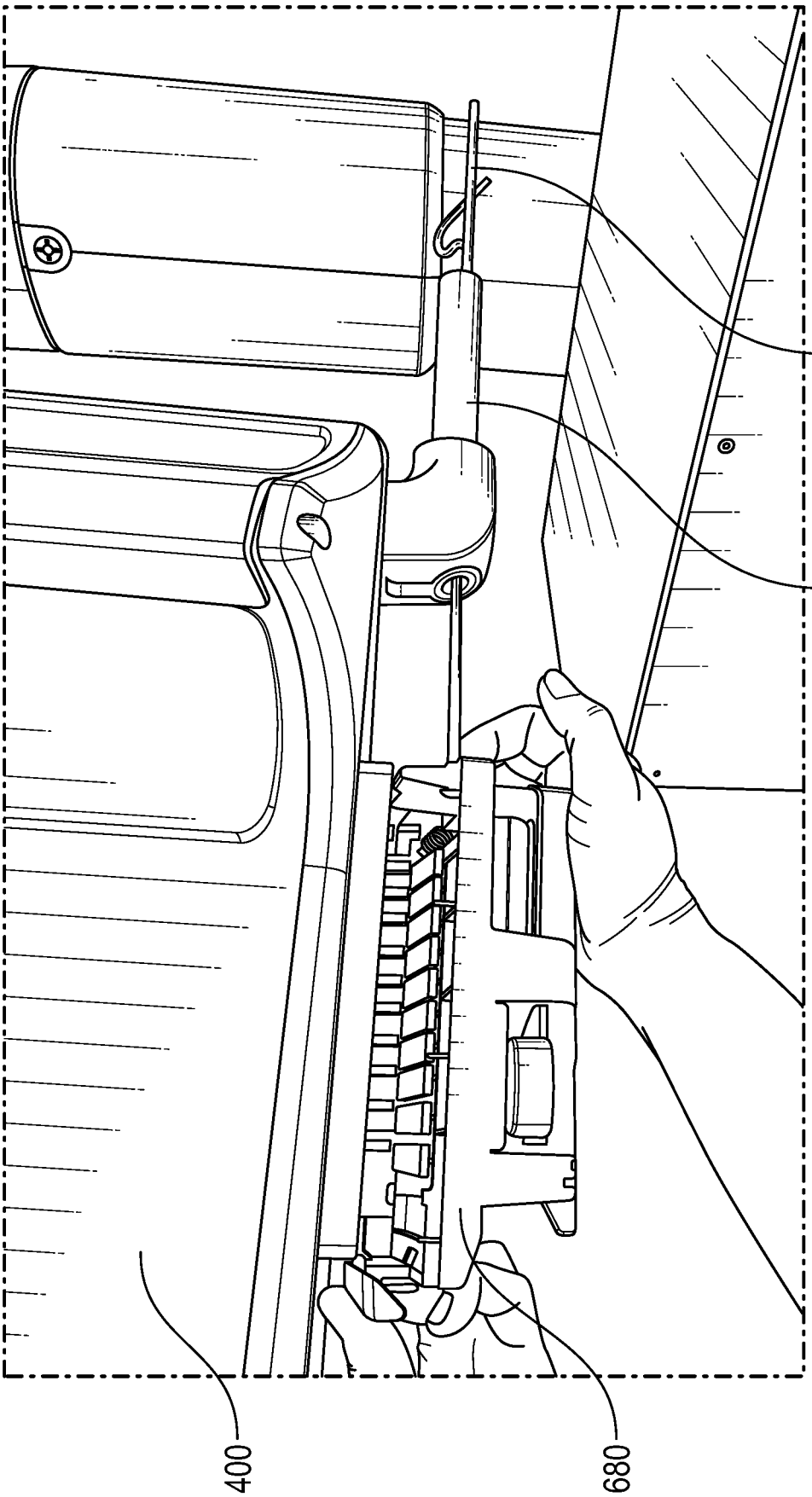



FIG. 4D

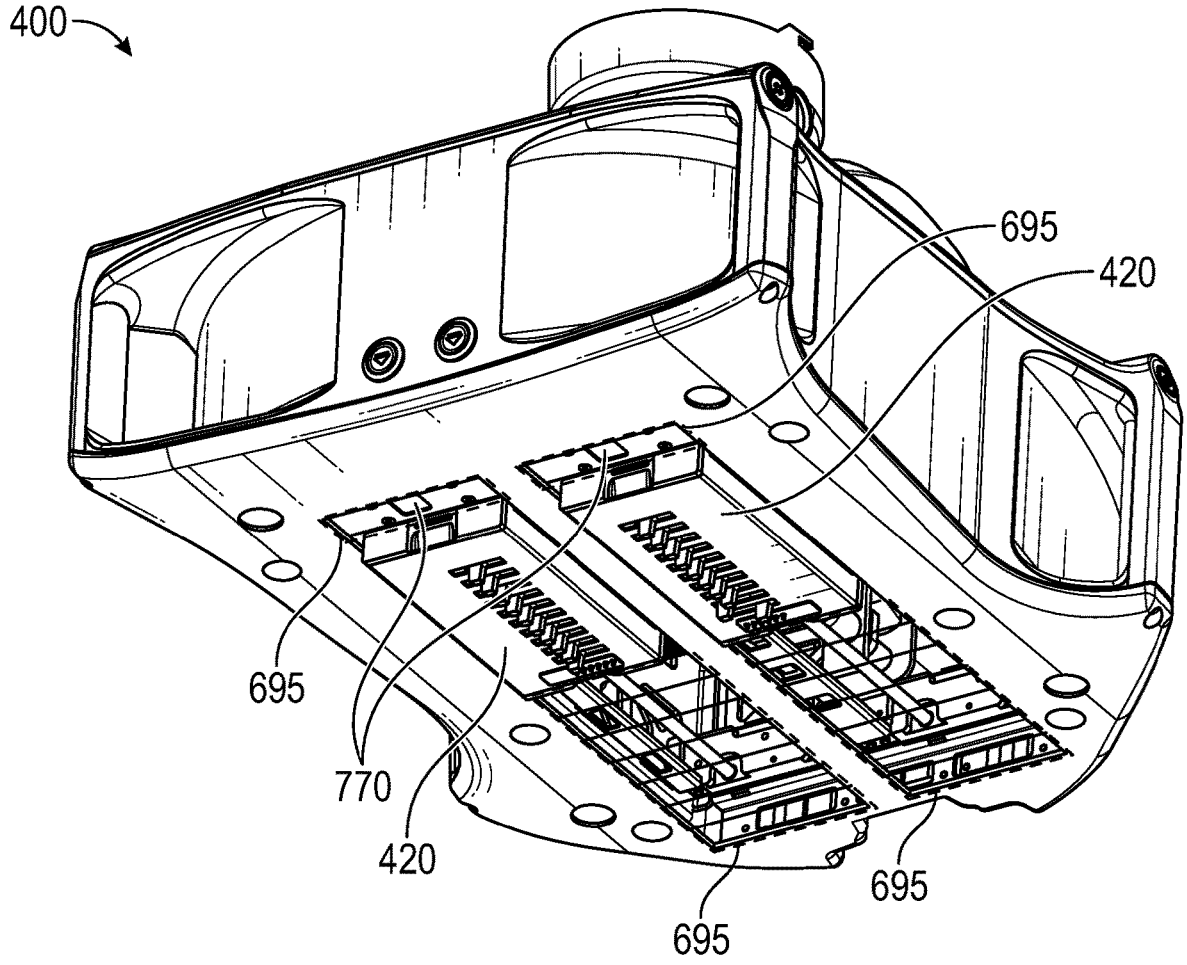



FIG. 5A

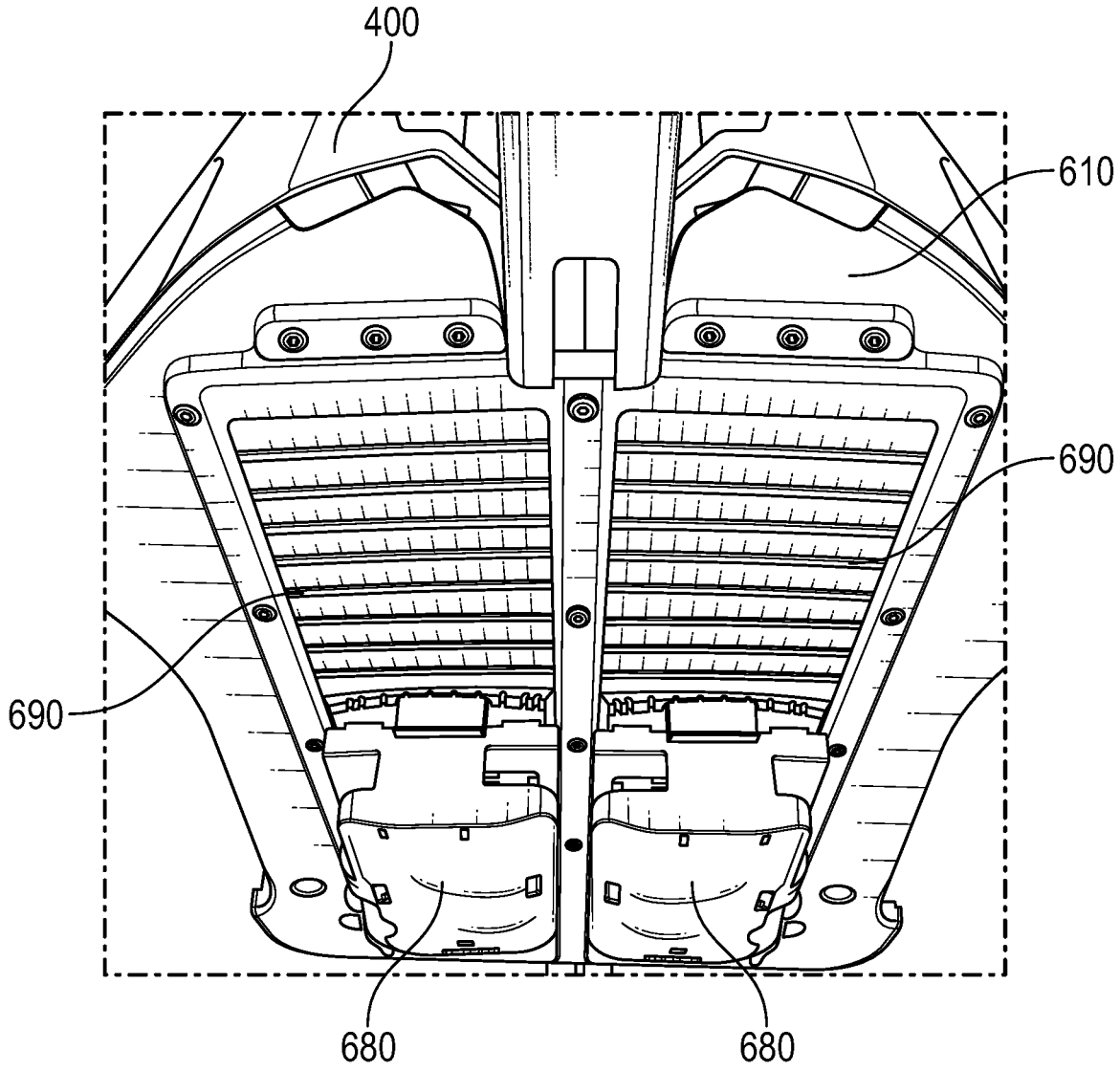



FIG. 5B

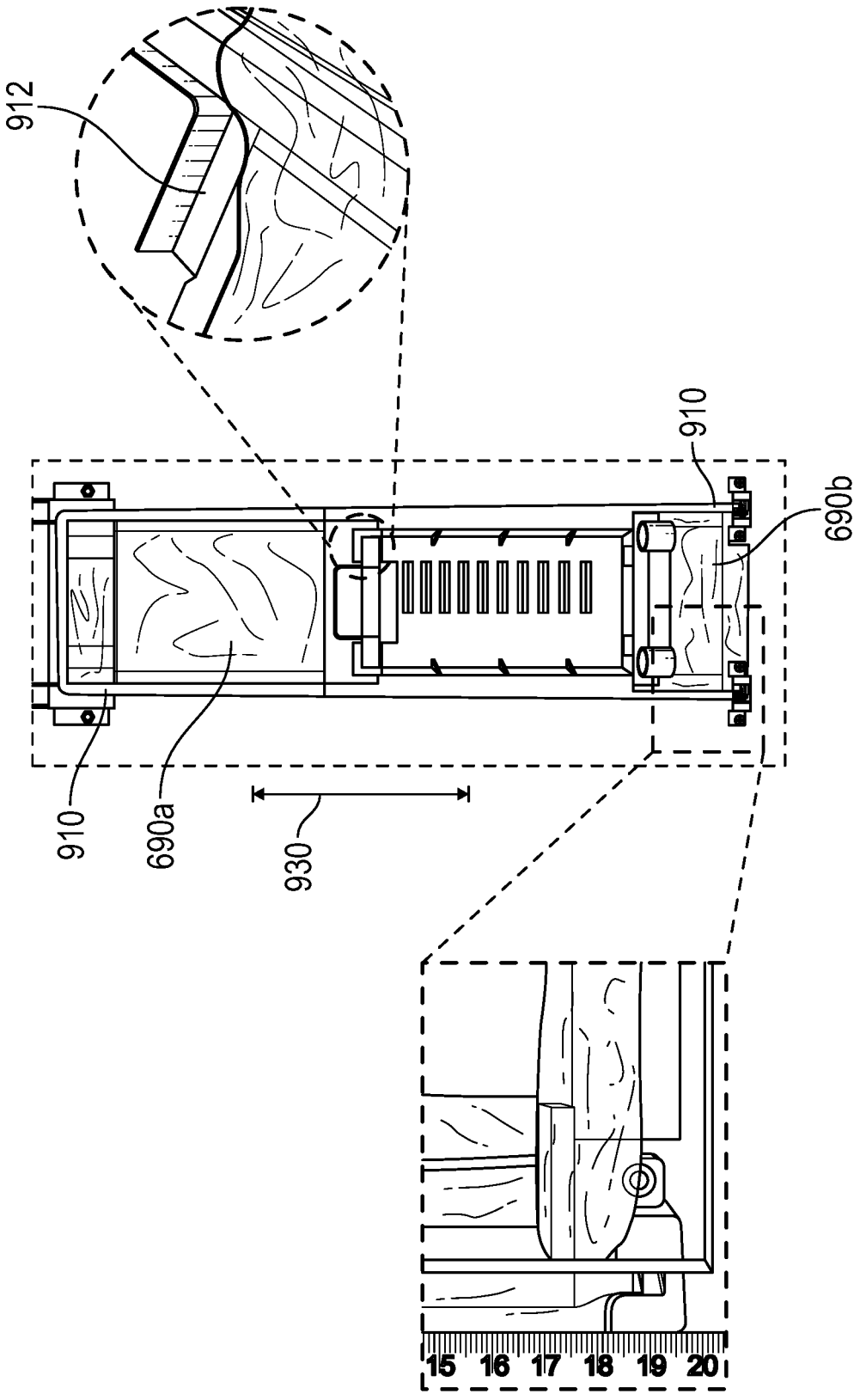



FIG. 5C

# EMERGENCY RELEASE AND STERILE BARRIERS FOR ROBOTIC SURGERY SYSTEMS

## TECHNICAL FIELD

**[0001]** This disclosure relates generally to robotic surgery systems and more particularly to an emergency release of surgical instruments of a robotic surgery system.

## DESCRIPTION OF RELATED ART

**[0002]** A robotic surgery system can employ one or more articulating instruments to perform surgical functions within a surgical site in a body cavity of a patient. The articulating instruments may be automatically controlled by the robotic surgery system in response to inputs from an input device having some means of sensing movements of a surgeon's hands. For example, the input device may include a pair of hand controllers that are grasped in the surgeon's hand and moved to cause corresponding movement of the articulating instruments. It is generally desirable that the movement of the articulating instruments closely mimic the surgeon's hand movements so that performing operations. In case of an emergency, it may be necessary to remove the articulating instruments from the surgical site. However, if the robotic surgery system fails, it may not be possible to remove the articulating instruments using an automated approach provided by the system. The present disclosure overcomes these and other problems associated with system and patient safety.

## SUMMARY

**[0003]** An instrument manipulator for a robotic surgery system can include a housing configured to support at least one surgical instrument. The instrument manipulator can include an actuator configured to move the housing forward toward a surgical site and backward away from the surgical site. The instrument manipulator can include a release connected to the housing. The release can be configured to engage with the actuator in a first configuration to allow the housing and the at least one surgical instrument to move forward toward the surgical site and backward away from the surgical site responsive to activation of the actuator. The release can be configured to disengage from the actuator in a second configuration to allow a user to manually move the housing and the at least one surgical instrument backward away from the surgical site. The instrument manipulator can include a user interface positioned at least partially on an exterior surface of the housing and configured to permit the user to transition the release from the first configuration to the second configuration, thereby facilitating retraction of the at least one surgical instrument away from the surgical site.

**[0004]** The instrument manipulator of any of the preceding paragraphs and/or any of the instrument manipulators disclosed herein can include one or more of the following features. Manual movement of the housing backward may not be permitted in the first configuration as a result of the engagement of the release with the actuator. The actuator includes a leadscrew. The instrument manipulator can include a motor configured to rotate the leadscrew to cause the leadscrew to advance and retract the housing. The release can include at least one of a half nut, a dual split nut, a torsion spring, or a radial split nut. The release can include a pin and at least one spring. The at least one spring can be configured to extend the pin vertically upward when the release is in the second configuration. The instrument manipulator can include a guide configured to engage with the pin to facilitate retraction of the housing away from the surgical site. The guide can include a cutout configured to limit the movement of the pin. The guide can include a rail. The user interface can include a button.

**[0005]** Disclosed is a central unit that includes at least one instrument manipulator of any of the preceding paragraphs and/or any of the instrument manipulators disclosed herein.

**[0006]** Disclosed are methods of operating the instrument manipulator of any of the preceding paragraphs and/or any of the instrument manipulators disclosed herein.

**[0007]** A method of manually retracting an instrument manipulator of a robotic surgery system can include activating an emergency release of the instrument manipulator to cause the emergency release to disengage from an actuator of the instrument manipulator. The method can include, while the emergency release is activated, manually moving the instrument manipulator and at least one surgical instrument supported by the instrument manipulator backward away from a surgical site.

**[0008]** The method of any of the preceding paragraphs and/or any of the methods disclosed herein can include one or more of the following features. Activating the emergency release of the instrument manipulator can include pressing a button located on an exterior surface of the instrument manipulator. The method can include reengaging the emergency release to the actuator by releasing the button, thereby allowing manipulation of the at least one surgical instrument by the robotic surgery system. The actuator can include a leadscrew. The emergency release can include a ping configured to be biased into a deactivated configuration by a spring. In the deactivated configuration, manual movement of the instrument manipulator is prevented. The emergency release can include at least one of a half nut, a dual split nut, a torsion spring, or a radial split nut. The method can include removing the at least one surgical instrument from the instrument manipulator subsequent to manually moving the instrument manipulator. The method can include removing the at least one surgical instrument from the instrument manipulator subsequent to manually retracting the instrument manipulator to a threshold distance away from the surgical site. The threshold distance can be defined by a stopper of the instrument manipulator configured to limit backward movement of the at least one surgical instrument.

**[0009]** In some cases, a robotic surgery system as described and/or illustrated is provided. In some implementations, one or more emergency release mechanisms as described and/or illustrated are provided. In some cases, one or more sterile barriers as described and/or illustrated are provided. In some cases, one or more sterile adapters as described and/or illustrated are provided. In some cases, one or more kits as described and/or illustrated are provided.

**[0010]** In some cases, a method of using and/or operating a robotic surgery system or any of its components as described and/or illustrated is provided. In some instances, methods for operating one or more emergency release mechanisms as described and/or illustrated are provided. In some cases, methods of preparing a robotic surgery apparatus for a medical procedure as described and/or illustrated are provided. Any of such methods can include positioning one or more sterile barriers and/or adapters on any of the

components of the robotic surgery system (or covering any of the components with any of the sterile barriers) as described and/or illustrated.

**[0011]** Any of the methods of any of the preceding paragraphs and/or described herein can be used with any of the emergency release mechanisms and/or robotic surgery systems. Any of the methods of any of the preceding paragraphs and/or described herein can be used with any of sterile barriers, adapters, kits, and/or robotic surgery systems.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** Embodiments of the present disclosure will now be described hereinafter, by way of example only, with reference to the accompanying drawings in which:

**[0013]** FIGS. **1**A-**1**C illustrate a robotic surgery system;

**[0014]** FIG. **2**A-**2**C illustrate a central unit and instruments of a robotic surgery system;

**[0015]** FIGS. **3**A-**3**L and **4**A-**4**D illustrate emergency release mechanisms for a robotic surgery system and methods of removing one or more surgical instruments;

**[0016]** FIG. **5**A illustrates a central unit of a robotic surgery system;

**[0017]** FIG. **5**B illustrates a sterile barrier positioned on a central unit of a robotic surgery system; and

**[0018]** FIG. **5**C illustrates the sterile barrier.

## DETAILED DESCRIPTION

### Overview of Robotic Surgery System

**[0019]** Referring to FIG. **1**A, a robotic surgery system is shown generally at **1000**. In some implementations, the robotic surgery system **1000** can be configured to facilitate a medical procedure (for example, surgery) performed via one or more incisions. For a single incision, a single access port can be inserted into the incision to provide access for one or more instruments (sometimes referred to as surgical instruments, tools or surgical tools) or cameras (or other non-tissue manipulating equipment, including advanced visualization equipment).

**[0020]** The system **1000** can include a workstation **102** and a patient cart **104**. One or more of the patient cart **104** or the workstation **102** can be moveable. The patient cart **104** can include a manipulator unit or central unit **400** to which one or more instrument insertion and visualization devices **108** can be attached or mounted. The central unit **400** can be supported by an elevating linkage assembly **300** (sometimes referred to as an arm) connected to a boom arm assembly **200** (sometimes referred to as a column) of the patient cart. The central unit **400** can be moveable, such as in three dimensions, to facilitate desired positioning of one or more surgical instruments or cameras. Movement of the central unit **400** can be facilitated by one or more of the arm **300** and column **200**. For example, the column **200** can facilitate vertical positioning of the central unit **400**, and the arm **300** can facilitate further vertical positioning in addition to lateral movement and rotation of the central unit **400**.

**[0021]** The instrument insertion and visualization device **108**, which can be removably mounted to the central unit **400**, can support at least one surgical instrument and one or more cameras (not shown) that image a site of interest, such as a surgical site. The instrument insertion and visualization device **108** can support two or more instruments (not shown). The one or more cameras can include a primary camera and at least one secondary camera. The primary camera and the secondary camera may provide different viewing angles, perform different functions and/or produce different images. At least one of the primary camera and the secondary camera may be a two-dimensional (2D) or a three-dimensional (3D) camera.

**[0022]** The workstation **102** can include an input device **112** that receives operator input and produces input signals and may also be configured to generate feedback to the operator or user. The feedback can be visual, auditory, haptic, or the like. The input device **112** can be implemented using a haptic interface available from Force Dimension, of Switzerland, for example. The operator can be a surgeon.

**[0023]** The workstation **102** can further include electronic circuitry **114** in communication with the input device for receiving the input signals and generating control signals for controlling the robotic surgery system, which can be transmitted to the patient cart **104** via an interface cable **116**. In some cases, data transmission can be wireless and the interface cable **116** may not be present. The electronic circuitry **114** can include one or more processors or controllers. The electronic circuitry **114** can function as a master for controlling movement of one or more surgical instruments or cameras mounted to the patient cart **104**. The patient cart can include electronic circuitry **118**, which can include one or more processors or controllers. The electronic circuitry **118** can function as a slave and be controlled by the electronic circuitry **114**. Communication between the electronic circuitry **114** of the workstation **102** and the electronic circuitry **118** of the patient cart **104** may wired (such as, via the cable **116**) or wireless. The workstation **102** may be located remotely from the patient cart **104**, such as outside the operating room or in a non-sterile area of the operating room.

**[0024]** The input device can include a right input device **132** and a left input device **112** for controlling respective right and left instruments (not shown). The right input device **132** can include a right hand controller **122** (sometimes referred to as a hand grip or handpiece), and the left input device **112** can include a left hand controller **124**. The right and left hand controllers **122** and **124** can be mechanically and/or electrically coupled to the respective input devices **132** and **112**. Alternatively, the right and left hand controllers **122** and **124** may be wirelessly coupled to the respective input devices **132** and **112** or may be wireless coupled directly to the workstation **102**. The right and left hand controllers **122** and **124** can be grasped by the operator's hands and moved to produce input signals at the respective input devices **132** and **112**.

**[0025]** In some cases, when there are two instruments at the patient cart **104**, the right and left hand controllers **122** and **124** may respectively control the two instruments. In some cases, when there are more than two instruments, the right and left hand controllers **122** and **124** may be used to select two of the multiple instruments that the operator wishes to use at any given time. In some cases, when there is only one instrument, one of the right and left hand controllers **122** and **124** may be used to select the single instrument.

**[0026]** The input devices **132** and **112** may generate input signals representing positions of the hand controllers **122** and **124** within an input device workspace (not shown). In some cases where the input devices **132** and **112** are coupled directly and wirelessly to the workstation, they would

include the necessary sensors to allow wireless control such as an accelerometer, a gyroscope and/or magnetometer. In other cases, a wireless connection of the input devices **132** and **112** to the workstation **102** may be accomplished by the use of camera systems alone or in combination with the described sensors. Such sensors for wireless functionality may also be placed in each handpiece to be used in conjunction with the input devices **132** and **112** to independently verify the input device data. The electronic circuitry **114** can be in communication with the input devices **132** and **112** for receiving the input signals.

**[0027]** The electronic circuitry **118** of the patient cart **104** can receive control signals from the electronic circuitry **114** and produce slave control signals operable to control the instrument insertion and visualization device **108** and one or more instruments (and their respective end effectors) and/or cameras during a surgical procedure. The one or more instruments can include dexterous tools, such as grippers, needle drivers, staplers, dissectors, cutters, hooks, graspers, scissors, coagulators, irrigators, and suction devices used for performing a surgical procedure (such as a laparoscopic surgical procedure). While both master and slave electronic circuitry **114** and **118** are illustrated, in some cases a single electronic circuitry may be used to perform both master and slave functions.

**[0028]** The workstation **102** can also include a user interface, such as a display **120** in communication with the electronic circuitry **114** for displaying information (such as, body cavity images) for a region or site of interest (for example, a surgical site, a body cavity, or the like) and other information to the operator. The display **120** can display real time images or other graphical depictions of a surgical site produced by one or more cameras of the visualization device (not shown) and/or one or more cameras of the instrument insertion and visualization device **108**. The workstation **102** may include right and left graphical depictions (not shown) displayed on the display **120** respectively for the right and left side instruments (not shown). The graphical depictions may be displayed at a peripheral region of the display **120** to prevent obscuring a live view of the surgical workspace also displayed on the display. The display **120** may further be operable to provide other visual feedback or instructions to the user.

**[0029]** The workstation **102** can include a second auxiliary display **123** to display auxiliary surgical information to the user, for example, patient medical charts, pre-operation images and surgical data. In some cases, the auxiliary display **123** may be a touch display and may also be configured to display graphics representing additional inputs for controlling the workstation **102**, the patient cart **104**, and/or specific functions thereof.

**[0030]** The workstation **102** can also include one or more controllers, such as one or more footswitches or pedals **126**, for controlling the robotic surgery system. For example, one or more pedals **126** can include a clutch pedal that allows repositioning the hand controllers **122** or **124** without corresponding movement of the respective associated instrument. The clutch pedals **126** can provide input signals to the electronic circuitry **114**, and the electronic circuitry may inhibit movement of the associated instrument while the footswitch **126** is depressed.

**[0031]** FIG. **1**B illustrates a close-up front perspective view of a portion of the patient cart **104**. The illustrated portion includes the central unit **400** (which can be shaped as a hexahedron), the arm **300**, and an upper portion of the column **200**. FIG. **1**C illustrates a close-up rear perspective view of the portion of the patient cart **104** illustrated in FIG. **1**B. FIGS. **1**A-**1**C illustrate an example of a robotic surgery system and its components, and certain elements may be removed, other elements added, two or more elements combined, or one element can be separated into multiple elements depending on the specification and requirements of the robotic surgery system.

**[0032]** Additional details of the robotic surgery system **1000** and its components, including one or more insertion devices, visualization devices, or cameras, are described in U.S. Publication Nos. 2020/0113640, which published on Apr. 16, 2020, 2020/0113414, which published on Apr. 16, 2020, 2020/0269310, which published on Nov. 26, 2020, and 2020/0367979, which published on Nov. 26, 2020, and U.S. Pat. Nos. 10,398,287, 10,426,561, and 10,881,477, the entire disclose of each of which is incorporated by reference and should be considered part of this specification.

**[0033]** As shown in FIG. **2**A, a bottom surface **410** of the central unit **400** can include one or more instrument interfaces **420** configured to support and actuate one or more surgical instruments (as illustrated, for example, in FIG. **2**C). Each instrument interface **420** can include a plurality of actuators **422** configured to interface (for example, mate with) with a plurality of actuators of a surgical instrument attached to the instrument interface (for instance, the actuators **322** of the surgical instrument illustrated in FIG. **2**C). For example, the protrusion of the actuator **422** can interface with (such as mate with) the opening in an actuator **322** of the surgical instrument (sometimes referred to as surgical instrument actuator). Movement of the actuators **422**, such as movement left and right (or up and down, or otherwise from one point to another point), can cause corresponding movement of the actuators of the surgical instrument. This can cause an end effector portion of the instrument (which can be located at the distal end of the instrument) to articulate or move (for example, in three dimensions), change orientation (for example, in three dimensions including rotation), and/or actuate or perform a function (such as, open or close a jaw of a grasper) as needed for performing the medical procedure.

**[0034]** To maintain sterility of the one or more surgical instruments, one or more sterile interfaces **680** (sometimes referred to as covers, interfaces, shields, or adapters) can be attached to or positioned on the instrument interfaces **420** that may not be sterile (for example, due to particular difficulty of sterilizing the plurality of actuators **422**). One or more sterile adapters **680** can be removably attached to the instrument interfaces **420**, and an instrument can be placed or positioned in contact with the sterile adapter(s) **680** when mounted on the instrument interfaces **420**. For example, when a single sterile adapter **680** is used to attach to the instrument interfaces **420**, the sterile adapter can be configured to (for example, sized and shaped) to coincide or substantially coincide with the size and shape of the instrument interfaces **420**. Sterile adapter **680** can have the same or substantially similar length and width as the instrument interface **420**. Additional details of the sterile adapter **680** are disclosed in U.S. Pat. No. 10,881,477, the entire disclose of which is incorporated by reference and should be considered part of this specification.

**[0035]** With reference to FIG. **2**B, the central unit **400** is shown in a rear view with surgical instruments **364** attached

to the instrument interfaces **420** (or loaded). With reference to FIG. **2**C, a surgical instrument **364** can include an instrument housing **365**, a shaft **368** connected to the housing, and an end effector **366** connected to the shaft. As illustrated in FIG. **2**B, the shaft **368** and the end effector **366** can be loaded through an opening **340** formed in a rear of an insertion device **210** (sometimes referred to as the CIT). The shaft **368** and the end effector **366** can be inserted through a passage, lumen, or channel **214** of the insertion device **210**. Left and right surgical instruments **364** can be positioned in such manner. A camera (not shown) can also be positioned in such manner. To insert one or more surgical instruments **364** or the camera into a surgical site (such as, a body cavity), the instrument interfaces **420** can be moved forward (to advance one or more surgical instruments **364**) or backward (to retract one or more surgical instruments **364**) as shown by the arrow **402**.

Emergency Release

**[0036]** Referring to FIG. **3**A, an instrument manipulator (sometimes referred to as an instrument drive unit (IDU)) is shown generally at **700**. The instrument manipulator can be part of the central unit **400** and can support and actuate a surgical instrument (for instance, as shown in FIG. **2**B in which instrument facings sides of instrument manipulators for left and right instruments are shown as instrument interfaces **420**). The instrument manipulator **700** can include a housing **710**, a first actuator **730**, and an emergency release **740** (sometimes referred to as release or release mechanism **740**). In FIG. **3**A, the housing **710** of the instrument manipulator **700** is shown in a fully deployed or advanced position (along the direction of the arrow **402**), which can place the instruments at or near a surgical site. As described herein, the housing **710** of the instrument manipulator **700** can be configured to support at least one surgical instrument. For example as shown in FIG. **4**D, the surgical instrument **364** can be attached, or supported by the instrument interface **420** of the housing **710** via a sterile adapter **680**. The first actuator **730** can include a leadscrew and be configured to move the housing **710** forward toward the surgical site and retract the housing **710** backward away from the surgical site. A motor **732** can facilitate motion of the housing **710**. For example, the motor **732** can be configured to rotate the first actuator **730** along a longitudinal axis of the first actuator **730** in a first direction, thereby moving the housing **710** forward toward the surgical site or in a second direction (which can be opposite the first direction), thereby moving the housing **710** backward from the surgical site. The release **740** of the instrument manipulator **700** can be connected to the housing **710**. In a first configuration (sometimes referred to as default or deactivated configuration), the release **740** can be configured to engage with the first actuator **730**. When the release **740** is engaged with the first actuator **730**, the housing **710** can move forward and backward responsive to movement of the first actuator **730**, as described herein. In the first configuration, manual movement of the housing may be prevented (for example, due to engagement with the first actuator **730**). In a second configuration (sometimes referred to as actuated or activated configuration), the release **740** can be configured to disengage from the first actuator **730**. When the release **740** is disengaged from the first actuator **730**, the housing **710** can be manually moved along a guide **760** (sometimes referred to as a rail **760**). The guide **760** can be utilized to encode position of the surgical instrument along the z-axis, which can be necessary for the correct operation of a robotic surgery system. Manual movement of the housing **710**, and any surgical instruments supported by the housing **710**, from the surgical site can be advantageous in cases of instrument manipulator **700** failure, mechanical failure, loss of power, an emergency, or the like. Advantageously, transitioning the release **740** to the second configuration to allow manual retraction of the surgical instrument(s) from the surgical site can facilitate patient safety in case of a malfunction, failure, or another emergency. The rail **760** can include a stopper **762** configured to limit the movement of the housing **710**, for instance, to not damage the housing **710** or any other components of the system. The stopper **762** can prevent manual movement of the housing **710** in one direction (such as, away from the surgical site) while permitting manual movement of the housing **710** in the opposite direction (such as, toward the surgical site). The stopper **762** can include an indentation or cutout along a section of the rail **760** as shown in FIG. **3**A. In some implementations, the rail **760** can include a channel or a slot configured to limit the movement of the housing **710**.

**[0037]** Referring to FIG. **3**B, the release **740** can include at least one of a single split nut (or half nut) mechanism, a dual split nut mechanism, a torsion spring mechanism, and a radial split nut mechanism configured to engage with and/or disengage with the first actuator **730**. A second actuator **744** of the release **740** can be connected to a half nut **745** and configured to facilitate engagement and disengagement of the half nut **745** from the first actuator **730** (which, as described herein, can be a leadscrew). The second actuator **744** can be actuated by a button **770** (illustrated in FIGS. **3**D and **4**A as being positioned on an exterior surface of the instrument manipulator **700**) configured to compress a spring **746** of the second actuator **744** and disengage the half nut **745** from the first actuator **730**, as shown in FIG. **3**B. The second actuator **744** can be configured to maintain the half nut **745** disengaged from the first actuator **730** while the button **770** is pressed, and to engage the half nut **745** with the first actuator **730** when the button **770** is released. The second actuator **744** can be biased (for instance, by the spring **746**) to facilitate engagement of the half nut **745** with the first actuator **730** in the default configuration. Pressing the button **770** can cause the second actuator **744** to disengage the half nut **745** from the first actuator **730**. In some cases, continuously pressing the button **770** can cause disengagement of the half nut **745** from the first actuator **730**. In some implementations, the second actuator **744** can be configured to maintain the half nut **745** disengaged from the first actuator **730** after a single press of the button **770**.

**[0038]** The second actuator **744** can include a stopping pin (which can be part of a plunger). The stopping pin can be configured to stay retracted (or in a stand-by position), as shown in FIG. **3**B, when the release **740** is in the default configuration (for instance, when the button **770** is not pressed). Activating the release **740**, can cause extension of the stopping pin vertically upward (as illustrated in FIG. **4**C). For example, when the button **770** is pressed, the plunger and consequently the stopping pin can move upward into a raised position. In such position, the stopping pin can engage the guide **760** to facilitate controlled manual retraction of the instrument manipulator **700**. With reference to FIG. **3**A, the stopper **762** along the rail **760** can limit manual movement of the housing **710** along the rail **760** in at least

one direction by securing the stopping pin in place when the stopping pin comes into contact with the stopper **762** (which can be a cutout in the rail **760**). FIGS. **4**B and **4**C show an example of a stopping pin in the raised position coming into contact with the stopper **762**. The motion of the stopping pin can be restricted by the stopper **762** of the rail **760**, thereby preventing any further manual movement of the housing **710** along the rail **760** beyond the stopper **762**. In FIGS. **4**B and **4**C, the housing **710** of the instrument manipulator **700** is shown in a fully retracted position away from the surgical site.

**[0039]** The instrument manipulator (or surgical manipulator) can include more than one housing to support multiple surgical instruments. For example, as illustrated in FIG. **3**C, an instrument manipulator **800** can include two housings **810***a*, **810***b*. Like the housing **710**, each housing **810***a*, **810***b*, can be configured to support a surgical instrument. Further, like the housing **710**, each housing **810***a*, **810***b*, can be configured to allow manual movement of each housing **810***a*, **810***b* away from a surgical site. The surgical manipulator **800** can include all the components of the surgical manipulator **700** including, but not limited to, the release **740**. Thus, the instrument manipulator **800** can operate as the instrument manipulator **700** described herein. As illustrated in FIG. **3**D, the instrument manipulator **800** can include at least one button **770** (two buttons are illustrated) configured to activate at least one release **740** (two releases (not shown) are included in the instrument manipulator **800**)

**[0040]** FIG. **3**E illustrates a release **740**A that can be similar to the release **740**. The release **740**A can include a dual split nut mechanism, which includes a pair of nuts **745**A and **745**B. In the default configuration of the release **740**A, the nut **745**A and **745**B can be engaged with the first actuator **730** (shown as leadscrew). In the activated configuration (for example, caused by pressing the button **770**), the nut **745**A and **745**B can pivot about a rod **772** and disengage from the first actuator **730**. Pressing the button **770** can rotate or linearly move the rod **772** causing the nut **745**A and **745**B to rotate and disengage from the first actuator.

**[0041]** FIG. **3**F illustrates the release **740**A in a default configuration in which the nut **745**A and **745**B is engaged with the first actuator **730**. Bars **774** and **776** replace the rod **772** and function similarly to the rod **772**.

**[0042]** FIG. **3**G illustrates a torsion spring (or torsional spring or helical spring) release **740**B that can be similar to the release **740**. The release **740**B can include a housing (a portion of which can be split into a nut **782** as shown in FIG. **3**G) and a torsion spring **784** positioned within the housing of the nut **782**. The portion of the housing of the nut **782** enclosing the torsion spring **784** can be split into two (or more) portions **782**A and **782**B separated by one or more gaps, thus forming a split nut configuration. The portions of the housing of the nut **782** can be held together by one or more banding clamps **786** (two such clamps are illustrated), which can be made from elastic material. The one or more banding clamps **786** may be omitted in implementations in which the housing is made of flexible material and a split nut configuration is utilized. In some cases, a half nut configuration (in which only one of the two portions **782**A or **782**B is present) may require a retention mechanism of the remaining half and the torsion spring. Torsion spring **784** can function as a nut that engages the first actuator **730** (shown as leadscrew) in the default configuration of the release **740**B. When force is applied the ends of the torsion spring **784** as a result of actuating the release **740**B (for instance, due to a press of the button **770**), the torsion spring **784** can expand radially and disengaging from the first actuator **730**. Expansion of the torsion spring **784** can cause the portions **782**A and **782**B to at least partially come apart (or split open or deflect). The nut **782** can be made at least partially from flexible material such that the portions **782**A and **782**B can bend. One or more banding clamps **786** can hold the portions **782**A and **782**B and the torsion spring **784** together. In some implementations, a single body nut **782** can be replaced with two half nuts.

**[0043]** FIGS. **3**I to **3**L illustrate a radial split nut release **740**C, which can be similar to the torsion spring release **740**B with the exception of different actuation being utilized. FIG. **3**H illustrates a perspective view of the release **740**C without the first actuator **730** (which is inserted through the opening **734**). FIG. **3**K illustrate a rear view of the release **740**C. With reference to FIG. **3**I, which illustrates a cross-sectional view of the release **740**C, a cam mechanism **790** (or cam) can be used to activate the emergency release (the cam mechanism **790** can serve a similar purpose as the second actuator **744**). The cam mechanism **790** can be actuated by pressing the button **770** and can rotate (as shown by the arrow **794**) to move apart (or open) a split nut mechanism, as illustrated in FIG. **3**J. A nut **792** (as shown in FIG. **3**H) can include two (or more) portions separated by one or more gaps (thereby forming a split nut configuration). For example, FIG. **3**G illustrates two portions **792**A and **792**B of the nut **792**, which in the default configuration engage with the first actuator **730**. FIG. **3**L illustrates three portions **792**A, **792**B, and **792**C of the nut **792**. The portions **792**A, **792**B, and **792**C can include threading that engages with the threading of the first actuator **730**, which can be a leadscrew. Responsive to the cam mechanism **790** being activated, the portions **792**A, **792**B, and **792**C can be moved apart (or deflected) to disengage from the first actuator (for instance, as shown in dashed lines for the portions **792**A and **792**B illustrated in FIG. **3**J). The portions **792**A, **792**B, and **792**C can be moved apart by one or more pegs of the cam mechanism **790**. The nut **792** can be made at least partially from flexible material such that the portions **792**A, **792**B, and **792**C can bend. One or more banding clamps can be utilized to hold together the portions **792**A, **792**B, and **792**C. In some implementations, a single body nut **792** can be replaced with two half nuts.

**[0044]** In some cases, a stopping pin **744'** can be connected to the cam mechanism **790** and rotated as illustrated. As described herein, the stopping pin **744'** can function as the stopping pin of the second actuator **744** to limit the movement of the housing **710** during manual retraction. The stopping pin **744'** can exit through the opening **795** in a housing of the release **740**C.

**[0045]** A method of manually retracting the instrument manipulator **700** can include one or more of the following steps. When the instrument manipulator (such as, **700**) is in a fully deployed position, which can be at or near the surgical site, the method can include activating the emergency release **740** to disengage the release from the first actuator **730**. In some implementations, prior to activating the emergency release **740**, any grip by an end effector of the surgical instrument may need to be released. Activating the emergency release from the first actuator **730** can include pressing the button **770**. The button **770** can be positioned on the exterior surface of the instrument manipulator **700** so

that it can be accessed by a user. Subsequent to activation of the emergency release **740**, the user can manually move the instrument manipulator **700** (for instance, along the rail **760**) and away from the surgical site. As described herein, the user may need to continue holding down the button to maintain the release **740** in activated state. The method can include releasing the button **770** when the instrument manipulator **700** is in a fully retracted position (which can be away from the surgical site). As described herein, such position can be reached responsive to contacting the stopper **762**. Releasing the button **770** can disengage the release **740** thereby preventing manual movement of the instrument manipulator **700**.

**[0046]** The method can also include removing one or more surgical instruments **364** from the instrument manipulator **700**. To protect the patient (for instance, from foreign particles falling into the surgical site), the method can include removing the one or more surgical instruments **364** when the instrument manipulator **700** is in the fully retracted position. In some cases, the one or more surgical instruments **364** can be removed from the instrument manipulator **700** even when the instrument manipulator **700** is not in the fully retracted position. Removing the one or more instruments from the instrument manipulator can include releasing one or more sterile adapters **680** from a housing of the instrument manipulator **700**.

**[0047]** It may be advantageous to facilitate removal of one or more surgical instruments **364** from the surgical site of in case of malfunction of the robotic surgery system (or any of its components), loss of power, emergency, or the like. With reference to FIG. **2**A (which illustrates the central unit **400** without a sterile barrier), the sterile adapter **680** can include a plurality of actuator covers **622** corresponding in size and shape to the plurality of actuators **422**. During the medical procedure, the actuators **422** (and actuator covers), which can be configured to move independently of one another, may not be in an aligned position due to the manipulation of the end effector portion of the surgical instrument. Because of the misalignment, it may not be possible to remove the surgical instrument by simply pulling out the instrument from the sterile adapter **680**. Instead, the sterile adapter **680** can be configured to allow the surgical instrument **364** to be removed when the robotic surgery system is in use by removing the sterile adapter **680** with the surgical instrument **364** installed. The surgical instrument **364** can become straightened (as shown for one of the instruments in FIG. **4**D) when disengaged from the instrument interface **420**. Additional implementations of removing the surgical instrument **364** (such as, by rotating the surgical instrument **364** within the sterile adapter **680**) are disclosed in U.S. Pat. No. 10,881,477, the entire disclose of which is incorporated by reference and should be considered part of this specification.

**[0048]** FIG. **4**D illustrates removal of the surgical instrument **364** when the instrument manipulator **700** in a fully retracted position, The surgical instrument **364** can be removed from the instrument manipulator **700** by detaching the sterile adapter **680** from the instrument manipulator **700**. To minimize the risk of injury to the patient or damage to the central unit **400** or the surgical instrument **364**, it may be beneficial to remove the sterile adapter **680** from the housing **710** once the housing **710** is in the fully retracted position (or, in some cases, prior to the housing being in the fully retracted position, such as, at a set distance prior to the housing being in the fully retracted position). When the sterile adapter **680** is detached from the housing **710** of the instrument manipulator **700**, the surgical instrument **364** can be configured to straighten (as is illustrated with the closer instrument shown in FIG. **4**D). This can allow the surgical instrument to be safely removed from an insertion device **210** (which can include one or more lumens or channels for guiding the surgical instruments).

Additional Approaches for Emergency Release

**[0049]** In some cases, emergency release can be activated the user (for instance, responsive to a press of the button **770**) and continue being engaged without further input from the user. For instance, the emergency release can include a ratchet, clutch, or the like.

**[0050]** Any of the emergency releases described herein can be modified to accommodate various robotic surgery systems. Such systems include, for example, a multi-arm (such as, a three-arm) robotic surgery system. In some cases, the emergency release can be activated by pushing the housing of an instrument manipulator (such as, in a direction away from the surgical site). This approach can be applicable to a robotic surgery system in which instruments are loaded from the side (such as, at an angle to the vertical direction). The emergency release can be activated responsive to the housing of an instrument manipulator being pushed at a predefined force threshold. This may prevent unintended or accidental activation of the emergency release. For example, the emergency release can be configured so that the force feedback created by operating the surgical instrument at the surgical site does not result in activation of the emergency release. The predefined force threshold can be selected so that an unreasonable amount of force to activate the emergency release is not required (thereby allowing the user to activate the emergency release without applying undue force). In some instances, the predefined force threshold can be about 100 N or less.

**[0051]** In some implementations, the emergency release mechanism can be activated by operating an instrument, which can be a custom instrument. For instance, the instrument can be inserted into a channel in the central unit and be configured to engage with the first actuator (such as, include a nut to engage with the leadscrew to detach the instrument manipulator from the leadscrew by turning the instrument). The instrument can be configured so that upon operation of the instrument, the housing of an instrument manipulator moves away from the surgical site. In some cases, the instrument can be operated by pushing and pulling the instrument, turning the instrument, pumping the instrument, activating one or more gears, or the like once the instrument is engaged with the first actuator. In some variations, the instrument can be operated by rotating the instrument once the instrument is engaged with the first actuator. The instrument can be engaged to the first actuator via an access located on an exterior surface of the housing of the instrument manipulator. For example, the access can be located in the area behind the instrument manipulator.

**[0052]** In some implementations, the one or more surgical instruments can be configured to automatically detach from the one or more instrument manipulators upon the one or more instrument manipulators reaching a particular location or position away from the surgical site. Such automatic detachment can occur subsequent to manual retraction caused by emergency release. The point at which the one or more surgical instruments automatically disengage from the

surgical manipulator will invariably depend on the characteristics or configuration of the robotic surgery system. For instance, the one or more instruments can be configured to automatically detach responsive to the one or more instrument manipulators reaching the stopper, as described herein. In robotic surgery system in which one or more instruments are loaded from the side, the location of automatic detachment of the one or more instruments can be a particular depth to which the one or more instrument has been retracted. Detaching the one or more surgical instruments from the surgical manipulator can cause the one or more surgical instruments to straighten, as described herein.

Sterile Barrier

**[0053]** The instrument manipulator **700** can include one or more instrument interfaces **420**, as shown in FIG. **5**A. One or more sterile adapters **680** can be removably attached to the instrument interfaces **420** (as illustrated in FIG. **5**B), and one or more instruments **364** can be supported by the sterile adapter(s) **680** mounted on the instrument interface(s) **420**. For example, when a single sterile adapter **680** is used to attach to the instrument interfaces **420**, the sterile adapter **680** can be configured to (for example, sized and shaped) to coincide or substantially coincide with the size and shape of the instrument interfaces **420**. Sterile adapter **680** can have the same or substantially similar length and width as the instrument interface **420**. It may be beneficial to establish and maintain sterility of one or more components of the instrument manipulator **700**, such as of the instrument interface(s) **420**.

**[0054]** To this end, the central unit **400** can be covered with a sterile barrier that can include a coupler **610** (shown in FIG. **5**B) configured to be positioned on the bottom surface of the central unit **400**. The coupler **610** can be shaped as a tray and be removably attached to the bottom surface (such as, by using one or more fasteners, which can be magnetic). Additional details of maintaining sterility of the components or the robotic surgery system are disclosed in U.S. Pat. No. 10,881,477, the entire disclose of which is incorporated by reference and should be considered part of this specification.

**[0055]** As shown in FIG. **5**B, the coupler **610** can include one or more openings (sometimes referred to as windows) to expose the one or more instrument interfaces **420** of the instrument manipulators **700**. The openings (shown as **695** in FIG. **5**A) can be moveable to facilitate the linear movement of the one or more instrument manipulators **700** as described herein. To maintain sterility of the one or more surgical instruments (such as, preventing any part of a surgical instrument from coming into contact with a non-sterile bottom surface of the central unit **400**), the openings can include flexible portions **690** (sometimes referred to as bellows), which can expand and compress to facilitate movement of the instrument manipulators **700**.

**[0056]** The one or more bellows **690** can be configured to create a barrier between the exterior and the interior portions of the central unit **400**. For example, the one or more bellows **690** can be positioned to cover the opening(s) (see **695** in FIG. **5**A) along the bottom surface of the central unit **400**. FIG. **5**B shows the one or more bellows **690** covering the openings along the bottom surface of the central unit **400**. Because the location of the instrument interfaces **420** along the bottom surface of the central unit can change as the instrument manipulator **700** moves forward toward a surgical site or backward away from the surgical site, the position of the openings along the bottom surface of the central unit **400** can change. Beneficially, the one or more bellows **690** can be configured to expand as the one or more instrument manipulators **700** move forward toward the surgical site and contract as the one or more instrument manipulators **700** move backward away from the surgical site. In some cases, contraction of the one or more bellows **690** is caused by movement toward the surgical side and expansion is caused by the opposite movement. This can allow the one or more bellows **690** to cover the openings along the bottom surface of the central unit **400** notwithstanding the changing position or size of the openings.

**[0057]** In some cases, in place of the one or more bellows **690**, flexible material, such as plastic, can be used. With reference to FIG. **5**C, the coupler **610** can include a frame or carriage **910** and flexible portions **690**A and **690**B (shown as being made from transparent material). The flexible portions can be positioned on opposite ends of the carriage **910**. Movement of the instrument manipulator causes one flexible portion to contract and the other to expand. The flexible portions can expand or contract as the instrument manipulator **700** moves forward toward a surgical site or backward away from the surgical site. This can allow the one or more flexible portions **690**A and **690**B to cover the openings along the bottom surface of the central unit **400** notwithstanding the position or size of the openings **695**.

**[0058]** The carriage **910** can facilitate expansion or contraction of the flexible portions **690**A and **690**B as the instrument manipulator **700** moves forward toward a surgical site or backward away from the surgical site. For example, the carriage **910** can include one or more rails configured to guide the flexible portions **690**A and **690**B as the flexible portions expand and contract. As the instrument manipulator **700** moves forward toward the surgical site or backward away from the surgical site, the one or more rails of the carriage **910** can guide the flexible portions **690**A and **690**B along the one or more rails in the directions shown by the arrow **930**. The flexible portions **690**A and **690**B can be attached (for instance, glued or welded) to one or more partitions **912** configured to move along the one or more rails. In some cases, each of the flexible portions **690**A and **690**B is attached to a respective partition **912**. Two rails can be positioned on the opposite sides of the carriage **910**.

**[0059]** The flexible portions **690**A and **690**B can be transparent, as shown in FIG. **5**C. Beneficially, the transparent properties can allow visualization of the bottom surface of the instrument manipulator **700**. For example, the one or more buttons **770** of the emergency release **740** can be visualized through the transparent material. Certain implementations can include non-transparent flexible portions (such as, illustrated in FIG. **5**B). The non-transparent portions may block the one or more buttons **770**. This may prevent quick and convenient access to the one or more buttons **770**. Because of this, nontransparent portions can include a marker configured to indicate the location of the one or more buttons **770** relative to the nontransparent portions. For example, the marker can include a visual marker or a tactile marker indicating the location of the one more buttons **770** along the bottom surface of the instrument manipulator **700**. Beneficially, the one or more buttons **770** disclosed herein can be accessed and activated through the nontransparent portions.

Other Variations

**[0060]** Those skilled in the art will appreciate that, in some embodiments, additional components and/or steps can be utilized, and disclosed components and/or steps can be combined or omitted. For example, although some embodiments are described in connection with a robotic surgery system, the disclosure is not so limited. Systems, devices, and methods described herein can be applicable to medical devices and medical procedures in general, among other uses.

**[0061]** The foregoing description details certain embodiments of the systems, devices, and methods disclosed herein. It will be appreciated, however, that no matter how detailed the foregoing appears in text, the systems, devices, and methods can be practiced in many ways. The use of particular terminology when describing certain features or aspects of the disclosure should not be taken to imply that the terminology is being redefined herein to be restricted to including any specific characteristics of the features or aspects of the technology with which that terminology is associated.

**[0062]** It will be appreciated by those skilled in the art that various modifications and changes can be made without departing from the scope of the described technology. Such modifications and changes are intended to fall within the scope of the embodiments. It will also be appreciated by those of skill in the art that parts included in one embodiment are interchangeable with other embodiments; one or more parts from a depicted embodiment can be included with other depicted embodiments in any combination. For example, any of the various components described herein and/or depicted in the figures can be combined, interchanged, or excluded from other embodiments.

**[0063]** With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations can be expressly set forth herein for sake of clarity.

**[0064]** Directional terms used herein (for example, top, bottom, side, up, down, inward, outward, etc.) are generally used with reference to the orientation or perspective shown in the figures and are not intended to be limiting. For example, positioning "above" described herein can refer to positioning below or on one of sides. Thus, features described as being "above" may be included below, on one of sides, or the like.

**[0065]** It will be understood by those within the art that, in general, terms used herein are generally intended as "open" terms (for example, the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims can contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (for example, "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (for example, the bare recitation of "two recitations," without other modifiers, typically means at least two recitations, or two or more recitations).

**[0066]** The term "comprising" as used herein is synonymous with "including," "containing," or "characterized by," and is inclusive or open-ended and does not exclude additional, unrecited elements or method steps.

**[0067]** Conditional language, such as "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements, and/or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without user input or prompting, whether these features, elements, and/or steps are included or are to be performed in any particular embodiment.

**[0068]** Language of degree used herein, such as the terms "approximately," "about," "generally," and "substantially" as used herein represent a value, amount, or characteristic close to the stated value, amount, or characteristic that still performs a desired function and/or achieves a desired result. For example, the terms "approximately", "about", "generally," and "substantially" may refer to an amount that is within less than 10% of, within less than 5% of, within less than 1% of, within less than 0.1% of, and/or within less than 0.01% of the stated amount.

**[0069]** It will be further understood by those within the art that any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, can be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B." Further, the term "each," as used herein, in addition to having its ordinary meaning, can mean any subset of a set of elements to which the term "each" is applied.

**[0070]** Conjunctive language such as the phrase "at least one of X, Y, and Z," unless specifically stated otherwise, is otherwise understood with the context as used in general to convey that an item, term, etc. may be either X, Y, or Z. Thus, such conjunctive language is not generally intended to imply that certain embodiments require the presence of at least one of X, at least one of Y, and at least one of Z.

**[0071]** The above description discloses embodiments of systems, apparatuses, devices, methods, and materials of the present disclosure. This disclosure is susceptible to modifications in the components, parts, elements, steps, and materials, as well as alterations in the fabrication methods and equipment. Such modifications will become apparent to those skilled in the art from a consideration of this disclosure or practice of the disclosure. Consequently, it is not intended

that the disclosure be limited to the specific embodiments disclosed herein, but that it cover all modifications and alternatives coming within the scope and spirit of the subject matter embodied in the following claims.

What is claimed is:

**1**. An instrument manipulator for a robotic surgery system, the instrument manipulator comprising:

a housing configured to support at least one surgical instrument;

an actuator configured to move the housing forward toward a surgical site and backward away from the surgical site;

a release connected to the housing and configured to:

engage with the actuator in a first configuration to allow the housing and the at least one surgical instrument to move forward toward the surgical site and backward away from the surgical site responsive to activation of the actuator; and

disengage from the actuator in a second configuration to allow a user to manually move the housing and the at least one surgical instrument backward away from the surgical site; and

a user interface positioned at least partially on an exterior surface of the housing and configured to permit the user to transition the release from the first configuration to the second configuration, thereby facilitating retraction of the at least one surgical instrument away from the surgical site.

**2**. The instrument manipulator of claim **1**, wherein manual movement of the housing backward is not permitted in the first configuration as a result of the engagement of the release with the actuator.

**3**. The instrument manipulator of claim **1**, wherein the actuator comprises a leadscrew.

**4**. The instrument manipulator of claim **3**, further comprising a motor configured to rotate the leadscrew to cause the leadscrew to advance and retract the housing.

**5**. The instrument manipulator of claim **1**, wherein the release comprises at least one of a half nut, a dual split nut, a torsion spring, or a radial split nut.

**6**. The instrument manipulator of claim **1**, wherein the release comprises a pin and at least one spring, wherein the at least one spring is configured to extend the pin vertically upward when the release is in the second configuration.

**7**. The instrument manipulator of claim **6**, further comprising a guide configured to engage with the pin to facilitate retraction of the housing away from the surgical site.

**8**. The instrument manipulator of claim **7**, wherein the guide comprises a cutout configured to limit movement of the pin.

**9**. The instrument manipulator of claim **7**, wherein the guide comprises a rail.

**10**. The instrument manipulator of claim **1**, wherein the user interface comprises a button.

**11**. A central unit comprising at least one instrument manipulator of claim **1**.

**12**. A method of manually retracting an instrument manipulator of a robotic surgery system, the method comprising:

activating an emergency release of the instrument manipulator to cause the emergency release to disengage from an actuator of the instrument manipulator; and

while the emergency release is activated, manually moving the instrument manipulator and at least one surgical instrument supported by the instrument manipulator backward away from a surgical site.

**13**. The method of claim **12**, further comprising removing the at least one surgical instrument from the instrument manipulator subsequent to manually moving the instrument manipulator.

**14**. The method of claim **13**, wherein removing the at least one surgical instrument from the instrument manipulator is performed subsequent to manually retracting the instrument manipulator to a threshold distance away from the surgical site.

**15**. The method of claim **14**, wherein the threshold distance is defined by a stopper of the instrument manipulator configured to limit backward movement of the at least one surgical instrument.

**16**. The method of claim **12**, wherein activating the emergency release of the instrument manipulator comprises pressing a button located on an exterior surface of the instrument manipulator.

**17**. The method of claim **16**, further comprising reengaging the emergency release to the actuator by releasing the button, thereby allowing manipulation of the at least one surgical instrument by the robotic surgery system.

**18**. The method of claim **12**, wherein the actuator comprises a leadscrew.

**19**. The method of claim **12**, wherein the emergency release comprises a pin configured to be biased into a deactivated configuration by a spring, and wherein in the deactivated configuration, manual movement of the instrument manipulator is prevented.

**20**. The method of claim **12**, wherein the emergency release comprises at least one of a half nut, a dual split nut, a torsion spring, or a radial split nut.

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