US010702348B2

(12) **United States Patent**
**Moll et al.**

(10) **Patent No.: US 10,702,348 B2**

(45) **Date of Patent: Jul. 7, 2020**

(54) **SURGICAL SYSTEM WITH CONFIGURABLE RAIL-MOUNTED MECHANICAL ARMS**

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(73) Assignee: **Auris Health, Inc.**, Redwood City, CA (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/195,206**

(22) Filed: **Nov. 19, 2018**

(65) **Prior Publication Data**

US 2019/0083183 A1 Mar. 21, 2019

**Related U.S. Application Data**

(63) Continuation of application No. 15/094,179, filed on Apr. 8, 2016, now Pat. No. 10,159,533.

(Continued)

(51) **Int. Cl.**

***A61B 34/30*** (2016.01)
***A61B 50/10*** (2016.01)

(Continued)

(52) **U.S. Cl.**

CPC .......... ***A61B 34/30*** (2016.02); ***A61B 1/00149*** (2013.01); ***A61B 34/00*** (2016.02);

(Continued)

(58) **Field of Classification Search**

CPC ... A61B 34/30; A61B 50/10; A61B 2090/571; A61B 1/00149; A61G 13/06;

(Continued)

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*Primary Examiner* — Nicholas F Polito

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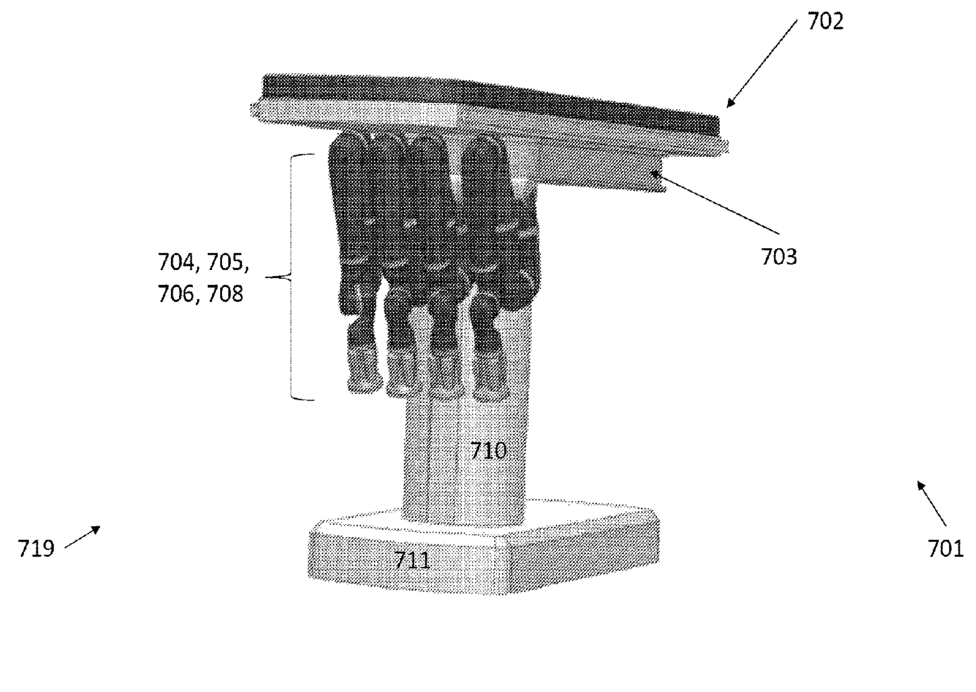
(57) **ABSTRACT**

A robotic surgical system comprises a horizontal platform to support a patient, a rail positioned about the horizontal platform, a carriage operatively coupled to and configured to translate along the rail, and a robotic arm operatively coupled to the carriage and translated about the patient by the rail. The robotic arm is configured to operate on the patient in a variety of positions provided by the translating carriage. The rail provides a rounded path for the carriage, such as a U-shaped path. The U-shaped path may comprise a first leg and a second leg, the first leg longer than the second leg. Furthermore, the system may comprise a plurality of carriages operatively coupled to the rail and a plurality of robotic arms. Also, the system may further comprise a central base which the horizontal platform can articulate relative to, such as by translating horizontally or vertically, rotating, or titling.

**21 Claims, 20 Drawing Sheets**



## Related U.S. Application Data

(60) Provisional application No. 62/145,418, filed on Apr. 9, 2015.

(51) **Int. Cl.**

| | |
|---|---|
| ***A61B 90/50*** | (2016.01) |
| ***A61G 13/06*** | (2006.01) |
| ***A61G 13/10*** | (2006.01) |
| ***A61B 34/20*** | (2016.01) |
| ***A61B 34/00*** | (2016.01) |
| ***A61B 1/00*** | (2006.01) |
| ***A61G 13/04*** | (2006.01) |
| *A61B 90/57* | (2016.01) |
| *A61B 1/313* | (2006.01) |
| *A61B 1/267* | (2006.01) |
| *A61B 1/31* | (2006.01) |
| *A61B 1/303* | (2006.01) |
| *A61B 1/307* | (2006.01) |
| *A61B 1/273* | (2006.01) |

(52) **U.S. Cl.**

CPC .............. ***A61B 34/20*** (2016.02); ***A61B 50/10*** (2016.02); ***A61B 90/50*** (2016.02); ***A61G 13/04*** (2013.01); ***A61G 13/06*** (2013.01); ***A61G 13/10*** (2013.01); *A61B 1/2676* (2013.01); *A61B 1/2736* (2013.01); *A61B 1/303* (2013.01); *A61B 1/307* (2013.01); *A61B 1/31* (2013.01); *A61B 1/3132* (2013.01); *A61B 2034/304* (2016.02); *A61B 2090/571* (2016.02); *A61G 13/101* (2013.01)

(58) **Field of Classification Search**

CPC ...... A61G 13/10; A61G 13/101; A61G 13/00; A61G 13/0036; A61G 13/0045; A61G 13/0054; A61G 13/0063; A61G 13/0072; A61G 13/0081; A61G 13/04; A61G 13/107

See application file for complete search history.

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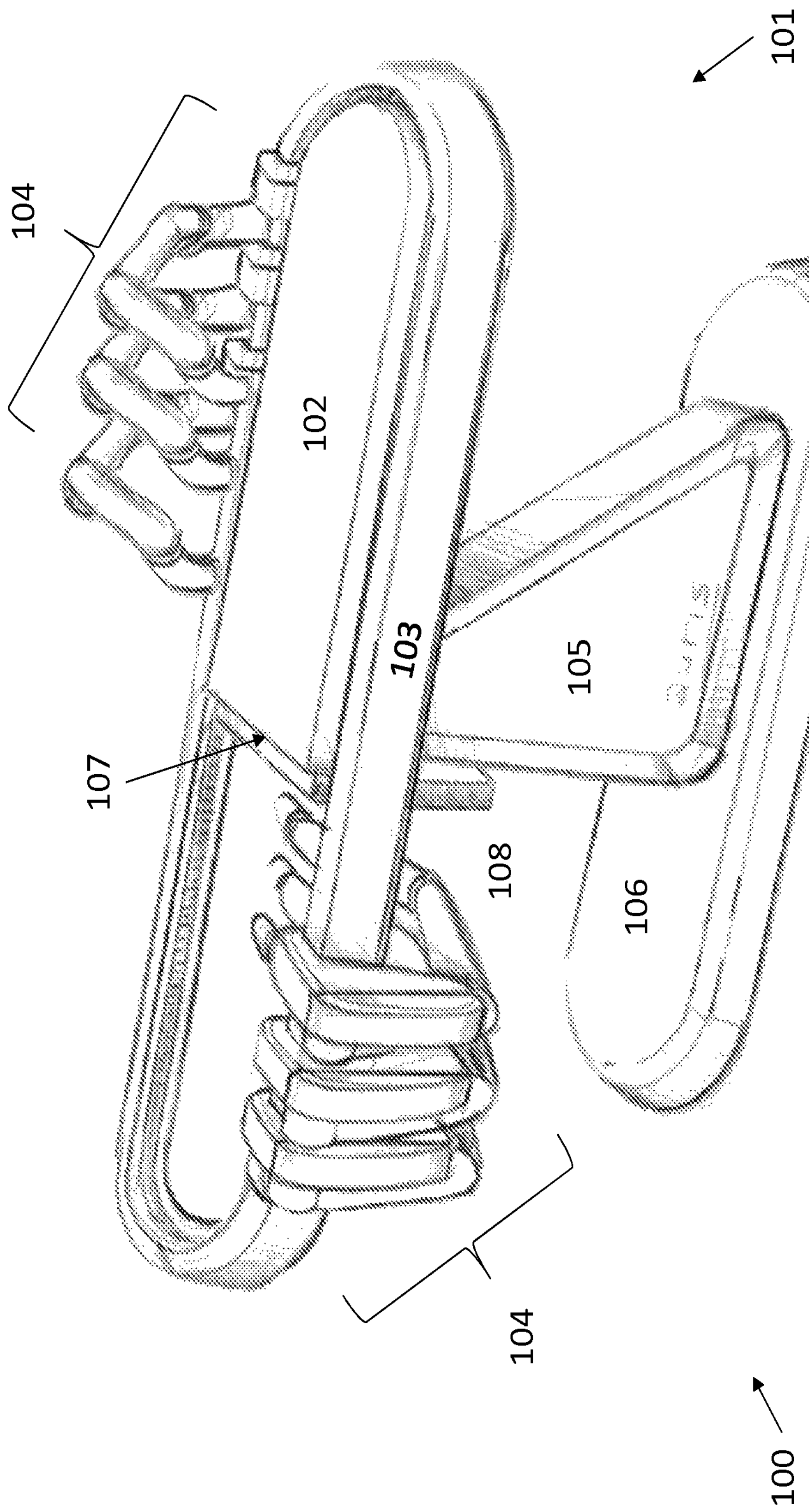


FIG. 1

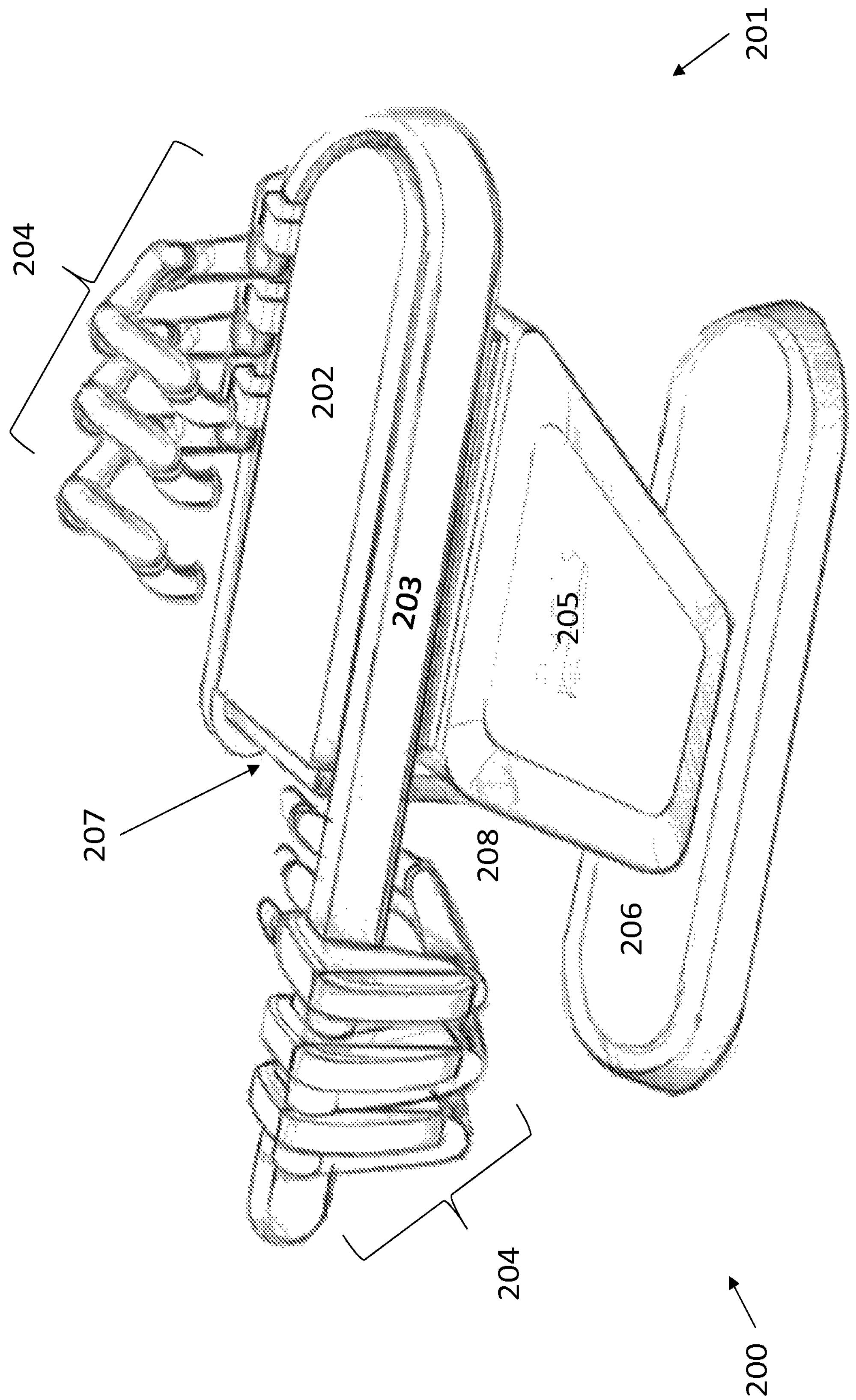


FIG. 2

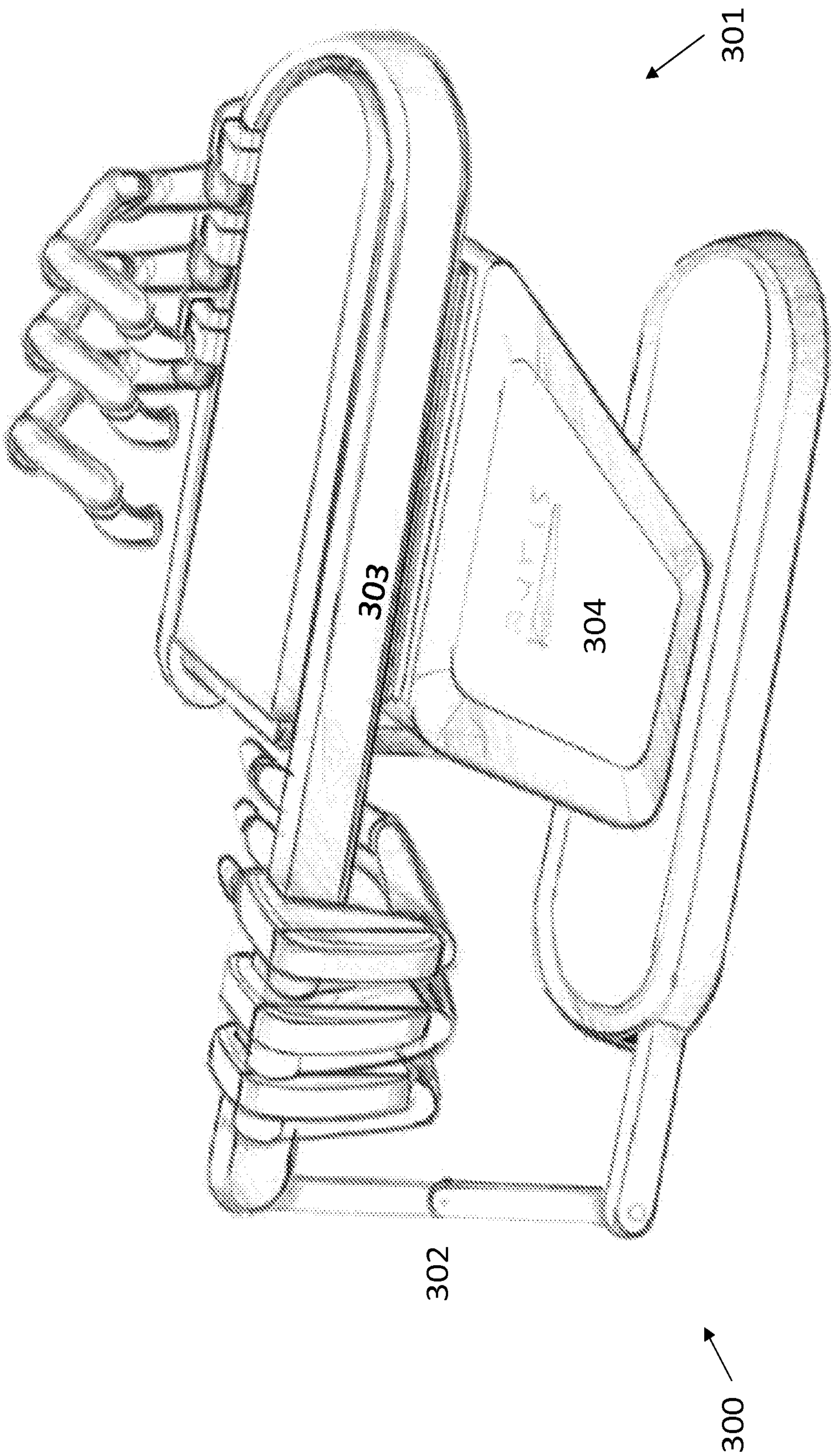


FIG. 3

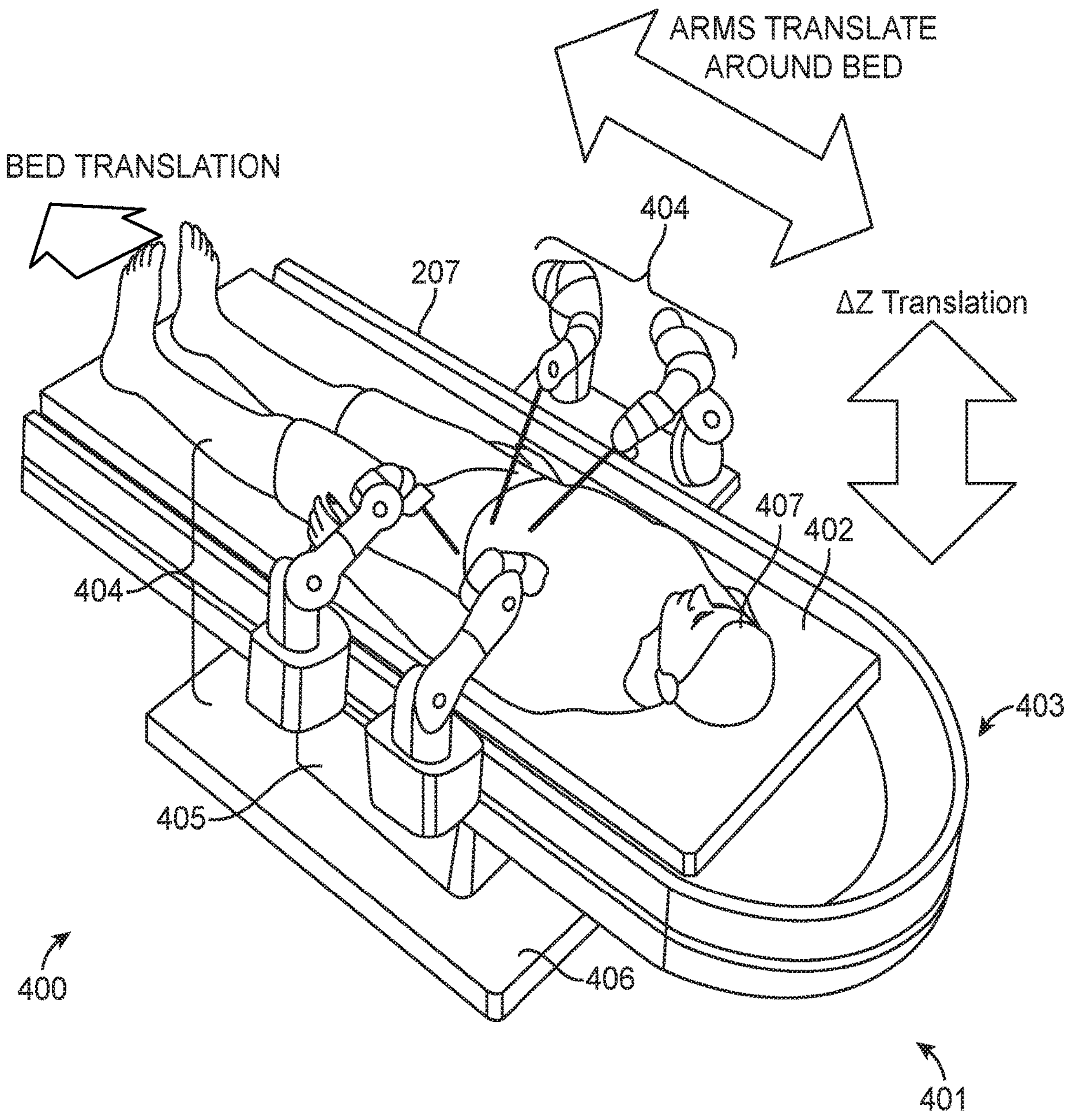
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FIG. 4

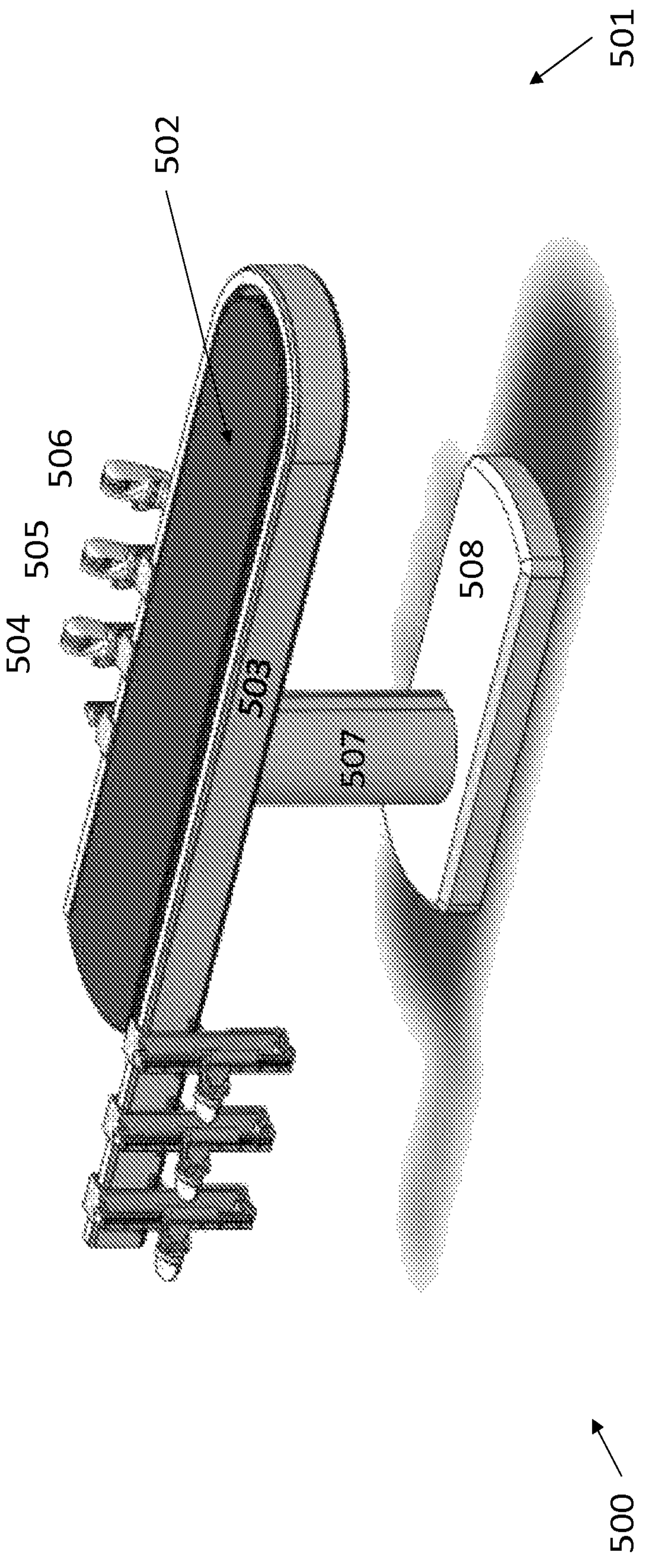


FIG. 5A

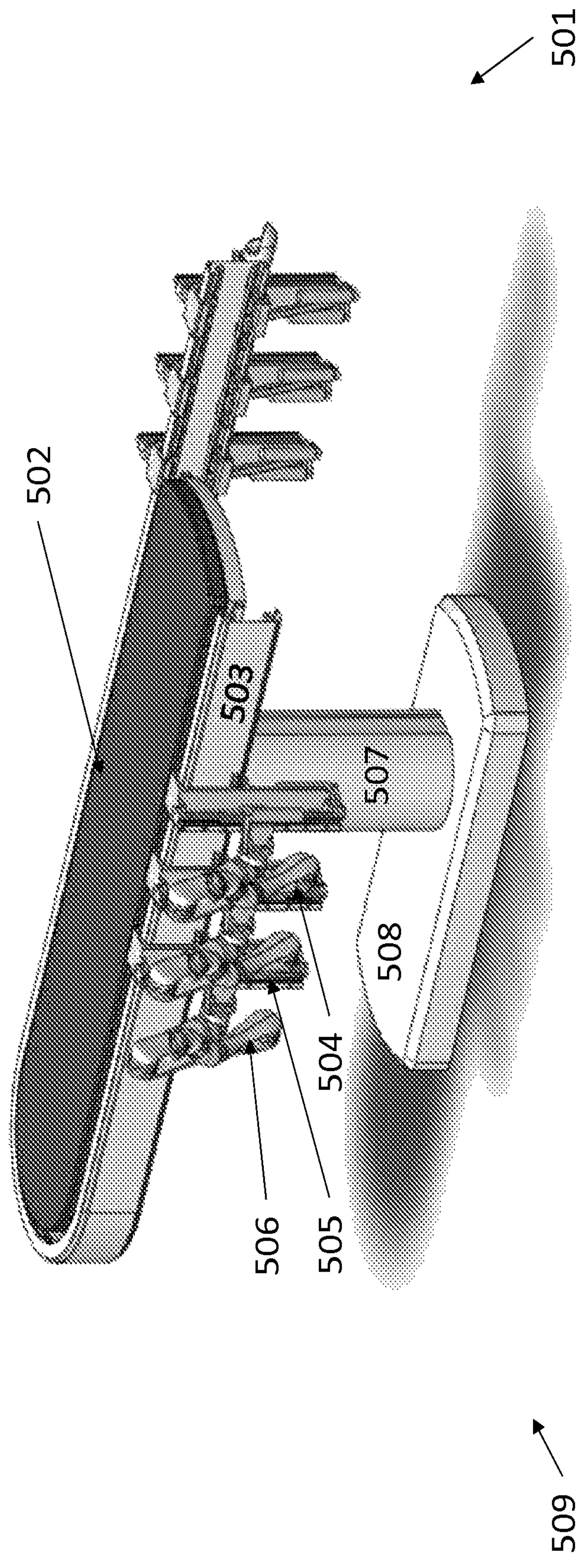


FIG. 5B

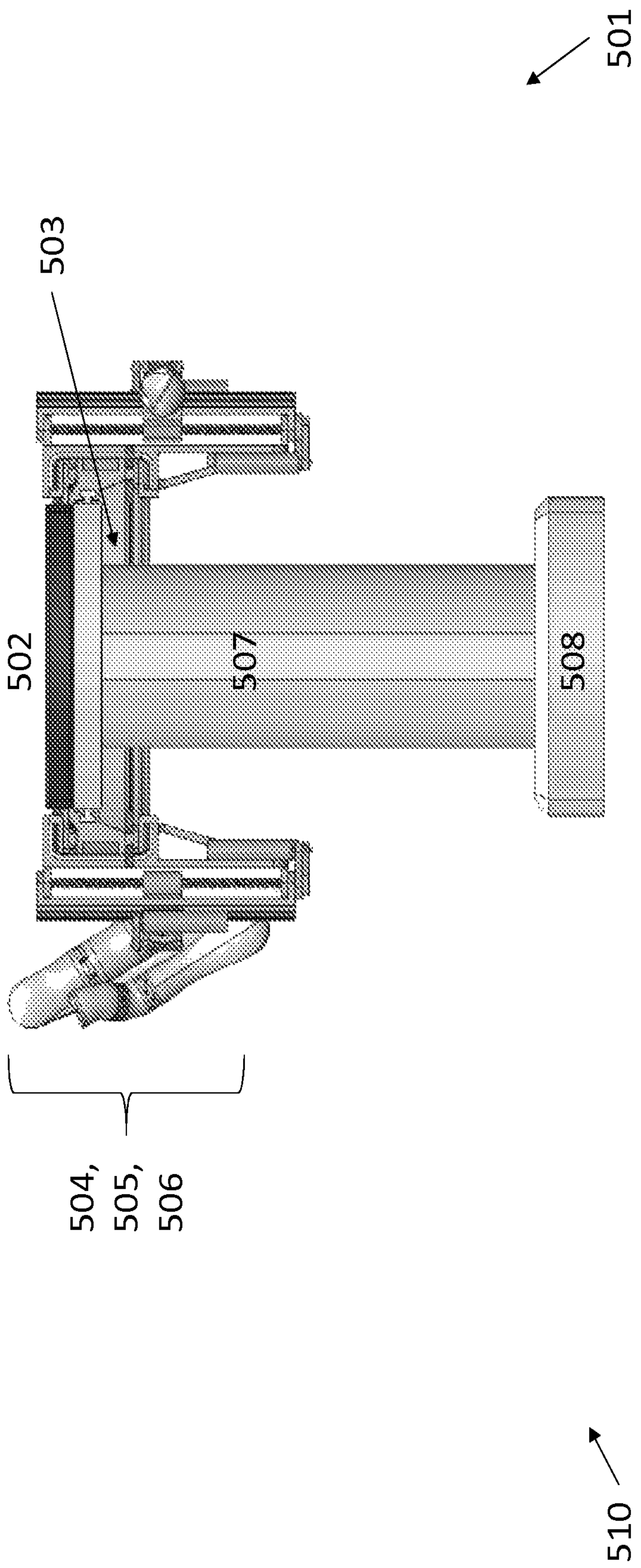


FIG. 5C

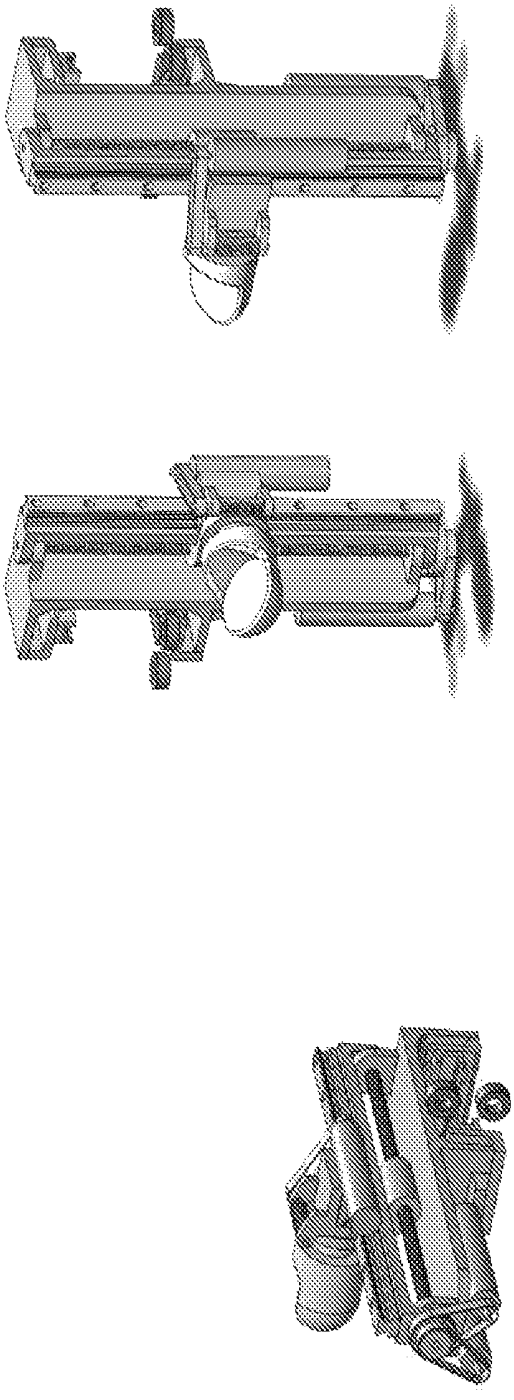


FIG. 5D

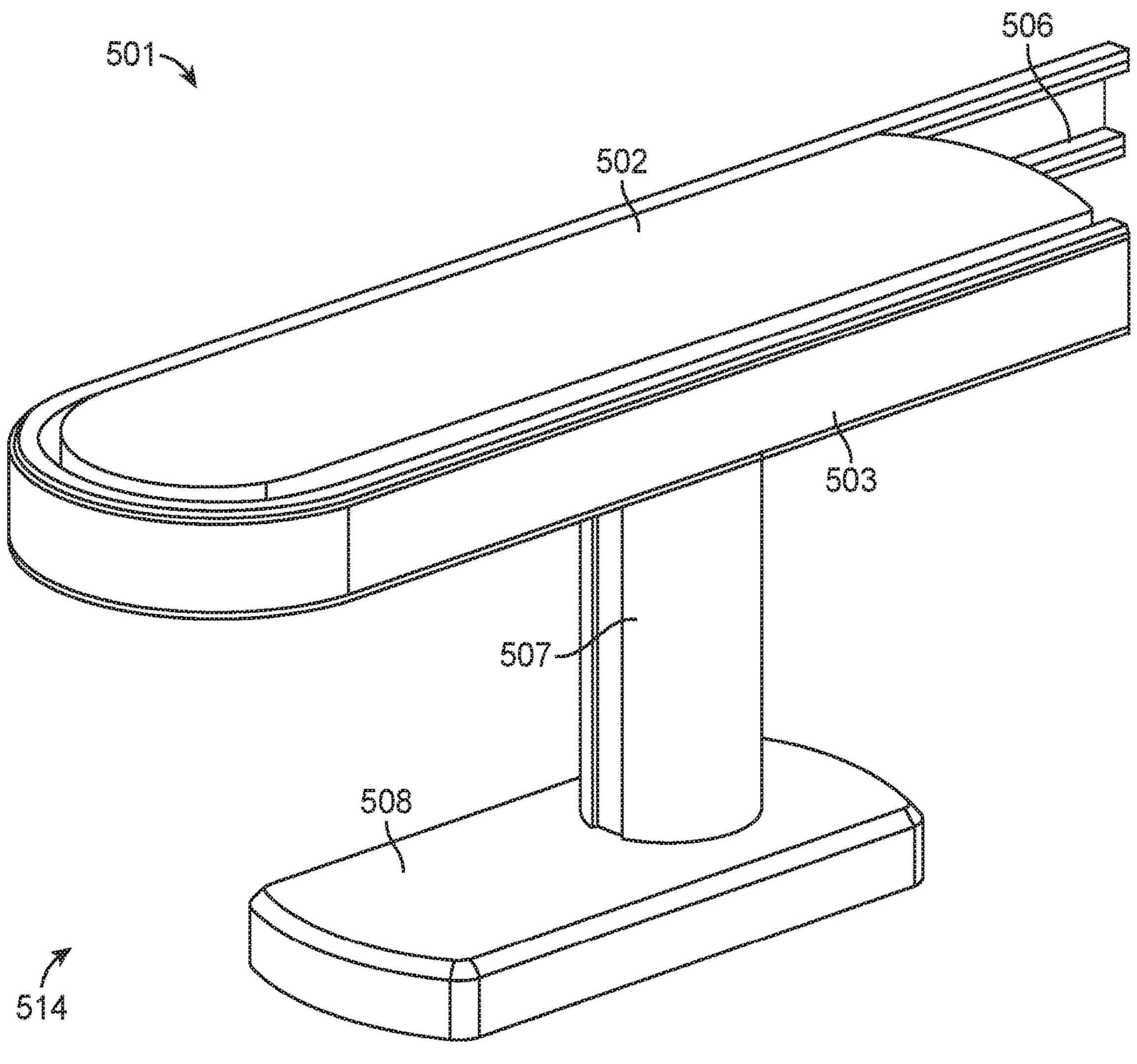


FIG. 5E

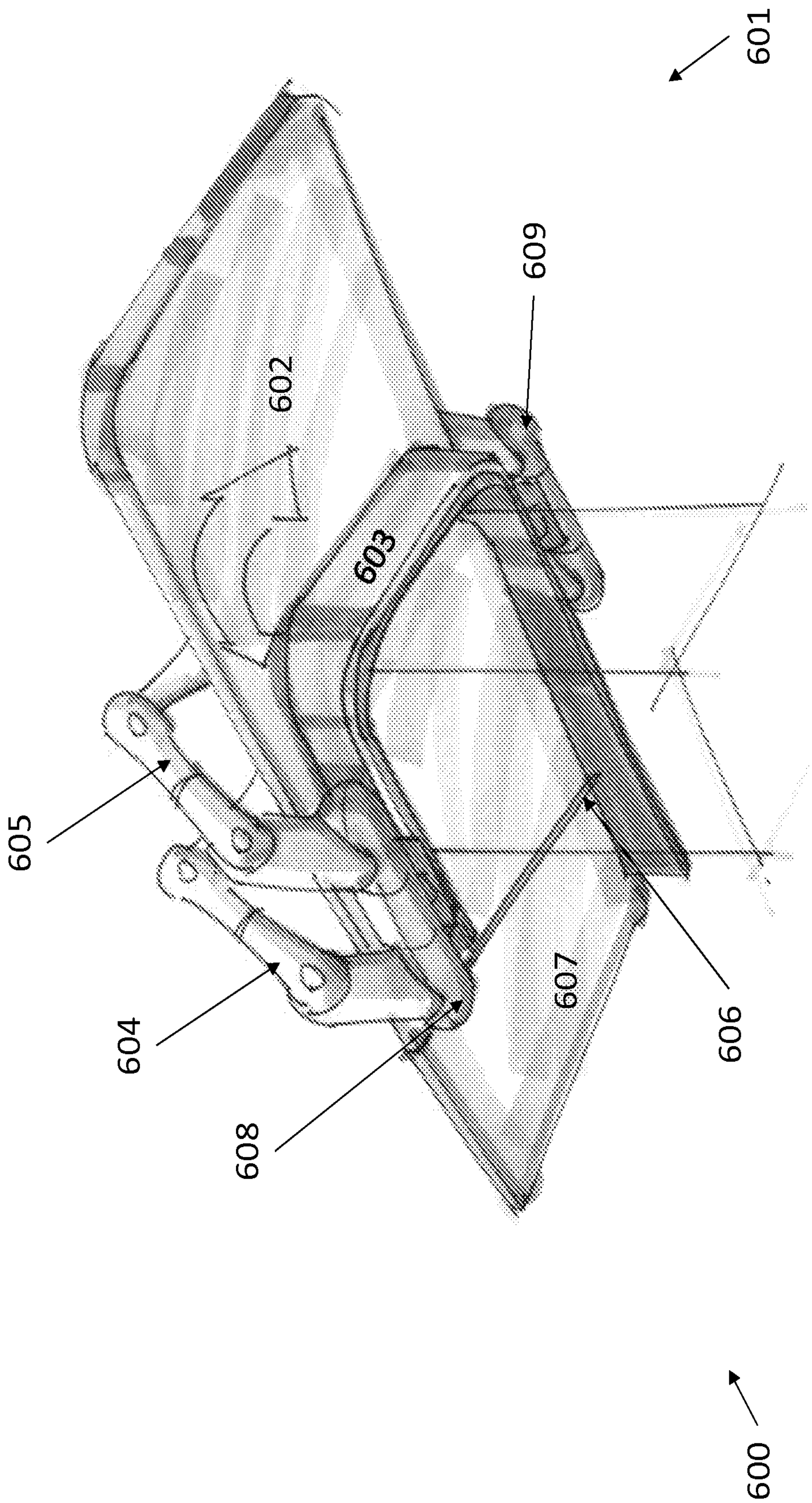


FIG. 6A

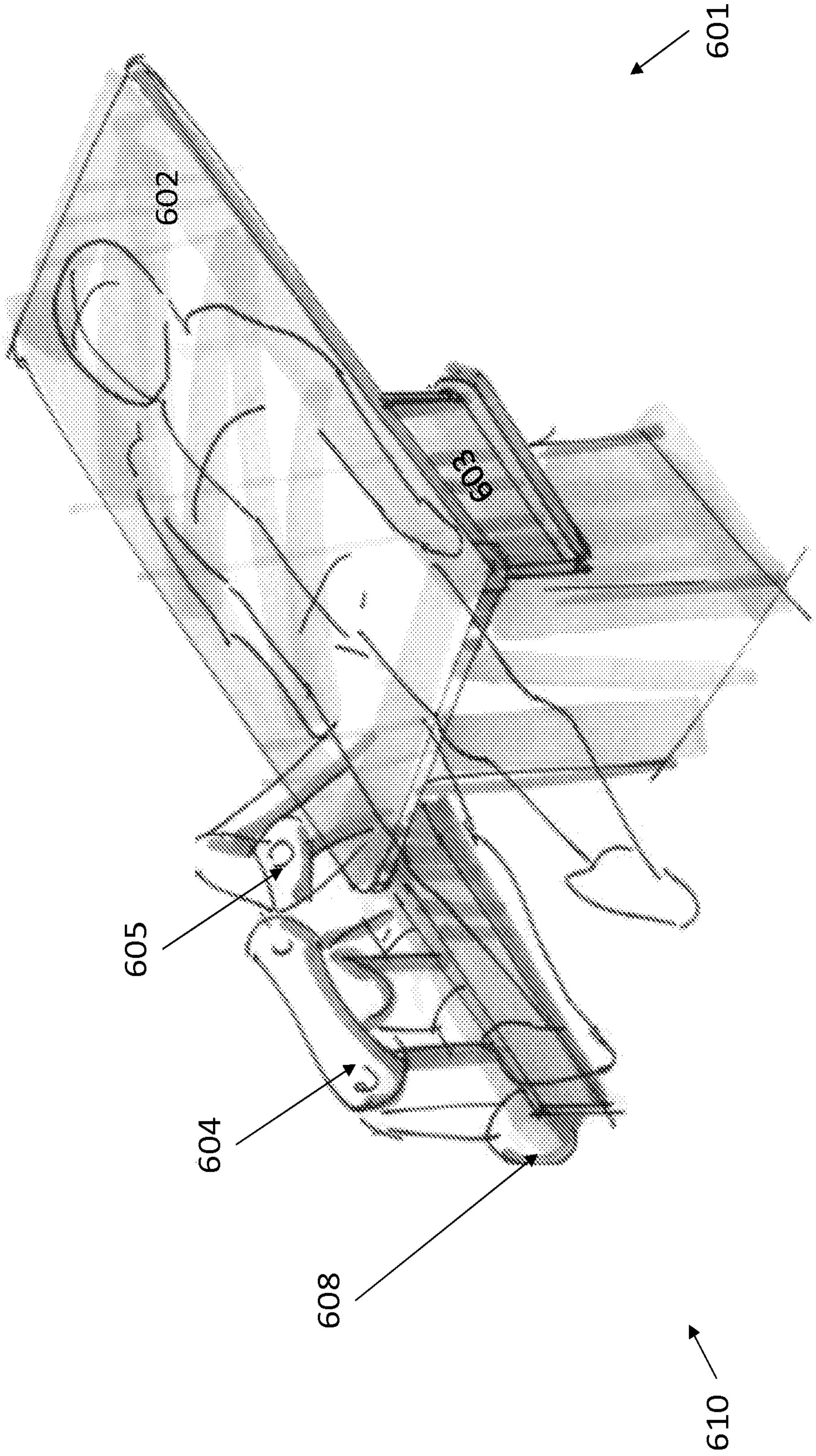


FIG. 6B

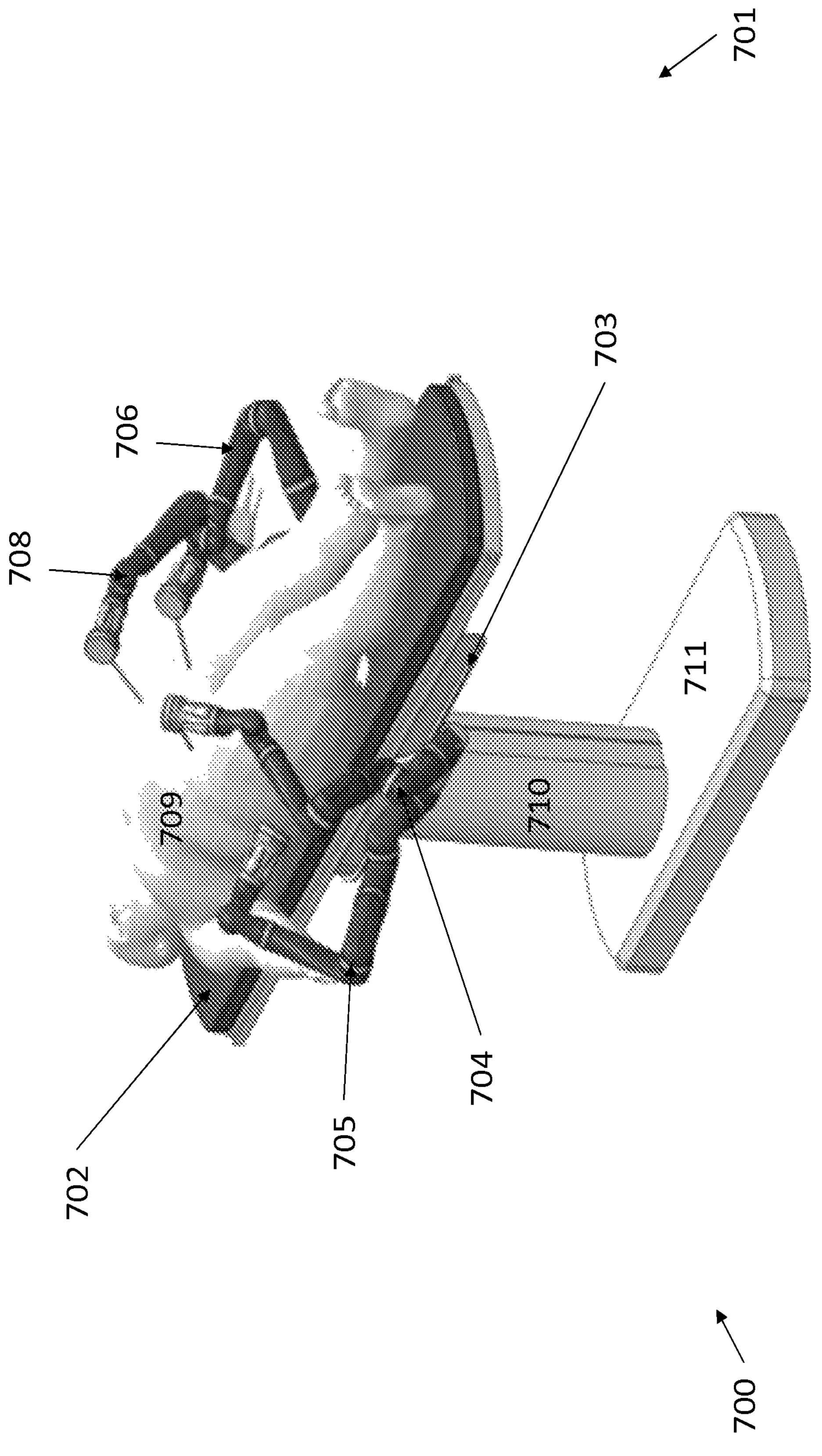


FIG. 7A

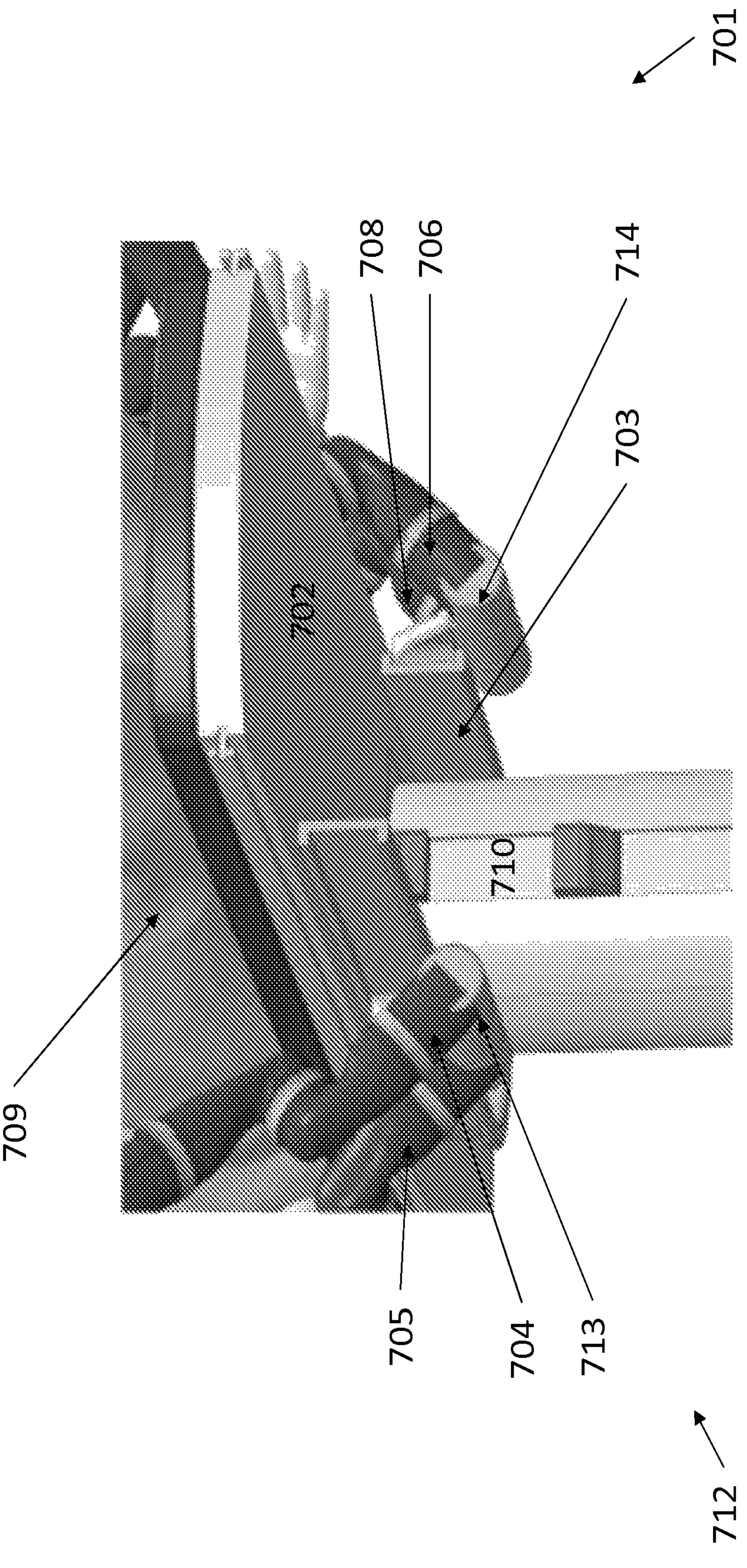


FIG. 7B

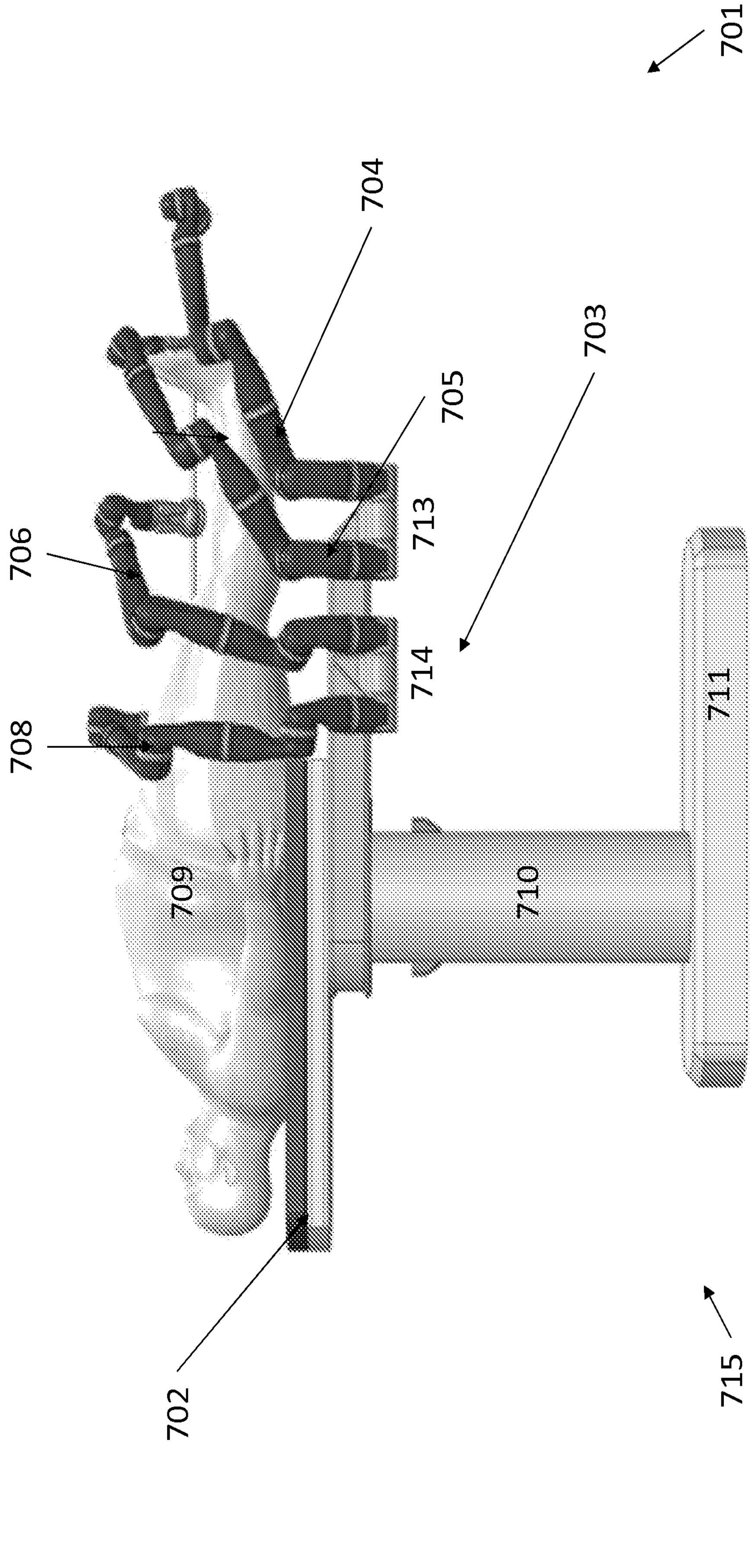


FIG. 7C

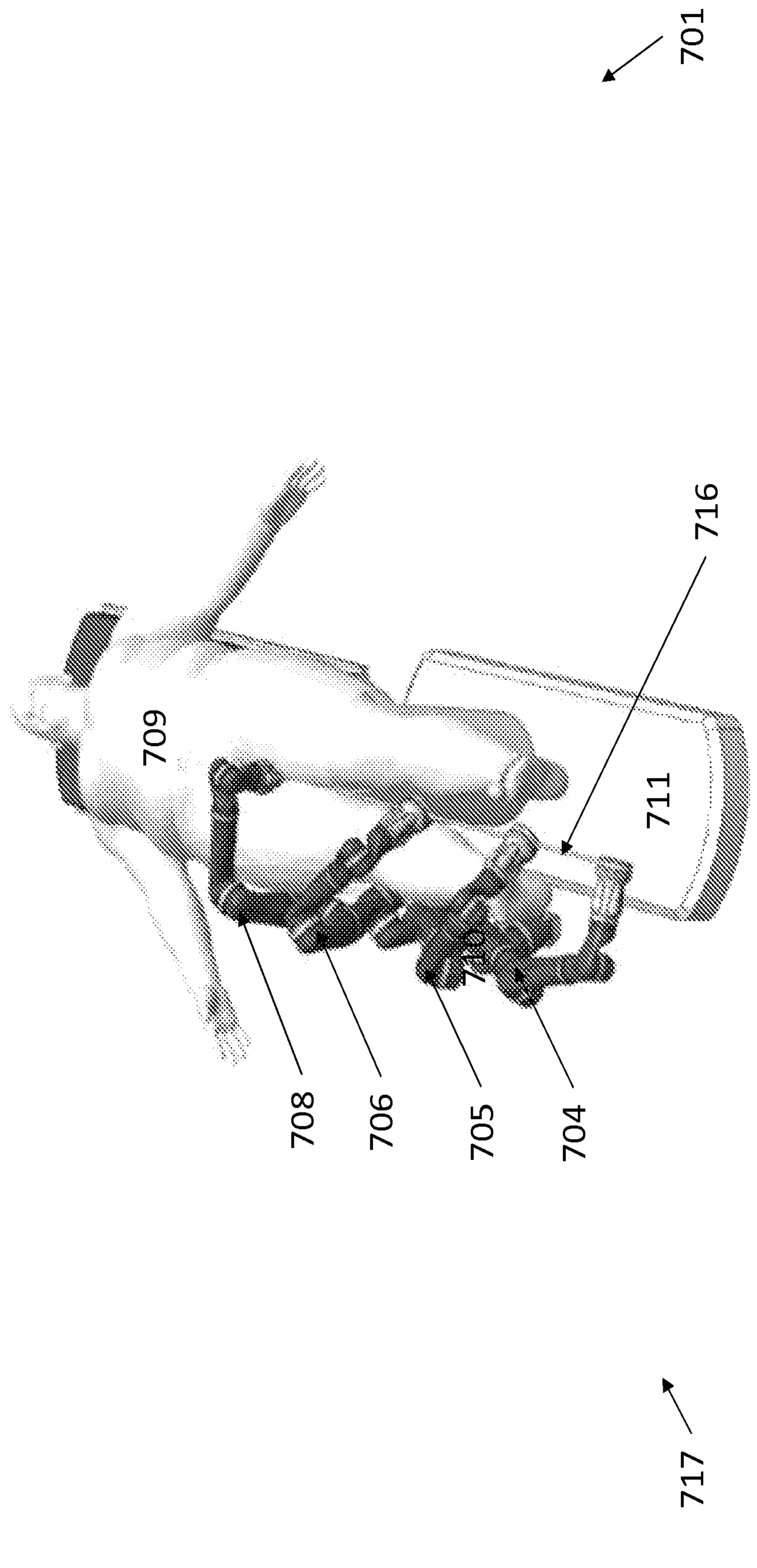


FIG. 7D

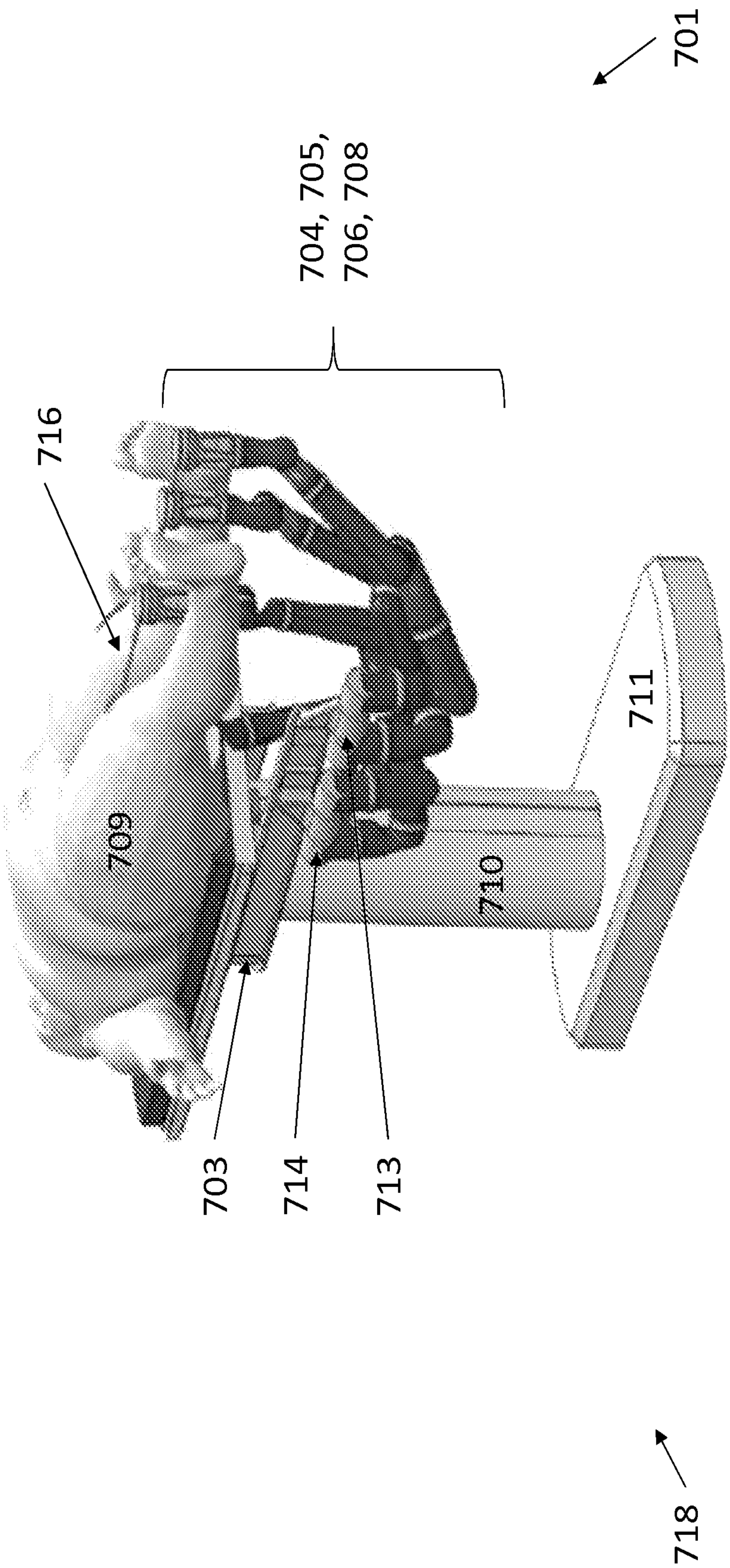


FIG. 7E

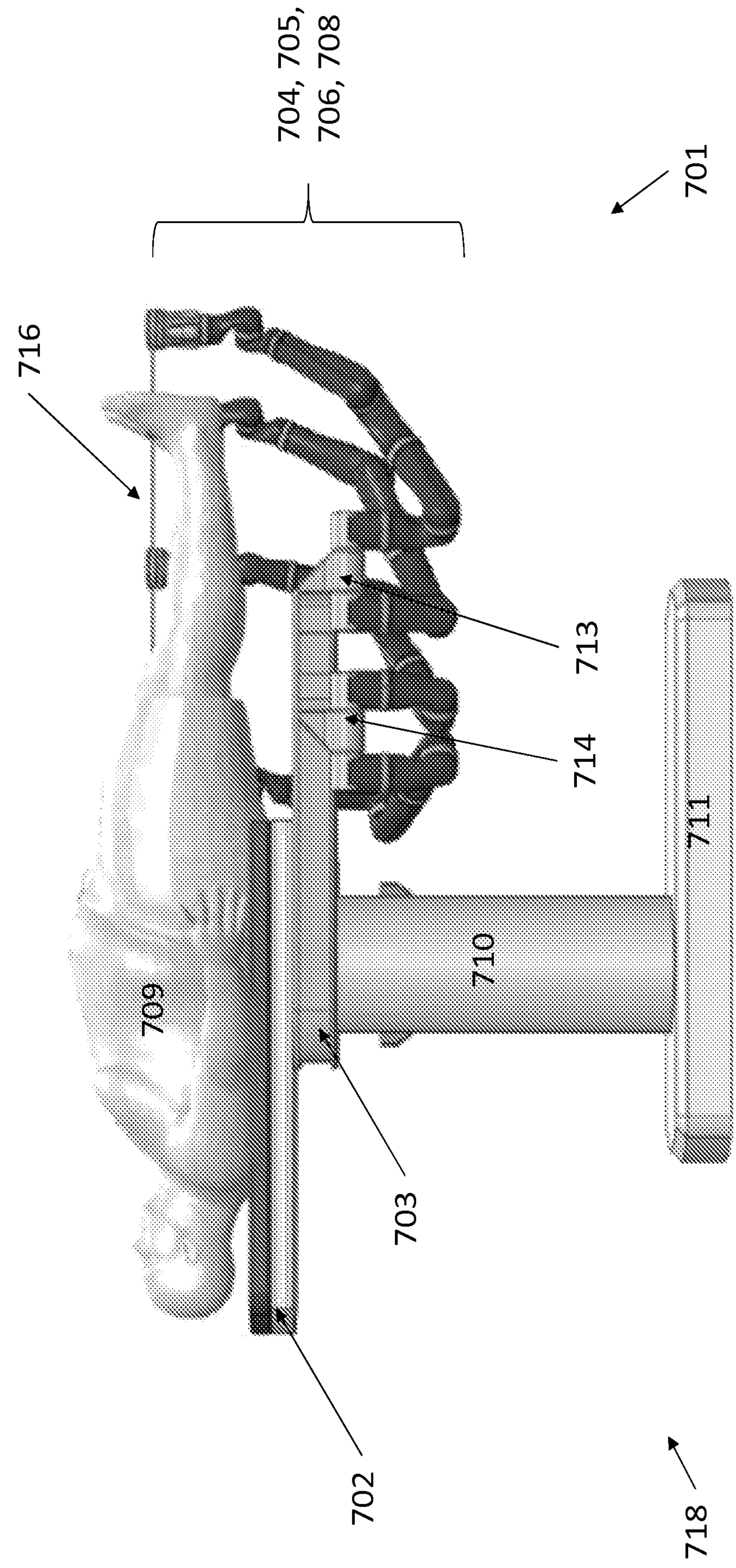


FIG. 7F

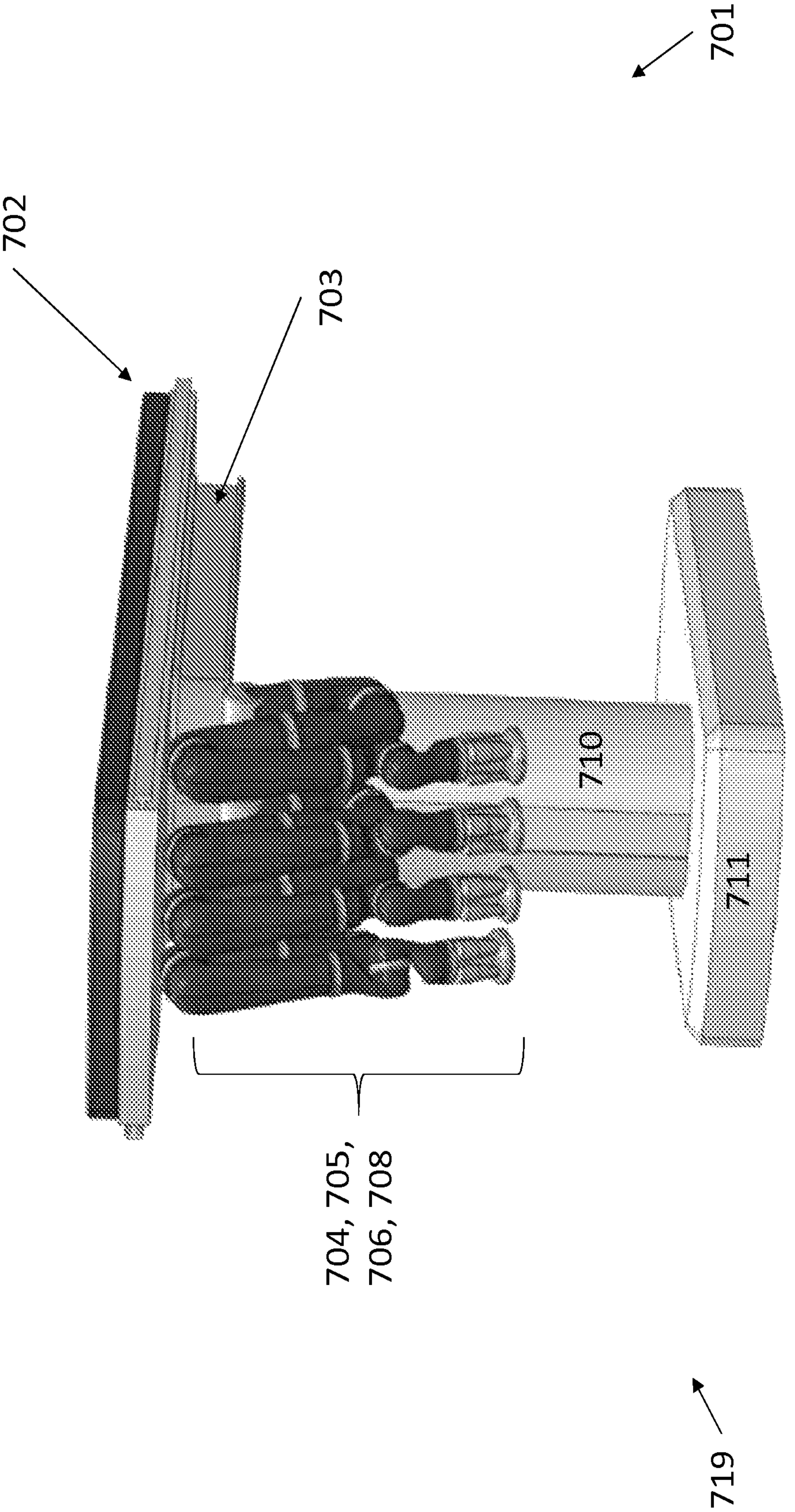


FIG. 7G

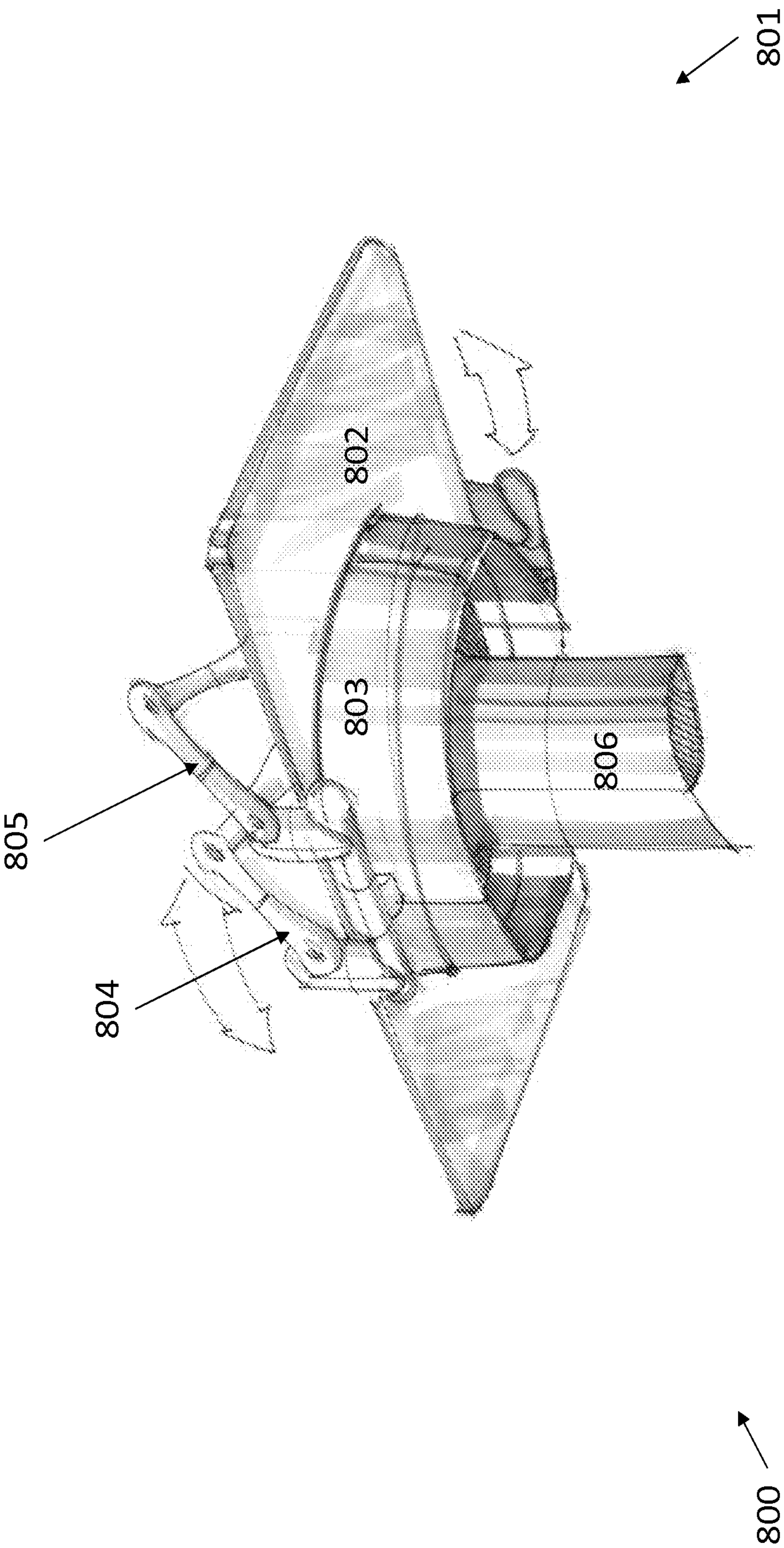


FIG. 8A

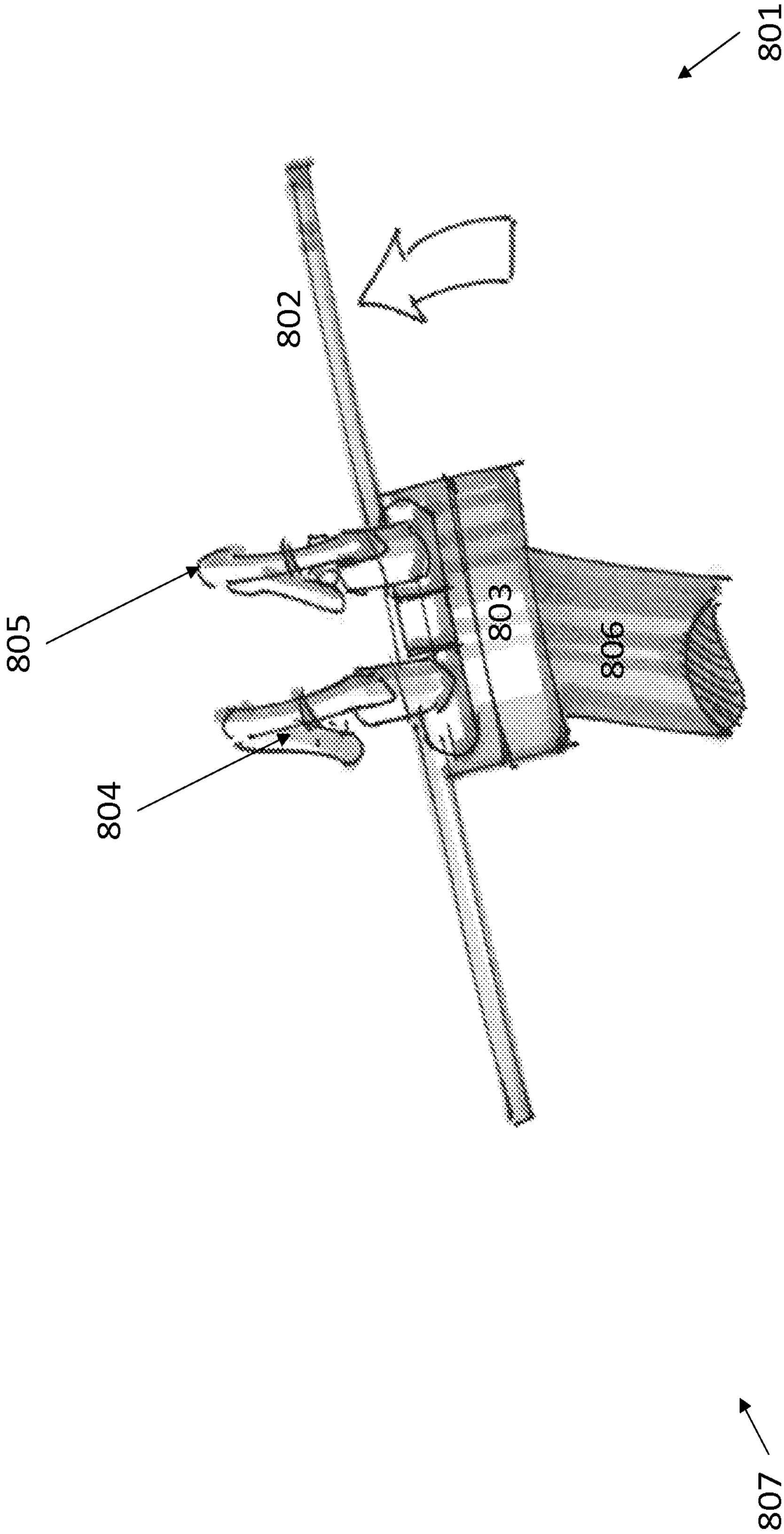


FIG. 8B

# SURGICAL SYSTEM WITH CONFIGURABLE RAIL-MOUNTED MECHANICAL ARMS

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 15/094,179, filed Apr. 8, 2016, which claims the benefit of U.S. Provisional Application No. 62/145,418, filed Apr. 9, 2015, each of which is incorporated herein by reference.

The present invention relates to medical instruments, tools, and methods that may be incorporated into a robotic system, such as those disclosed in U.S. patent application Ser. No. 14/523,760, filed Oct. 24, 2014, U.S. Provisional Patent Application No. 62/019,816, filed Jul. 1, 2014, U.S. Provisional Patent Application No. 62/037,520, filed Aug. 14, 2014, and U.S. Provisional Patent Application No. 62/057,936, filed Sep. 30, 2014, the entire contents of which are incorporated herein by reference.

## INCORPORATION BY REFERENCE

All publications and patent applications mentioned in this specification are herein incorporated by reference in their entirety to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

## FIELD OF THE INVENTION

The field of the present invention relates to a robotics platform that may be used in a number of surgical procedures. More particularly, the field of the invention pertains to robotic platforms that enable robotically-controlled tools to perform diagnostic and therapeutic surgical procedures.

## BACKGROUND OF THE RELATED ART

Use of robotic technologies presents a number of advantages over traditional, manual surgery procedures. In addition to other advantages, robotic surgeries often allow for greater precision, control, and access. Despite these advantages, however, the pre-existing robotics platforms have built-in limitations that are tied to their structural designs and underpinnings. In the absence of a truly flexible system, hospitals and health care practitioners are forced to acquire a variety of robotic systems in order to robotically perform a variety of procedures. The high capital costs, combined with the relatively specialization of the systems, have slowed adoption of robotics platforms for surgery.

Accordingly, there is a need for a robotics platform that is configurable for a number of procedures.

## BRIEF SUMMARY OF THE INVENTION

In general, the present invention provides a medical device that comprises a rail having a rounded path, a carriage configured to translate along the rail, the carriage being operatively coupled to the rail, a robotic arm operatively coupled to the carriage, and a horizontal platform proximate to the rail, wherein the robotic arms are configured to perform medical procedures on a patient on the platform. In one aspect, the rounded path is U-shaped. In one aspect, the U-shaped path comprises of a first leg and a second leg, wherein the first leg is longer than the second leg. In another aspect, the rail is configured around a central base. In one aspect, the central base is shaped like a column.



In another aspect, a horizontal platform is operatively coupled to the top of the base. In one aspect, the rail is disposed below the platform. In one aspect, the rail is around the platform. In one aspect, the arm is configured to be angled over platform.

In another aspect, the platform is a surgical bed, configured to support the weight of a patient. In one aspect, the surgical bed comprises a first part and a second part, wherein the second part is configured to articulate relative to the first part.

In another aspect, the rail is configured around a horizontal platform. In one aspect, the platform is a surgical bed, configured to support the weight of a patient.

In another aspect, the rounded path is circular. In one aspect, the rail is disposed below the platform. In one aspect, the rail is around the platform.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described, by way of example, and with reference to the accompanying diagrammatic drawings, in which:

FIG. **1** illustrates a surgical bed with an oval track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention;

FIG. **2** illustrates a surgical bed with a U-shaped track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention;

FIG. **3** illustrates an alternative robotics platform to system **201** from FIG. **2**;

FIG. **4** illustrates a surgical bed with a rounded track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention;

FIG. **5**A illustrates a surgical bed with a rounded track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention;

FIG. **5**B illustrates the surgical bed with a rounded track from FIG. **5**A, consistent with an embodiment of the present invention;

FIG. **5**C illustrates the surgical bed with a rounded track from FIGS. **5**A, **5**B, consistent with an embodiment of the present invention;

FIG. **5**D illustrates several views of carriages for mechanical arms used in system **501** from FIGS. **5**A, **5**B;

FIG. **5**E illustrates the surgical bed with a rounded track from FIG. **5**A, consistent with an embodiment of the present invention;

FIGS. **6**A and **6**B illustrate a surgical bed with a rounded track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention;

FIG. **7**A illustrates a surgical bed with a rounded track for robotic arms underneath the edge of the bed, consistent with an embodiment of the present invention;

FIG. **7**B illustrates the underside of the surgical bed with a rounded track from FIG. **7**A;

FIG. **7**C illustrates the surgical bed with a rounded track from FIGS. **7**A, **7**B;

FIG. **7**D illustrates the surgical bed with a rounded track from FIGS. **7**A, **7**B, **7**C;

FIG. **7**E illustrates the surgical bed with a rounded track from FIG. **7**C;

FIG. **7**F illustrates the surgical bed with a rounded track from FIG. **7**E;

FIG. **7**G illustrates the surgical bed with a rounded track from FIGS. **7**A-**7**F; and

FIGS. **8**A and **8**B illustrate a surgical bed with a rounded track for robotic arms underneath the edge of the bed, consistent with an embodiment of the present invention.

## DETAILED DESCRIPTION OF THE DRAWINGS

Although certain preferred embodiments and examples are disclosed below, inventive subject matter extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses, and to modifications and equivalents thereof. Thus, the scope of the claims appended hereto is not limited by any of the particular embodiments described below. For example, in any method or process disclosed herein, the acts or operations of the method or process may be performed in any suitable sequence and are not necessarily limited to any particular disclosed sequence. Various operations may be described as multiple discrete operations in turn, in a manner that may be helpful in understanding certain embodiments; however, the order of description should not be construed to imply that these operations are order dependent. Additionally, the structures, systems, and/or devices described herein may be embodied as integrated components or as separate components.

In clinical applications, the design of the base of the robotics platform often constrains the types of procedures that may be performed by the system. For example, in a system where robotic appendages are only available around the abdomen, urology procedures are precluded from being performed. Likewise, robotic arms below the abdomen may not be useful for laparoscopic procedures. Accordingly, the present invention provides a flexible design such that robotic arms may be delivered to multiple access points in a patient around a surgical bed.

FIG. **1** illustrates a surgical bed with an oval track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention. As shown in the isometric view **100** of the robotic system **101**, the system **101** comprises of a surgical bed **102**, a rail **103** for mechanical arms **104**, a support stand **105**, and a system base **106**. The surgical bed allows for a hinge **107** such that a portion **108** of surgical bed **102** may be declined at a different angle from the rest of the bed. This may be desirable for certain operations, such as when performing a procedure that requires access a patient's lower abdomen, such as ureteroscopy or hysteroscopy.

Encircling the surgical bed **102**, the rail **103** provides a structure to slidingly translate the mechanical arms **104** to a desired location around the surgical bed **102**. The rail **103**, which may be referred to as a "track", and the mechanical arms **104** may be slidingly translated along it in order to facilitate access for the arms. The rail **103** also provides allows for the conveyance and reception of power, controls, fluidics, aspiration to the mechanical arms **104**. The rail **103** may be fully circular and surround all sides of the surgical bed **102**.

The mechanical arms **104** may be operatively coupled to the rail **103**. The mechanical arms may also be robotic. The translation of the mechanical arms **104** may be actuated either manually or robotically. The mechanical arms **104** may be coupled independently to the rail **103** or in groups via a mechanical carriage that may slide around the rail **103**. In addition to providing structural support to the mechanical arms **104**, the carriage may be used to convey and receive power, controls, fluidics, and aspiration to and from the arms **104** to the rail **103**.

In combination or individually, the support stand **105** and the system base **106** may be used to house electronics, fluidics, pneumatics, and aspiration. The electronics may be used from control, localization, navigation of the arms **104**. Thus, as a robotically-driven platform, system **101** provides for a comprehensive surgical bed and tool solution that may be used to perform any number of procedures around a patient.

FIG. **2** illustrates a surgical bed with a U-shaped track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention. As shown in the isometric view **200** of the robotic system **201**, the system **201** comprises of a surgical bed **202**, a rail **203** for mechanical arms **204**, a support stand **205**, and a system base **206**. Like in system **101**, the surgical bed **202** allows for a hinge **207** such that a portion **208** of surgical bed **202** may be declined at a different angle from the rest of the bed **202**. As discussed earlier, this may be desirable for certain operations, such as when performing a procedure that requires access a patient's lower abdomen, such as ureteroscopy, hysteroscopy, or colonoscopy.

Running along the surgical bed **202**, the rail **203** provides a structure to slidingly translate the mechanical arms **204** to a desired location around the surgical bed **202**. Unlike rail **103**, rail **203** uses a U-shape that enhances access the surgical bed **202**. This may provide advantages when position the patient and accessing operative sites on a patient's lower abdomen. The longer leg of the rail **203** allows for the mechanical arms to be aligned to convey a medical instrument into the patient by means of a "virtual rail" such as one discussed in the aforementioned patent applications. As before, the rail **203** may be referred to as a "track", and the mechanical arms **204** may be slidingly translated along it in order to facilitate access for the arms. The rail **203** also provides allows for the conveyance and reception of power, controls, fluidics, aspiration to the mechanical arms **204**.

In combination or individually, the support stand **205** and the system base **206** may be used to house electronics, fluidics, pneumatics, and aspiration. The electronics may be used from control, localization, navigation of the arms **204**. Thus, as a robotically-driven platform, system **201** provides for an improved, comprehensive surgical bed and tool solution that may be used to perform any number of procedures around a patient.

As deployed, the mechanical arms **104** from system **101** and mechanical arms **204** and system **201** are positioned to perform endolumenal procedures to access the access points in the lower abdomen (e.g., urology, ureteroscopy, hysteroscopy, or colonoscopy) and upper abdomen (e.g., bronchoscopy, gastro-intestinal).

FIG. **3** illustrates an alternative robotics platform to system **201** from FIG. **2**. As shown in isometric view **300**, system **301** incorporates all the technologies disclosed with respect to system **201** with the additional vertical translation apparatus **302** that enables control over the vertical height of the rail **303**. System **301** thus allows for vertical translation of the rail **303** relative to the support stand **304**.

FIG. **4** illustrates a surgical bed with a rounded track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention. As shown in the isometric view **400** of the robotic system **401**, the system **401** comprises of a surgical bed **402**, a rail **403** (or "track") for mechanical arms **404**, a support stand **405**, and a system base **406**. The surgical bed **402** may be configured to translate horizontally to position patient **407** relative to mechanical arms **404**.

Encircling the surgical bed **402**, the rail **403** provides a structure to slidingly translate the mechanical arms **404** to a desired location around the surgical bed **402**. The rail **403**, which may be referred to as a "track", and the mechanical arms **404** may be slidingly translated along it in order to facilitate access for the arms. The rail **403** also provides allows for the conveyance and reception of power, controls, fluidics, aspiration to the mechanical arms **404**.

The mechanical arms **404** may be operatively coupled to the rail **403**. The mechanical arms **404** may also be robotic. The translation of the mechanical arms **404** may be actuated either manually or robotically. The mechanical arms **404** may be coupled independently to the rail **403** or in groups via a mechanical carriage that may slide around the rail **403**. In addition to providing structural support to the mechanical arms **404**, the carriage may be used to convey and receive power, controls, fluidics, and aspiration to and from the arms **404** to the rail **403**. The ability to translate the arms **404** and translate the bed **402** allows for nearly unlimited access to different portions of the anatomy of patient **407**.

In combination or individually, the support stand **405** and the system base **406** may be used to house electronics, fluidics, pneumatics, and aspiration. The electronics may be used from control, localization, navigation of the arms **404**. Thus, as a robotically-driven platform, system **401** provides for a comprehensive surgical bed and tool solution that may be used to perform any number of procedures around a patient. The support stand **405** may also translate vertically, allowing for easier access to the patient **407** and operative site.

As deployed in view **400**, mechanical arms **404** may be positioned to access the abdomen of patient **407** for laparoscopic procedures.

FIG. **5**A illustrates a surgical bed with a rounded track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention. As shown in the isometric view **500** of the robotic system **501**, the system **501** comprises of a surgical bed **502**, a rail **503** (or "track") for mechanical arms **504**, **505**, **506**, a support stand **507**, and a system base **508**. The surgical bed **502** may be configured to translate horizontally to position a patient relative to mechanical arms **504**, **505**, **506**.

Encircling the surgical bed **502**, the rail **503** provides a structure to slidingly translate the mechanical arms **504**, **505**, **506** to a desired location around the surgical bed **502**. The rail **503**, which may be referred to as a "track", and the mechanical arms **504**, **505**, **506** may be slidingly translated along it in order to facilitate access for the arms **504**, **505**, **506**. The rail **503** also provides allows for the conveyance and reception of power, controls, fluidics, aspiration to the mechanical arms **504**, **505**, **506**.

The mechanical arms **504**, **505**, **506** may be operatively coupled to the rail **503**. The mechanical arms **504**, **505**, **506** may also be robotic. The translation of the mechanical arms **504**, **505**, **506** may be actuated either manually or robotically. The mechanical arms **504**, **505**, **506** may be coupled independently to the rail **503** or individually or in groups via mechanical carriages that may slide around the rail **503**. In addition to providing structural support to the mechanical arms **504**, **505**, **506** a carriage may be used to convey and receive power, controls, fluidics, and aspiration to and from the arms **504**, **505**, **506** to the rail **503**. The ability to translate the arms **504**, **505**, **506** and translate the bed **502** allows for nearly unlimited access to different portions of the anatomy of a patient.

In combination or individually, the support stand **507** and the system base **508** may be used to house electronics, fluidics, pneumatics, and aspiration. The electronics may be used from control, localization, navigation of the arms **504**, **505**, **506**. Thus, as a robotically-driven platform, system **501** provides for a comprehensive surgical bed and tool solution that may be used to perform any number of procedures around a patient. The support stand **507** may also translate vertically, allowing for easier access to the patient and operative site.

As deployed in view **500**, mechanical arms **504**, **505**, **506** may be positioned to access the abdomen of patient for laparoscopic procedures, while the carriages on the other side of rail **503** may be positioned to hold mechanical arms to create a virtual rail for access points in the lower abdomen (e.g., urology, ureteroscopy, or hysteroscopy).

FIG. **5**B illustrates the surgical bed with a rounded track from FIG. **5**A, consistent with an embodiment of the present invention. Reverse isometric view **509** provides a different perspective of the robotic system **501**, surgical bed **502**, rail **503** (or "track") for mechanical arms **504**, **505**, **506** a support stand **507**, and a system base **508**.

FIG. **5**C illustrates the surgical bed with a rounded track from FIGS. **5**A, **5**B, consistent with an embodiment of the present invention. Rear view **510** provides a different perspective of the robotic system **501**, surgical bed **502**, rail **503** (or "track") for mechanical arms **504**, **505**, **506**, support stand **507**, and a system base **508**.

FIG. **5**D illustrates several views of carriages for mechanical arms used in system **501** from FIGS. **5**A, **5**B, **5**C, consistent with an embodiment of the present invention. Side views **511**, **512**, **513** provide different perspectives on a mechanically-driven carriage in system **501**.

FIG. **5**E illustrates the surgical bed with a rounded track from FIG. **5**A, consistent with an embodiment of the present invention. View **514** provides a different perspective of the robotic system **501**, surgical bed **502**, rail **503** (or "track"), support stand **507**, and system base **508**, absent mechanical arms **504**, **505**, **506**.

FIG. **6**A illustrates a surgical bed with a rounded track for robotic arms along the edge of the bed, consistent with an embodiment of the present invention. As shown in the view **600**, the system **601** comprises of a surgical bed **602**, a rail **603** (or "track") for mechanical arms **604**, **605**. The surgical bed **602** may be configured to translate horizontally to position a patient relative to mechanical arms **604**, **605**. The surgical bed **602** allows for a hinge **606** such that a portion **607** of surgical bed **602** may be declined at a different angle from the rest of the bed **602**. As discussed earlier, this may be desirable for certain operations, such as when performing a procedure that requires access a patient's lower abdomen, such as ureteroscopy, hysteroscopy, or colonoscopy.

Underneath the surgical bed **602**, the rail **603** provides a structure to slidingly translate the mechanical arms **604**, **605** to a desired location around the surgical bed **602**. The rail **603**, which may be referred to as a "track", and the mechanical arms **604**, **605** may be slidingly translated along it in order to facilitate access for the arms **604**, **605**. The rail **603** also provides allows for the conveyance and reception of power, controls, fluidics, aspiration to the mechanical arms **604**, **605**. As shown in FIG. **6**A, there may be a shorter leg and longer leg portion of the U-shape rail **603**. In some embodiments, the rail **603** may be fully circular, rather than a U-shaped.

The mechanical arms **604**, **605** may be operatively coupled to the rail **603**. The mechanical arms **604**, **605** may also be robotic. The translation of the mechanical arms **604**, **605** may be actuated either manually or robotically. The mechanical arms **604**, **605** may be coupled independently to the rail **603** or individually or in groups (as shown) via a mechanical carriage **608** that may slide around the rail **603**. In addition to providing structural support to the mechanical arms **604**, **605**, the carriage **606** may be used to convey and receive power, controls, fluidics, and aspiration to and from the arms **604**, **605** to the rail **603**. The ability to translate the arms **604**, **605** and translate the bed **602** allows for nearly unlimited access to different portions of the anatomy of a patient.

Not shown, system **601** may also incorporate a support stand and the system base to house electronics, fluidics, pneumatics, and aspiration. The electronics may be used from control, localization, navigation of the arms **604**, **605**. Thus, as a robotically-driven platform, system **601** provides for a comprehensive surgical bed and tool solution that may be used to perform any number of procedures around a patient. The support stand may also translate vertically, allowing for easier access to the patient and operative site. The support stand may also support vertical translation of the rail **603** in order to facilitate access to particular anatomical access points.

As deployed in view **600**, mechanical arms **604**, **605** on carriage **608** may be positioned to access the abdomen of patient for procedures, such as laparoscopy or endoscopy, while a carriage **609** on the other side of rail **603** may be positioned to hold additional mechanical arms.

FIG. **6**B illustrates the surgical bed with a rounded track from FIG. **6**A. As shown in the view **610**, mechanical arms **604**, **605** on carriage **608** may be slidingly translated to the long side of the rail **603**. View **610** also provides a view of a support base. As deployed in view **610**, mechanical arms **604**, **605** on carriage **608** may be positioned to form a virtual rail for access to the anatomical lumens in the lower abdomen for various procedures, such as ureteroscopy, hysteroscopy, or colonoscopy. To facilitate access surgical bed **602** has been slidingly translated forwards from the rail **603**.

FIG. **7**A illustrates a surgical bed with a rounded track for robotic arms underneath the edge of the bed, consistent with an embodiment of the present invention. As shown in the view **700**, the system **701** comprises of a surgical bed **702**, a rail **703** (or "track") for mechanical arms **704**, **705**, **706**, **708**. The surgical bed **702** may be configured to translate horizontally to position patient **709** relative to mechanical arms **704**, **705**, **706**, **708**. The surgical bed **702** may include a hinge such that the lower portion of surgical bed **702** may be declined at a different angle from the rest of the bed **702**. As discussed earlier, this may be desirable for certain operations, such as when performing a procedure that requires access a patient's lower abdomen, such as ureteroscopy, hysteroscopy, or colonoscopy.

Underneath the surgical bed **702**, the rail **703** provides a structure to slidingly translate the mechanical arms **704**, **705**, **706**, **708** to a desired location around the surgical bed **702**. The rail **703**, which may be referred to as a "track" and the mechanical arms **704**, **705** may be slidingly translated along it in order to facilitate access for the arms **704**, **705**, **706**, **708**. The rail **703** also provides allows for the conveyance and reception of power, controls, fluidics, aspiration to the mechanical arms **704**, **705**, **706**, **708**.

The mechanical arms **704**, **705**, **706**, **708** may be operatively coupled to the rail **703**. The mechanical arms **704**, **705**, **706**, **708** may also be robotic. The translation of the mechanical arms **704**, **705**, **706**, **708** may be actuated either manually or robotically. The mechanical arms **704**, **705**, **706**, **708** may be coupled independently to the rail **703** or individually or in groups via a mechanical carriage that may slide around the rail **703**. In addition to providing structural support to the mechanical arms **704**, **705**, **706**, **708**, the carriage may be used to convey and receive power, controls, fluidics, and aspiration to and from the arms **704**, **705**, **706**, **708** to the rail **703**. The ability to translate the arms **704**, **705**, **706**, **708** and translate the bed **702** allows for nearly unlimited access to different portions of the anatomy of a patient.

System **701** may also incorporate support stand **710** and system base **711** to house electronics, fluidics, pneumatics, and aspiration. The electronics may be used from control, localization, navigation of the arms **704**, **705**, **706**, **708**. Thus, as a robotically-driven platform, system **701** provides for a comprehensive surgical bed and tool solution that may be used to perform any number of procedures around a patient. The rail **703** on support stand **710** may also translate vertically, allowing for easier access to the patient and operative site. The support stand may also telescope.

As deployed in view **700**, mechanical arms **704**, **705**, **706**, **708** may be positioned to access the abdomen of patient **709** for laparoscopic procedures, using a variety of rigid or semi-rigid laparoscopic instruments.

FIG. **7**B illustrates the underside of the surgical bed with a rounded track from FIG. **7**A. As shown in the view **712**, mechanical arms **704**, **705**, **706**, **708** may be coupled to the rail **703** using carriages **713** and **714**, which may be slidingly translated along rail **703**. Carriages **713** and **714** may be oriented at various angles from rail **703** to provide an additional access to the patient **709**. View **712** also provides a view of a support base **709** which shows structures to vertically translate rail **703** and bed **702**.

FIG. **7**C illustrates the surgical bed with a rounded track from FIGS. **7**A, **7**B. As shown in side view **715**, carriages **713** and **714** may be positioned along rail **703** such that mechanical arms **704**, **705**, **706**, **708** may be arranged to form a virtual rail to guide an endoscopic device **716** into an anatomical lumen in the lower abdomen of patient **709** for a procedure such as ureteroscopy, hysteroscopy, or colonoscopy.

FIG. **7**D illustrates the surgical bed with a rounded track from FIGS. **7**A, **7**B, **7**C. Top view **717** provides a different perspective of the positioning of mechanical arms **704**, **705**, **706**, **708** to form a virtual rail to guide an endoscopic device **716** into an anatomical lumen in the lower abdomen of patient **709** for a procedure such as ureteroscopy, hysteroscopy, or colonoscopy.

FIG. **7**E illustrates the surgical bed with a rounded track from FIG. **7**C. Isometric view **718** provides an alternative positioning of mechanical arms **704**, **705**, **706**, **708** to form a virtual rail to guide an endoscopic device **714** into an anatomical lumen in the lower abdomen of patient **709** for a procedure such as ureteroscopy, hysteroscopy, or colonoscopy. In view **717**, the carriages **713** and **714** may be oriented below rail **703** to position mechanical arms **704**, **705**, **706**, **708** such that the virtual rail is positioned lower than shown in FIGS. **7**C and **7**D.

FIG. **7**F illustrates the surgical bed with a rounded track from FIG. **7**E. Side view **719** provides a different perspective of the positioning of carriages **713** and **714** such that mechanical arms **704**, **705**, **706**, **708** form a virtual rail to guide an endoscopic device **716** into an anatomical lumen in the lower abdomen of patient **709** for a procedure such as ureteroscopy, hysteroscopy, or colonoscopy.

FIG. **7**G illustrates the surgical bed with a rounded track from FIGS. **7**A-**7**F. View **719** shows stowage of mechanical arms **704**, **705**, **706**, **708** through positioning of carriages **713** and **714** together along rail **703** under surgical bed **702**.

FIGS. **8**A and **8**B illustrate a surgical bed with a rounded track for robotic arms underneath the edge of the bed, consistent with an embodiment of the present invention. As shown in the view **800**, the system **801** comprises of a surgical bed **802**, a rail **803** (or "track") for mechanical arms, such as **804**, **805**. The surgical bed **802** may be configured to translate horizontally to position a patient relative to the mechanical arms. As shown in view **807** from FIG. **8**B, the surgical bed **802** may tilted on the support stand **806** to improve physician access to the patient.

Underneath the surgical bed **802**, the rail **803** provides a structure to slidingly translate the mechanical arms **804**, **805** to a desired location around the surgical bed **802**. The rail **803**, which may be referred to as a "track", and the mechanical arms **804**, **805** may be slidingly translated along it in order to facilitate access for the arms. The rail **803** also provides allows for the conveyance and reception of power, controls, fluidics, aspiration to the mechanical arms.

The mechanical arms may be operatively coupled to the rail **803**. The mechanical arms may also be robotic. The translation of the mechanical arms **804**, **805** may be actuated either manually or robotically. The mechanical arms **804**, **805** may be coupled independently to the rail **803** or individually or in groups via a mechanical carriage that may slide around the rail **803**. In addition to providing structural support to the mechanical arms **804**, **805** the carriage may be used to convey and receive power, controls, fluidics, aspiration to and from the arms **804**, **805** to the support base **806**. The ability to translate the arms **804**, **805** and translate the bed **802** allows for nearly unlimited access to different portions of the anatomy of a patient.

System **801** may also incorporate support stand **806** to house electronics, fluidics, pneumatics, and aspiration. The electronics may be used from control, localization, navigation of the arms **804**, **805**. Thus, as a robotically-driven platform, system **801** provides for a comprehensive surgical bed and tool solution that may be used to perform any number of procedures around a patient. The rail **803** on support stand **806** may also translate vertically, allowing for easier access to the patient and operative site. The support stand may also telescope.

As deployed in view **800**, mechanical arms **804**, **805** may be positioned to access the abdomen of a patient for laparoscopic procedures, using a variety of rigid or semi-rigid laparoscopic instruments.

The aforementioned embodiments of the present invention may be designed to interface with robotics instrument device manipulators, tools, hardware, and software such as those disclosed in the aforementioned patent applications that are incorporated by reference. For example, the embodiments in this specification may be configured to be driven by an instrument drive mechanism or an instrument device manipulator that is attached to the distal end of a robotic arm through a sterile interface, such as a drape. As part of a larger robotics system, robotic control signals may be communicated from a remotely-located user interface, down the robotic arm, and to the instrument device manipulator to control the instrument or tool.

For purposes of comparing various embodiments, certain aspects and advantages of these embodiments are described. Not necessarily all such aspects or advantages are achieved by any particular embodiment. Thus, for example, various embodiments may be carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other aspects or advantages as may also be taught or suggested herein.

Elements or components shown with any embodiment herein are exemplary for the specific embodiment and may be used on or in combination with other embodiments disclosed herein. While the invention is susceptible to various modifications and alternative forms, specific examples thereof have been shown in the drawings and are herein described in detail. The invention is not limited, however, to the particular forms or methods disclosed, but to the contrary, covers all modifications, equivalents and alternatives thereof.

What is claimed is:

**1**. A medical system comprising:

a base;

a stand coupled to the base;

a bed supported by the stand, the bed having a first edge and a second edge, the first edge being longer than the second edge;

a first rail portion extending along of the first edge of the bed;

at least one arm attached to the first rail portion; and

control electronics configured to (i) stow the at least one arm by moving the at least one arm towards the second edge and beneath the bed supported by the stand, wherein the at least one arm is stowed within a perimeter defined by the bed when viewed from above, and (ii) raise the at least one arm over the first edge to perform a medical procedure.

**2**. The medical system of claim **1**, further comprising a second rail portion extending along a length of the bed and at least one arm attached to the second rail portion.

**3**. The medical system of claim **1**, wherein the bed is configured to translate horizontally relative to the first rail portion.

**4**. The medical system of claim **1**, wherein the bed comprises a hinge such that a lower portion of the bed can be declined at a different angle from remaining portions of the bed.

**5**. The medical system of claim **1**, wherein the control electronics are configured to stow the at least one arm by slidingly translating the at least one arm along the first rail portion toward the second edge.

**6**. The medical system of claim **1**, wherein the at least one arm attached to the first rail portion comprises two arms forming a virtual rail to guide an endoscopic device.

**7**. The medical system of claim **1**, further comprising a second rail portion extending along a third edge of the bed opposite the first edge, and at least one arm attached to the second rail portion, wherein the control electronics are further configured to control the at least one arm attached to the first rail portion and the at least one arm attached to the second rail portion to extend upwardly over the opposing first and third edges of the bed to perform the medical procedure.

**8**. The medical system of claim **1**, further comprising:

a second rail portion extending along a length of the bed; and

at least two arms attached to the second rail portion.

**9**. The medical system of claim **1**, wherein the at least one arm attached to the first rail portion comprises at least two arms, and wherein the control electronics are configured to stow the at least two arms by moving the at least two arms together towards the second edge and beneath the bed.

**10**. The medical system of claim **1**, wherein the bed has a longitudinal centerline bisecting the second edge, and wherein the control electronics are configured to stow the at least one arm in a position overlapping the longitudinal centerline and between the second edge and the stand.

**11**. A medical system comprising:

a base;

a stand coupled to the base;

a bed supported by the stand, the bed having a substantially rectangular shape defining a longitudinal centerline extending over the stand;

first and second rail portions extending along the bed on opposing sides of the stand;

a first arm attached to the first rail portion;

a second arm attached to the second rail portion; and

control electronics configured to (i) stow the first arm and the second arm by moving the first arm and the second arm to positions beneath the bed with the first arm overlapping the longitudinal centerline, wherein the first arm and the second arm are stowed within a perimeter defined by the bed when viewed from above, and (ii) raise the first arm and the second arm over the bed to perform a medical procedure.

**12**. The medical system of claim **11**, wherein the first arm and the second arm are each capable of robotic control.

**13**. The medical system of claim **11**, wherein the first rail portion and the second rail portion are capable of vertical translation.

**14**. The medical system of claim **11**, further comprising:

a third arm attached to the first portion,

wherein the first and third arms form a virtual rail to guide an endoscopic device into an anatomical lumen.

**15**. The medical system of claim **14**, wherein the endoscopic device is a tool used for ureteroscopy, hysteroscopy or colonoscopy.

**16**. The medical system of claim **11**, wherein the first arm is coupled to a carriage that translates along the first rail portion.

**17**. The medical system of claim **11**, wherein the first arm and the second arm are capable of extending upwardly over opposing sides of the bed.

**18**. The medical system of claim **11**, further comprising:

a third arm attached to the first rail portion; and

a fourth arm attached to the second rail portion,

wherein the first to fourth arms are capable of manual and robotic control.

**19**. A medical system comprising:

a base;

a stand coupled to the base;

a bed supported by the stand;

a rail extending along the bed;

a first arm attached to the rail;

a second arm attached to the rail; and

control electronics configured to:

drive the first and second arms to move to a first configuration in which the first and second arms are positioned together along the rail for stowage, wherein the first arm and the second arm are stowed within a perimeter defined by the bed when viewed from above, and

drive the first and second arms to move to a second configuration in which the first and second arms are spaced apart along the rail to perform a medical procedure.

**20**. The medical system of claim **19**, further comprising:

a first carriage supporting the first arm and slidingly attached to the rail portion; and

a second carriage supporting the second arm and slidingly attached to the rail portion,

wherein control electronics are further configured to:

drive the first and second carriages to slidingly translate to a position together on the rail portion to stow the first and second arms beneath the bed, and

drive the first and second carriages to slidingly translate to a position spaced apart on the rail portion to position the first and second arms for the medical procedure.

**21**. The medical system of claim **19**, wherein the control electronics are further configured to:

drive first and second carriages to slidingly translate towards an end of the bed to stow the first and second arms beneath the bed, and

drive the first and second carriages to slidingly translate along a longitudinal side of the bed to perform the medical procedure.

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| 专利名称(译) | 带有可配置导轨式机械臂的手术系统 | | |
| 公开(公告)号 | US10702348 | 公开(公告)日 | 2020-07-07 |
| 申请号 | US16/195206 | 申请日 | 2018-11-19 |
| [标]发明人 | MOLL FREDERIC H<br>YU ALAN LAU | | |
| 发明人 | MOLL, FREDERIC H.<br>YU, ALAN LAU | | |
| IPC分类号 | A61B34/20 A61B1/00 A61B90/50 A61G13/04 A61B34/00 A61B34/30 A61G13/06 A61G13/10 A61B50/10 A61B90/57 A61B1/313 A61B1/267 A61B1/31 A61B1/303 A61B1/307 A61B1/273 | | |
| CPC分类号 | A61B1/00149 A61B90/50 A61G13/10 A61B34/20 A61B50/10 A61B34/30 A61G13/06 A61G13/04 A61B34/00 A61G13/101 A61B1/303 A61B1/2676 A61B2090/571 A61B2034/304 A61B1/307 A61B1/3132 A61B1/31 A61B1/2736 | | |
| 优先权 | 62/145418 2015-04-09 US | | |
| 其他公开文献 | US20190083183A1 | | |


摘要(译)

一种机器人外科手术系统,包括:水平平台,用于支撑患者;轨道,其围绕水平平台定位;滑架,其可操作地联接至该轨道并被配置为沿轨道平移;以及机器人臂,其可操作地联接至该滑架并通过该臂绕患者平移。 轨。 机械臂被配置为在由平移托架提供的各种位置上对患者进行操作。 导轨为托架提供了圆形的路径,例如U形路径。 该U形路径可包括第一支腿和第二支腿,第一支腿长于第二支腿。 此外,该系统可以包括可操作地联接到轨道的多个托架和多个机械臂。 而且,系统还可以包括中央基座,水平平台可以相对于中央基座铰接,例如通过水平或垂直平移,旋转或倾斜。