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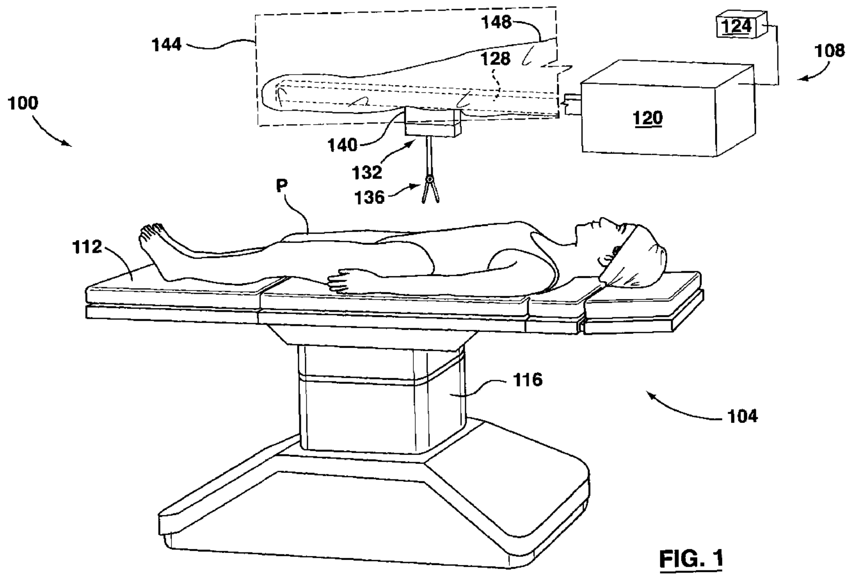


FIG. 1

(57) Abstract: A system is shown for driving a robotic instrument (132) including motion transfer mechanisms (196) both mounted on a framework or base (6), and a robotic arm (128), upon which the instrument (132) via base (6) may be detachably mounted, for linear motion there-along. The drive unit (172) for the linear motion may be situated in a housing or base (6) of the instrument (132) and the motion transfer means (196). Sterile adapters (Figure 14) are used to separate the sterile and non sterile environments during a medical operation. These adapters may include fittings for the supply of data (Figure 14), electrical energy (Figure 13) and sensor signals (Figure 12). A power pack (140) is shown in figure 4.

WO 2013/075204 A1

APPARATUS AND SYSTEMS FOR DRIVING A ROBOTIC INSTRUMENT

FIELD

[0001] The present specification here relates in general to a field of robotic instruments, and more particularly, to a robotic instrument for use in surgery.

BACKGROUND

[0002] With the gradual transition of medical surgery from the conventional process of making a long incision in the patient's body for performing a surgery to the next generation of surgery, i.e. minimal invasive surgery (MIS), continuous research is going on to develop and integrate robotic instruments in a system which can be used for MIS purposes. Such integration can help a surgeon perform a surgery in an error-free manner, and at the same time work in a realistic environment that gives the surgeon a feel of conventional surgery.

SUMMARY

[0003] In accordance with an aspect of the invention, there is provided an apparatus for driving a robotic instrument configured to perform medical procedures. The apparatus includes a housing. The apparatus also includes a first mount disposed on the housing, the second mount configured to mount the robotic instrument. The apparatus further includes a second mount disposed on the housing, the first mount configured to mount the housing on a robotic arm. Furthermore, the apparatus includes a drive unit disposed at least partially in the housing, the drive unit configured to provide a motion for driving the robotic instrument.

[0004] The apparatus may further include a motion transfer mechanism for transferring the motion provided by the drive unit to the robotic instrument.

[0005] The motion transfer mechanism may include a first rotatable member configured to mate with a second rotatable member disposed on the robotic instrument.

[0006] The first rotatable member may be configured to engage the second rotatable member coaxially.

[0007] The first rotatable member may be configured to frictionally engage the second rotatable member.

[0008] The first rotatable member may be configured to magnetically engage the second rotatable member.

[0009] The first rotatable member may be configured to engage the second rotatable member via a fluid.

[0010] The fluid may be air.

[0011] The apparatus may further include a rotatable gear configured to transfer the motion to the robotic instrument.

[0012] The rotatable gear may be configured to mate with a drive gear of the robotic instrument.

[0013] The first mount may be configured to be mounted on a barrier, the barrier configured to separate a non-sterile environment from a sterile environment.

[0014] The apparatus may be disposed in the sterile environment.

[0015] The first mount may be configured to engage an adapter having a sterile side within the sterile environment and a non-sterile side within the non-sterile environment. The sterile side may be configured to engage the second mount and the non-sterile side configured to engage the robotic arm.

[0016] The apparatus may further include an electrical connector configured to receive electrical signals.

[0017] The electrical connector may be disposed on the first mount.

[0018] The electrical signals may be for controlling the drive unit.

[0019] The electrical signals may be for transferring data.

[0020] The data may include information related to a state of the robotic instrument.

[0021] The electrical signals may be for supplying power to the drive unit.

[0022] The electrical connector may be a male connector.

[0023] The apparatus may further include an adapter. The electrical connector may be configured to connect to the adapter. The adapter may be configured to transfer electrical signals between a non-sterile environment and a sterile environment.

[0024] The second mount may be configured to releasably connect with the robotic instrument.

[0025] The apparatus may further include a second drive unit disposed in the housing, the second drive unit configured to provide a second motion for moving the apparatus along the robotic arm.

[0026] The second motion may be for driving a lead screw to move a portion of a rail system.

[0027] The apparatus may further include a second drive unit disposed in the housing, the second drive unit configured to provide a second motion for moving the robotic instrument relative to the housing.

[0028] The first mount may be configured to releasably mount on a rail system of the robotic arm.

[0029] The drive unit may be a motor.

[0030] In accordance with another aspect of the invention, there is provided a rail system for providing linear motion. The rail system includes a first portion mounted on a robotic arm. Furthermore, the rail system includes a second portion slidably connected to the first portion. In addition, the rail system includes a drive unit configured to move the first portion relative to the second portion.

[0031] The rail system may further include a third portion slidably connected to the second portion. The drive unit may be further configured to move the third portion relative to the second portion.

[0032] The drive unit may be disposed on the second portion.

[0033] The first and second portion may move in a first motion relative to each other.

[0034] The second and third portion may move in a second motion relative to each other.

[0035] The first motion and the second motion may be concurrent and opposite in direction.

[0036] The rail system may further include a trocar holder disposed on the first portion. The trocar holder may be configured to hold a portion of a trocar.

[0037] The third portion may be configured to mount a barrier. The barrier may be configured to separate a non-sterile environment from a sterile environment.

[0038] The apparatus may be disposed in the non-sterile environment.

[0039] The trocar holder may be disposed in the non-sterile environment. The trocar holder may be configured to hold a portion of a trocar piercing through the barrier.

[0040] The third portion may be configured to engage an adapter having a sterile side within a sterile environment and a non-sterile side within a non-sterile environment. The sterile side may be configured to engage a power pack and the non-sterile side configured to engage the third portion.

[0041] In accordance with another aspect of the invention, there is provided a system for driving a robotic instrument. The system includes a robotic arm. Furthermore, the system includes a barrier disposed on the robotic arm, the barrier configured to separate a non-sterile environment from a sterile environment such that the robotic arm is in the non-sterile environment. In addition, the system includes a powerpack disposed on the robotic arm such that the powerpack is in the sterile environment, the powerpack configured for driving a robotic instrument.

[0042] The powerpack may include a rotatable gear configured to transfer a motion to the robotic instrument.

[0043] The rotatable gear may be configured to mate with a drive gear of the robotic instrument.

[0044] The system may further include an adapter having a sterile side within the sterile environment and a non-sterile side within the non-sterile environment, the sterile side configured to engage the powerpack and the non-sterile side configured to engage the robotic arm.

[0045] The powerpack may include an electrical connector configured to receive electrical signals.

[0046] The electrical signals may be for controlling the drive unit.

[0047] The electrical signals may be for transferring data.

[0048] The data may include information related to a state of the robotic instrument.

[0049] The electrical signals may be for supplying power to the drive unit.

[0050] The electrical signals may be received from a signal source in the non-sterile environment.

[0051] The electrical connector may be a male connector.

[0052] The system may further include an adapter, wherein the electrical connector is configured to connect to the adapter. The adapter may be configured to transfer electrical signals between a non-sterile environment and a sterile environment.

[0053] The robotic arm may include a rail system having a first portion and a second portion. The barrier may be disposed on the second portion.

[0054] The powerpack may include a second drive unit. The second drive unit may be configured to provide a second motion for moving a first portion of the rail system relative to a second portion of the rail system.

[0055] The powerpack may be configured to releasably mount on the rail system.

[0056] The system may further include a trocar holder disposed on the rail system. The trocar holder may be configured to hold a portion of a trocar.

[0057] The trocar holder may be disposed in the non-sterile environment. The trocar holder may be configured to hold a portion of a trocar piercing through the barrier.

BRIEF DESCRIPTION OF THE DRAWINGS

[0058] Reference will now be made, by way of example only, to the accompanying drawings in which:

[0059] Figure 1 is a perspective view of an operating theater according to an embodiment;

[0060] Figure 2 is a view of a system for driving a robotic instrument in accordance with an embodiment;

[0061] Figure 3 is a view of the system for driving a robotic instrument and the robotic instrument in accordance with the embodiment of Figure 2;

[0062] Figure 4 is a perspective view of a powerpack in accordance with an embodiment;

[0063] Figure 5 is another perspective view of the powerpack in accordance with the embodiment of Figure 4;

[0064] Figure 6 is top view of the internal components of the powerpack in accordance with the embodiment of Figure 4;

[0065] Figure 7 is a view of a system for driving a robotic instrument in accordance with another embodiment;

[0066] Figure 8 is a view of the system for driving a robotic instrument and the robotic instrument in accordance with the embodiment of Figure 7;

[0067] Figure 9 is a top view of an adapter in accordance with an embodiment;

[0068] Figure 10 is a bottom view of the adapter in accordance with the embodiment of Figure 9;

[0069] Figure 11 is a perspective view of a powerpack in accordance with another embodiment;

[0070] Figure 12 is another perspective view of the powerpack in accordance with the embodiment of Figure 11;

[0071] Figure 13 is top view of the internal components of the powerpack in accordance with the embodiment of Figure 11;

[0072] Figure 14 is a top view of an adapter in accordance with another embodiment;

[0073] Figure 15 is a bottom view of the adapter in accordance with the embodiment of Figure 14;

[0074] Figure 16 is a perspective view of a rail system in accordance with an embodiment in an extended position;

[0075] Figure 17 is a perspective view of the rail system in accordance with the embodiment of Figure 16 in a retracted position;

[0076] Figure 18 is a view of a system for driving a robotic instrument in accordance with an embodiment including a trocar holder;

[0077] Figure 19 is a view of a trocar holder in accordance with an embodiment;

[0078] Figure 20 is a view of a trocar mount in accordance with an embodiment;

[0079] Figure 21 is a view of a trocar in accordance with an embodiment;

[0080] Figure 22 is a view of a trocar holder and trocar mount in accordance with another embodiment;

[0081] Figure 23 is a view of a trocar holder in accordance with yet another embodiment;

[0082] Figure 24 is a cross sectional view of a trocar mount in accordance with another embodiment showing internal components;

[0083] Figure 25 is a view of a trocar in accordance with another embodiment;

[0084] Figure 26 is a perspective view of a rail system in accordance with another embodiment in an extended position;

[0085] Figure 27 is a perspective view of the rail system in accordance with the embodiment of Figure 26 in a retracted position;

[0086] Figure 28 is a view of a system for driving a robotic instrument in accordance with another embodiment;

[0087] Figure 29 is a view of the system for driving a robotic instrument and the robotic instrument in accordance with the embodiment of Figure 28;

[0088] Figure 30 is a view of a motion transfer mechanism in accordance with an embodiment;

[0089] Figure 31 is a view of a motion transfer mechanism in accordance with another embodiment;

[0090] Figure 32 is a view of a rotatable member of the motion transfer mechanism in accordance the embodiment of Figure 31;

[0091] Figure 33 is a view of another rotatable member of the motion transfer mechanism in accordance the embodiment of Figure 31;

[0092] Figure 34 is a view of a motion transfer mechanism in accordance with yet another embodiment; and

[0093] Figure 35 is a perspective view of a powerpack in accordance with yet another embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0094] Referring to Figure 1, a schematic representation of an operating theater in a sterile environment for medical procedures such as Minimal Invasive Surgery (MIS) is shown at 100. It is to be understood that the operating theater 100 is purely exemplary and it will be apparent to those skilled in the art that a variety of operating theaters are contemplated. The operating theater 100 includes a surgical table 104 and a surgical system 108. The surgical table 104 includes a surface 112 supported by a base 116. It is to be understood that the surgical table 104 is not particularly limited to any particular structural configuration. A patient P rests on the surface 112. The surgical system 108 includes a base unit 120, an input device 124, at least one robotic instrument 132, and a system 144 for driving the robotic instrument 132.

[0095] In a present embodiment, the base unit 120 is generally configured to support and control the system 144 in response to the input control signals from input device 124 under the control of a surgeon or other medical professional. In terms of providing physical support, the base unit 120 is mechanically structured to support the system 144, and the robotic instrument 132, and their associated movement. For example, the base unit 120 can be bolted to a fixed structure such as a wall, floor, or ceiling. Alternatively, the base unit 120 can have a mass and a geometry such that when the base unit 120 is free-standing, it will support the system 144 and the robotic instrument 132. In some embodiments, the base unit 120 can include a moveable cart to provide easy movement of the base unit 120 around the operating theater 100. In terms of providing control, the base unit 120 can include mechanical controls (not shown), or electrical controls (not shown), or both. For example, mechanical controls can include gears, cables or other motion transfer mechanisms (not shown) connected to a motor for moving a robotic arm 128 of the system 144. Other mechanical controls can also involve hydraulics. In some embodiments, the base unit 120 can be further configured to supply electrical signals to a powerpack 140 of the system 144.

[0096] Referring again to Figure 1, the system 144 includes the robotic arm 128, a barrier 148, and the powerpack 140. The system is generally configured to support the robotic instrument 132 physically. In terms of providing physical support, the system 144 is mechanically structured to support the robotic instrument 132 and its associated movements. For example, the robotic arm 128 can be constructed from materials such that the robotic arm 128 is rigid enough to be suspended above the patient P. In addition, the system 144 can be configured so that robotic instrument 132 is positionable in relation to the base unit 120 and surface 112. For example, the robotic arm 128 can include a moveable joint (not shown) for providing a pivotal degree of freedom. In other examples, the robotic arm 128 can include a rail system for linear movement of the robotic instrument 132. It will now be understood that the movement of the robotic arm 128 can be controlled by the base unit 120 through various controls described above.

[0097] In general terms, the system 144 and the robotic instrument 132 are generally configured for performing MIS responsive to inputs from the input device 124 mediated by the base unit 120, and the system 144. However, it is to be re-emphasized that the structure shown in Figure 1 is a schematic, non-limiting representation only. For example, although only one system 144 is shown in Figure 1, it is to be understood that the surgical system 108 can be modified to include a plurality of systems 144, each system 144 having its own separate robotic arm 128, separate barrier 148 and separate powerpack 140 for supporting separate robotic instruments 132. Furthermore, it is also to be understood that where the surgical system 108 includes a plurality of systems 144 and robotic instruments 132, each system 144 or robotic instrument 132 can have different structures. Indeed, different configurations are contemplated herein.

[0098] In use, the system 144 drives the robotic instrument 132. Driving the robotic instrument 132 involves providing a motion to move an end-effector assembly 136 of the robotic instrument 132 in accordance with at least one degree of freedom. A degree of freedom refers to an ability of the end-effector assembly 136 to move according to a specific motion. For example, a degree of freedom can include a rotation of the end-effector assembly 136 or a component thereof about a single axis. Therefore, for each axis of rotation, the end-effector assembly 136 is said to have a unique degree of freedom. Another example of a degree of freedom can include a translational movement along a path. It will now be apparent that each additional degree of freedom increases the versatility of the end-effector assembly 136. By providing more degrees of freedom, it will be possible to position the end-effector assembly 136 in a wider variety of positions or locations to reach around obstacles.

[0099] Referring to Figure 2, an embodiment of the system 144 for driving the robotic instrument 132 is shown. It is to be understood that the system 144 is purely exemplary and it will be apparent to those skilled in the art that a variety of systems for driving robotic instruments are contemplated including other embodiments discussed in greater detail below. The system 144 includes a robotic arm 128, a barrier 148, and a powerpack 140 connected to the robotic arm through the barrier.

[00100] In the present embodiment, the robotic arm 128 of the system 144 is generally configured to support the robotic instrument 132 and can include many configurations. As discussed above, the robotic arm 128 is mechanically structured to support itself, the powerpack 140, the robotic instrument 132, and their associated movements. Some examples of suitable materials from which the robotic arm 128 is constructed include steel, titanium, plastics, composites and other materials commonly used to provide structural support. In addition, the robotic arm 128 can be configured so that the robotic instrument 132 and the system 144 are positionable in relation to the base unit 120 and the surface 112. In the present embodiment, the powerpack 140 is mounted to the robotic arm 128. In other embodiments, the robotic arm 128 can include a slidable connection mechanism or a rotatable joint to provide additional degrees of freedom to position the system 144 and the robotic instrument 132.

[00101] Referring to Figure 3, a robotic instrument 132 is shown connected to the powerpack 140 of the system 144. The barrier 148 extends around the robotic arm 128 and is generally configured to separate a first environment 152 from a second environment 156. In the present embodiment, the robotic arm 128 is disposed in the first environment 152 while the powerpack 140 and the robotic instrument 132 are disposed in the second environment 156. Furthermore, in the present embodiment, the first environment 152 is non-sterile, and the second environment 156 is sterile. In other embodiments, the robotic arm 128 can also be at least partially located in a sterile environment such that the barrier 148 is used to prevent potential contamination of the robotic arm 128 from the surgery. However, it is to be appreciated that in order to perform surgery and to reduce the risk of infection or other adverse side effects to the patient P, the second environment 156 should be sterile. By creating the separate first environment 152 for the robotic arm 128, the robotic arm and other equipment in the first environment 152 are easier to maintain because they would not need to be sterilized before each surgery. It is to be understood that the barrier 148 is not particularly limited to any material and that several different types of materials are contemplated. The barrier 148 is typically manufactured from materials which are flexible and sterilizable or disposable such that the barrier 148 can be shipped in a sterilized state for one-time use. Some examples of suitable materials include plastic, cloth, composites, laminates and other materials commonly used in surgical operating theatres to establish and maintain a sterile field. The exact configuration of the barrier 148 is not particularly limited. In the present embodiment, the barrier 148 is a loose covering that permits the powerpack 140 to be mounted on the robotic arm 128 through the barrier. In other embodiments, the barrier 148 can be an elastic fitted covering such that the barrier does not loosely hang. It is to be appreciated that an advantage of using a barrier that is tightly fitted to the robotic arm 128 is that the probability of having the barrier interfere with the surgery or become caught in a moving part is reduced.

[00102] Referring to Figures 4 to 6, an embodiment of the powerpack 140 is shown. The powerpack 140 is an apparatus generally configured to drive the robotic instrument 132 and can include many configurations. In the present embodiment, the powerpack 140 includes a housing 160, a first mount 164, a second mount 168 and a drive mechanism 172. Referring back to Figure 3, in the present embodiment, the powerpack 140 is disposed in the second environment 156, which is sterile. It is to be understood that the powerpack 140, including its components such as the housing 160, the first mount 164, the second mount 168 and the drive mechanism 172, is not particularly limited to any material and that several different types of materials are contemplated. Because the powerpack 140 should be sterile during surgery, the powerpack is typically constructed from materials which can withstand the harsh conditions of a sterilization process carried out prior to an actual surgery. Some examples of suitable materials include stainless steel, such as surgical stainless steel, titanium, plastics, composites and other materials commonly used in surgical instruments. Furthermore, different components in the powerpack 140 can comprise different materials. In addition, individual components can also include more than one type of material. For example, the drive mechanism 172 can be an electric motor, which typically includes some steel components as well as some plastic components, which are both sterilizable.

[00103] The housing 160 of the present embodiment is shown in Figures 4 to 6. In the present embodiment, the housing 160 is substantially shaped like a rectangular box and is generally configured to house the drive mechanism 172. It is to be understood that in other embodiments, the drive mechanism 172 can be modified such that it is only partially housed within the housing 160. For example, the drive mechanism 172 can be modified such that a portion of the drive mechanism 172 extends from the housing to facilitate an electrical connection and/or a mechanical connection. The housing 160 can also serve to protect the internal components of the powerpack 140 from physical damage. In the present embodiment, the housing 160 includes at least one opening. However, in other embodiments, the housing can be sealed to provide a separate environment for the internal components such that the internal components do not need to be sterilized.

[00104] The first mount 164 of the present embodiment is shown in Figure 4. In the present embodiment, the first mount 164 is a clip extending from a side of the housing 160. The first mount 164 is generally configured to mount the robotic instrument 132. As shown in Figure 3, in the present embodiment, a first surface 133 of the robotic instrument 132 is configured to engage with a surface 165 of the powerpack 140. The first mount 164 extends to a second surface 134 of the robotic instrument 132, which is opposite the first surface 133, to hold the robotic instrument against the surface 165 of the powerpack 140 (surface 165 shown in Figure 3). In addition, as shown in Figure 4, the surface 165 of the powerpack 140 is slightly recessed. Therefore, the robotic instrument 132 can be positioned in the recess to provide for better mounting. Furthermore, it will now be appreciated that the present embodiment allows the robotic instrument to be easily released from the first mount 164. By releasably mounting the robotic instrument 132, the first mount 164 allows for quick and efficient interchangeability of the robotic instrument 132 if desired. The exact configuration of the first mount 164 is not particularly limited. In the present embodiment shown in Figures 2-3, the first mount 164 is a clip as described above. In other embodiments, the first mount 164 can include other mounting mechanisms. For example, the first mount 164 can be modified to be a magnet configured to mate with a magnetic portion on the robotic instrument 132. In another example, the first mount 164 can be modified to be holes for receiving bolts or ball locking pins from the robotic instrument 132. In another example, the first mount 164 can be modified to be a more permanent mount, such as a plurality of rivets, for applications where it is desirable to have the robotic instrument 132 more securely mounted on the powerpack 140.

[00105] The second mount 168 of the present embodiment is shown in Figure 5. In the present embodiment, the second mount 168 includes holes to receive a bolt on a side of the housing 160 that is configured to be mounted to the robotic arm 128. The second mount 168 is generally configured to mate with a mounting mechanism (not shown) on the robotic arm 128 and is not particularly limited. In other embodiments, the second mount 168 can be modified to include other mounting mechanisms. For example, the second mount 168 can be modified to be a magnet configured to mate with a magnetic portion on the robotic arm 128, pegs or pins for locking the powerpack 140 on the robotic arm 128, clips to clip onto the robotic arm 128, or combinations thereof. Furthermore, since the powerpack 140 is generally disposed in the second environment 156, which is sterile, it can be advantageous to modify the second mount 168 to be releasably mounted on the robotic arm. For example, the second mount 168 can be modified to be a pin with a ball lock mechanism for quick attachment and release from the robotic arm. In another example, the second mount 168 can be modified to be a pin configured to engage a latch. In addition, the second mount 168 of the present embodiment is configured to mount the powerpack 140 on the barrier 148 such that the mounting mechanism on the robotic arm 128 can penetrate the barrier 148 in the present embodiment. In other embodiments, the second mount 168 may include a mounting boss and/or a mounting clip (not shown) to releasably mount the powerpack 140 to the robotic arm 128. In further embodiments, the barrier 148 can be modified to allow for the powerpack 140 to be mounted without penetration. In further embodiments, the barrier 148 can be modified to have a hole to match a footprint of the powerpack 140 such that the powerpack is directly mounted on the robotic arm 128. In embodiments where the barrier includes the hole, it is preferable for the barrier 148 to be sealed against either a portion of the robotic arm 128 or the powerpack 140 such that the first environment 152 and the second environment 156 remain sufficiently separated.

[00106] The drive mechanism 172 of the present embodiment is shown in Figure 6. In the present embodiment, the drive mechanism 172 is an electric motor. The drive mechanism is generally configured to provide a motion for driving the robotic instrument 132. In the present embodiment, the drive mechanism 172 moves a motion transfer mechanism 196. The motion transfer mechanism 196 is generally configured to mate with a corresponding mechanism (not shown) of the robotic instrument 132. In particular in the present embodiment, the motion transfer mechanism 196 is a rotatable gear configured to transfer the motion from the drive mechanism 172 to the robotic instrument 132. The motion transfer mechanism 196 is configured to mate with a drive gear (not shown) on the robotic instrument 132. In other embodiments, such as an embodiment where the drive mechanism 172 is directly connected to the robotic instrument, the motion can be directly transferred. The drive mechanism 172 is not particularly limited. As mentioned above, the present embodiment shown in Figure 6, the drive mechanism 172 is an electric motor. In other embodiments, the drive mechanism 172 can be modified to be a hydraulic mechanism, a pneumatic mechanism, magnetic actuators or a piezoelectric motor.

[00107] It is to be re-emphasized that the powerpack 140 shown in Figures 4 to 6 is a schematic, non-limiting representation only. For example, although only one drive mechanism 172 and motion transfer mechanism 196 is shown in Figure 6, it is to be understood that the powerpack 140 can be modified to include a plurality of drive mechanisms 172, each system 172 having its own separate motion transfer mechanism 196. Each additional drive mechanism provides an additional degree of freedom for the robotic instrument 132. Furthermore, it is also to be understood that where the powerpack 140 includes a plurality of drive mechanisms 172, each drive mechanism 172 can be modified to have different structures or of different types.

[00108] In operation, referring back to the embodiment shown in Figures 4 to 6 the powerpack 140 of the system 144 is for driving the robotic instrument 132. In the present embodiment, the system 144 is ultimately controlled by the base unit 120. In particular, the powerpack 140 is controlled to drive the robotic instrument 132 causing specific motions of the end-effector assembly 136. The method of controlling the powerpack 140 is not particularly limited. For example, the powerpack 140 can be controlled using electrical signals through a wired connection or electromagnetic signals wirelessly received through an antenna or photo sensor.

[00109] In general terms, the system 144 is configured to drive the robotic instrument 132 by providing the motion for driving the robotic instrument 132 in the second environment 156 and

proximate to the robotic instrument. It will now be appreciated, with the benefit of this specification that fewer motion transfer mechanisms would be required than if the motion were to be provided commencing and extending from the base unit 120. By reducing the amount of motion transfer mechanisms, such as cables, fewer moving parts would need to be serviced over the life of the surgical system 108. It is to be re-emphasized that the system 144 shown in Figures 2 to 6 is a non-limiting representation only. Notwithstanding the specific example, it is to be understood that other equivalent structures and motion transfer mechanisms can be devised to perform the same function as the system 144. For example, the drive mechanism 172 can be modified to provide a motion that is not rotational, such as a linear motion.

[00110] Referring to Figures 7 and 8, another embodiment of a system for driving a robotic instrument 132a is shown generally at 144a. Like components of the system 144a bear like reference to their counterparts in the system 144, except followed by the suffix "a". The system 144a includes a robotic arm 128a, an adapter 200a, a barrier 148a, and a powerpack 140a. The barrier 148a extends from the adapter 200a.

[00111] In the present embodiment, the robotic arm 128a of the system 144a is similar to the robotic arm 128 and is generally configured to support the system 144a and the robotic instrument 132a as shown in Figure 8. In particular, the robotic arm 128a is mechanically structured to support itself, the adapter 200a, the powerpack 140a, the robotic instrument 132a, and their associated movements. The materials from which the robotic arm 128a can be constructed are not particularly limited to any material and that several different types of materials are contemplated such as those contemplated for the robotic arm 128. In the present embodiment, the adapter 200a is mounted to the robotic arm 128a. In another embodiment, the adapter 200a can be modified to include a pin configured to engage a latch for mounting the powerpack 140a or the robotic arm 128a. In other embodiments, the robotic arm 128a can include a slidable connection mechanism or a rotatable joint to provide other types of movements to position the powerpack 140a and the robotic instrument 132a, which both are ultimately connected to the robotic arm 128a through the adapter 200a.

[00112] Referring to Figures 9 and 10, in the present embodiment, the adapter 200a is generally configured to facilitate mounting the powerpack 140a on the robotic arm 128a. Therefore, the adapter 200a includes a plurality of holes 209a configured to allow for the powerpack 140a to be mounted on the robotic arm 128a through the holes 209a. In other embodiments, the adapter 200a may include a mounting boss and/or a mounting clip (not shown) to releasably mount the powerpack 140a to the robotic arm 128a. In other embodiments, the adapter 200a can include a first mount (not shown) on a non-sterile side 204a (Figure 8) to mount the adapter to the robotic arm 128a and a second mount (not shown) on a non-sterile side 208a to mount the powerpack 140a to the adapter 200a. It is to be understood that the adapter 200a is not particularly limited to any material and that several different types of materials are contemplated. In the present embodiment, the adapter 200a is made of plastic and is generally shipped in a sterile package with the barrier 148a attached thereto. This allows for one-time use of the adapter 200a and barrier 148a so that the adapter does not need to be sterilized. Furthermore, by making the adapter from plastic, the cost of the adapter can be low enough to allow for one-time use. In other embodiments, the adapter 200a can be made of a sterilizable material such that the adapter can be used several times. In such non-disposable applications, the adapter 200a would need to be constructed from materials which can withstand the harsh conditions of a sterilization process carried out prior to an actual surgery. Some examples of suitable materials include stainless steel, such as surgical stainless steel, titanium, higher grade plastics, composites and other materials commonly used in surgical instruments. Furthermore, it will now be apparent that once in use, the non-sterile side 204a faces the first environment 152a and is configured to engage the robotic arm 128a. The sterile side 208a faces the second environment 156a and is configured to engage the second mount of the powerpack 140a.

[00113] Referring to Figures 7 to 10, the barrier 148a extends from the adapter 200a around the robotic arm 128a and is generally configured to separate the first environment 152a from the second environment 156a. The exact configuration of the barrier 148a is not particularly limited. In the present embodiment, the barrier 148a is a loose covering that extends from the adapter 200a and permits the powerpack 140a to be mounted on the adapter 200a. In other embodiments, the barrier 148a can be modified to be separate from the adapter 200a and can be configured to seal with the adapter 200a. It is to be appreciated that an advantage of using a barrier 148a extending from the adapter 200a is that connecting the powerpack 140a to the robotic arm 128a prior to surgery is facilitated.

[00114] The powerpack 140a is generally configured to drive a robotic instrument and can include many configurations and can be similar in many respects to the powerpack 140. In fact, the powerpack 140a can be identical to the powerpack 140 such that the powerpack 140a is capable of mounting directly onto the robotic arm 128a without the adapter 200a. Therefore, the adapter 200a is optional.

[00115] Referring to Figures 11 to 13, another embodiment of a powerpack 140b is shown.

Like components of the powerpack 140b bear like references to their counterparts in the powerpack 140, except followed by the suffix "b". The powerpack 140b is generally configured to drive a robotic instrument. In the present embodiment, the powerpack 140b includes a housing 160b having a surface 165b, a first mount 164b, a second mount 168b, a drive mechanism 172b, and an electrical connector 212b. In the present embodiment, the electrical connector 212b is a male connector. It is to be understood that in most applications, it is desirable to use a male electrical connector because they are more durable than female connectors when used on the powerpack 140b. However, in other embodiments, the electrical connector 212b can be modified to be a female connector to meet requirements of other applications.

[00116] The powerpack 140b functions similar to the powerpack 140 described above. One difference is that the powerpack 140b includes the electrical connector 212b generally configured to receive electrical signals. As described above, the powerpack 140b is configured to drive a robotic instrument (not shown) by providing a motion. It is to be understood that the motion is generated using a power source and that the motion is ultimately controlled by input from an input device (not shown). Therefore, the electrical signals received at the electrical connector 212b are generally for driving the drive mechanism 172b of the powerpack 140b. In particular, the electrical signals can provide power to the drive mechanism 172b. In addition, the electrical signals can also transfer data to a microprocessor (not shown) within the powerpack 140b, which would subsequently control the drive mechanism 172b. In the present embodiment, the data can further include information related to the state of the robotic instrument 132 and the powerpack 140b. For example, the state of the robotic instrument 132 and the powerpack 140b can include data related to the lifecycle of the robotic instrument 132 and the powerpack 140b for monitoring the use of each component.

[00117] The state of the robotic instrument 132 can be obtained via the powerpack 140b through various means. For example, the powerpack 140b can communicate with the robotic instrument 132 via a wired connection (not shown) or wirelessly using electromagnetic signals received through an antenna or photo sensor. In other embodiments, the powerpack 140b can not communicate with the robotic instrument 132 where the data is not necessary or where the robotic instrument 132 is capable of communicating directly with the base unit 120.

[00118] It will now be apparent, with the benefit of this specification, that the powerpack 140b can be combined with a modified adapter 200b similar to the adapter 200a as shown in Figure 14. Like components of the adapter 200b bear like references to their counterparts in the adapter 200a, except followed by the suffix "b". For example, the adapter 200b also includes a barrier 148b extending from the adapter. In particular, the electrical connector 212b is configured to be received by an electrical connector 216b on the adapter 200b. The electrical connector 216b is generally configured to mate with the electrical connector 212b on a sterile side 208b of the adapter 200b.

[00119] Referring to Figure 15, a second electrical connector 220b is disposed on the non-sterile side 204b of the adapter 200b. The electrical connector 220b is generally configured to mate with another connector (not shown) on a robotic arm 128 for sending and/or receiving electrical signals. Therefore, it is to be understood that the adapter 200b is generally configured to transfer electrical signals between the non-sterile side 204b, which is in a non-sterile environment, and the sterile side 208b, which is in a sterile environment.

[00120] As discussed above, it is to be understood that the robotic arm 128 can be modified to include a rail system 224c. Referring to Figures 16 and 17, an embodiment of the rail system 224c is shown. The rail system 224c is generally configured to provide linear motion. The linear motion increases the degrees of freedom of a system for driving a robotic instrument (not shown), which allows the robotic instrument to be positioned more precisely. In the present embodiment, the rail system 224c includes a first portion 228c, a second portion 232c, a drive mechanism 236c, and an optional trocar holder 240c. The second portion 232c is slidably connected to the first portion 228c and can be moved between an extended position as shown in Figure 16 and a retracted position as shown in Figure 17. The drive mechanism 236c is configured to move the first portion 228c relative to the second portion 232c. The method by which the drive mechanism relatively moves the first and second portions 228c and 232c is not particularly limited. In the present embodiment, the drive mechanism 236c is a motor disposed on the second portion 232c and configured to rotate a lead screw 244c. By rotating the lead screw 244c, which is connected to the first portion 228c, the first and second portions 228c and 232c are moved relative to each other. In other embodiments, the drive mechanism 236c can be modified to use hydraulics, pneumatics, magnetic actuators or piezoelectric actuators to move the first portion 228c relative to the second portion 232c.

[00121] In the present embodiment, the trocar holder 240c is disposed on the first portion 228c. Referring to Figure 18, the trocar holder 240c of the present embodiment is shown to be disposed in a first environment 152c. The trocar holder 240c is generally configured to support a trocar mount 416c and a trocar 500c.

[00122] Referring to Figure 19, the present embodiment of the trocar holder 240c is shown in greater detail. The trocar holder 240c can include many different configurations and is mechanically structured such that the trocar holder can support the trocar mount 416c and the trocar 500c. The materials from which the trocar holder is constructed are not particularly limited and include materials from which the robotic arm 128c is constructed. In the present embodiment, the trocar holder 240c includes a first opening 408c and a second opening 412c, which will each be described in greater detail below.

[00123] Referring to Figure 20, the present embodiment of the trocar mount 416c is shown in greater detail. The trocar mount 416c can include many different configurations and is generally configured to mount a trocar 500c and connect to the trocar holder 240c. The trocar mount 416c is also configured to be disposed in a second environment 156c, which is separated from the first environment 152c by a barrier 148c. It is to be understood that the trocar mount 416c is not particularly limited to any material and that several different types of materials are contemplated. Because the trocar mount 416c needs to be sterilized, the trocar mount is typically constructed from materials which can withstand the harsh conditions of a sterilization process carried out prior to an actual surgery. Some examples of suitable materials include stainless steel, such as surgical stainless steel, titanium, plastics, composites and other materials commonly used in surgical instruments. In the present embodiment, the trocar mount 416c includes a connector having a first mount pin 420c and a second mount pin 424c. The trocar mount 416c further includes a first opening 428c, and a second opening 432c. The first and second mount pins 420c and 424c are generally configured to connect the trocar mount 416c to the trocar holder 240c. In particular, the first and second mount pins 420c and 424c are configured to be received by the first and second openings 408c and 412c of the trocar holder 240c, respectively. In the present embodiment, two mount pins and corresponding openings are shown. In other embodiments, the first and second mount pins 420c and 424c can be modified to have different diameters and the first and second openings 428c and 432c can be modified accordingly such that they can receive the pins. The use of different diameters for the first and second mount pins 420c and 424c can limit the number of possible configurations that the trocar mount 416c can connect to the trocar holder 240c. It is to be appreciated that other embodiments can include more mount pins on the trocar mount 416c or entirely different types of connectors. In other embodiments, the mount pins can be disposed on the trocar holder 240c with the openings for receiving the mount pins defined on the trocar mount 416c. In further embodiments, only a single mount pin can be used. However, in embodiments where a single mount pin is used, the mount pin and opening are generally configured such that rotation of the trocar mount relative to the trocar holder is limited. For example, the mount pin can be shaped as a square or other polygon with sharp corners to restrict rotation.

[00124] Referring to Figure 21, the present embodiment of the trocar 500c is shown in greater detail. The trocar 500c can include many different configurations and is not very limited. In the present embodiment, the trocar 500c includes a connector having a first trocar pin 504c, and a second trocar pin 508c. The first and second trocar pins 504c and 508c are generally configured to mount the trocar 500c on the trocar mount 416c. In particular, the first and second trocar pins 504c and 508c are configured to be received by the first and second openings 428c and 432c of the trocar mount 416c, respectively. In the present embodiment, two trocar pins and corresponding openings are shown. It is to be appreciated that other embodiments can include more trocar pins on the trocar 500c or entirely different types of connectors. In other embodiments, the trocar pins can be disposed on the trocar mount with the openings for receiving the trocar pins defined on the trocar 500c. In further embodiments, only a single trocar pin can be used. However, in embodiments where a single trocar pin is used, the trocar pin and opening are generally configured such that rotation of the trocar 500c relative to the trocar mount 416c is limited. For example, the trocar pin can be shaped as a square or other polygon with sharp corners to restrict rotation.

[00125] In use, the trocar 500c is generally configured to be mounted efficiently during a surgical procedure. A first environment 152c and a second environment 156c are separated with the barrier 148c such that the robotic arm 128c including the rail system 224c, which further includes the trocar holder 240c, would be disposed in the first environment 152c. Once the first and second environments 152c and 156c have been separated, the trocar mount 416c is connected to the trocar holder 240c. In the present embodiment, the mount pins 420c and 424c of the trocar mount 416c pierce the barrier 148c prior to being received by the openings 408c and 412c. It is to be understood that connecting the trocar mount 416c to the trocar holder 240c is preferably completed prior to positioning the robotic arm 128c near the patient P. This is advantageous as it allows the trocar mount 416c to be connected to the trocar holder 240c while away from patient where more space is generally available to maneuver the trocar mount 416c relative to the trocar holder 240c. This facilitates the aligning of the mount pins 420c and 424c with the openings 408c and 412c. Furthermore, by merely piercing the barrier 148c as in the present embodiment, the separation between first and second environments 152c and 156c is maintained as long as the trocar mount 416c is not removed. Once the trocar mount 416c is connected to the trocar holder 240c, the robotic arm 128c is positioned near the patient P such that the trocar 500c, which would already be at least partially inserted into the patient P, can be mounted onto the trocar mount 416c.

[00126] It is to be understood that the trocar holder 240c, the trocar mount 416c, and the trocar can be modified and that variations are contemplated. As an example, Figure 22 shows another type of connector for connecting a trocar mount 416ca to a trocar holder 240ca. In the present embodiment, the trocar holder 240ca includes a first magnet 436ca and a second magnet 440ca. The trocar mount 416ca includes a first magnet 444ca and a second magnet 448ca. The first and second magnets 420c and 424c of the trocar mount 416ca are generally configured to connect the trocar mount 416ca to the trocar holder 240ca magnetically. In particular, the first and second magnets 436ca and 440ca of the trocar holder 240ca are configured to engage the first and second magnets 444ca and 448ca of the trocar mount 416ca, respectively. Therefore, it is to be appreciated that by magnetically connecting the trocar mount 416ca to the trocar holder 240ca, it is not necessary to pierce the barrier (not shown). In the present embodiment, two pairs of magnets are shown. It is to be appreciated that other embodiments can include more pairs of magnets. In other embodiments, magnets can only be disposed on one of the trocar mount or the trocar holder when the other includes a ferromagnetic material. In further embodiments, there can also be a single pair of magnets or a single magnet disposed on one of the trocar mount or the trocar holder when the other includes a ferromagnetic material. However, in embodiments where a single magnet (or single pair of magnets) is used, a means for restricting rotation should be provided. For example, a physical feature, such as a lip or recess can be used. In another example, the magnet can simply be strong enough such that the force of friction would preclude any rotation.

[00127] In another example, Figure 23 shows a modification of the trocar holder 240c. In the present embodiment, the trocar holder 240cb includes a first holder latch 452cb, a second holder latch 456cb and a handle 460cb. The first and second holder latches 452cb and 456cb are generally configured to lock the corresponding mount pins (not shown) releasably. For example, the handle 460cb can be configured to operate the first and second holder latches 452cb and 456cb such that the first and second holder latches 452cb and 456cb can lock or release the corresponding mount pins.

[00128] In yet another example, Figure 24 shows a modification of the trocar mount 416c. In the present embodiment, the trocar holder 416cc includes a first mount latch 464cc and a second mount latch 468cc. The first and second mount latches 464cc and 468cc are generally configured to lock the corresponding trocar pins (not shown) releasably.

[00129] In yet another example, Figure 25 shows a modification of the trocar 500c. In the present embodiment, the trocar 500cd includes an elongated portion 513cd, a cannula 512cd and a housing 516cd. Therefore, a different housing 516cd and/or a different cannula 512cd can be used with the elongated portion 513cd. For example, different applications can require a different housing or cannula. In other embodiments still, the elongated portion 513cd and the cannula 512cd can be modified to form a single unitary piece (not shown).

[00130] Referring to Figures 26 and 27, another embodiment of an optional rail system 224d is shown. Like components of the rail system 224d bear like references to their counterparts in the rail system 224c, except followed by the suffix "d". The rail system 224d is generally configured to provide linear motion. In the present embodiment, the rail system 224d includes a first portion 228d, a second portion 232d, a third portion 234d, a drive mechanism 236a, and an optional trocar holder 240d. The second portion 232d is slidably connected to the first portion 228d and can be moved between an extended position as shown in Figure 26 and a retracted position as shown in Figure 27. The third portion 234d is slidably connected to the second portion 232d and can be moved between an extended position as shown in Figure 26 and a retracted position as shown in Figure 27. The drive mechanism 236d is configured to move the first portion 228d relative to the second portion 232d. In addition, the drive mechanism 236d is also configured to move the third portion 234d relative to the second portion 232d. The method by which the drive mechanism moves the first, second, and third portions 228d, 232d, and 234d is not particularly limited. In the present embodiment, the drive mechanism 236d is a motor disposed on the second portion 232d and configured to rotate first and second lead screws 244d and 248d, respectively. By rotating the lead screws 244d and 248d, which are connected to the first portion 228d and the third portion 232d in opposite directions, the first and third portions 228d and 234d are moved relative to the second portion 232d in opposite directions such that the first and third portions 228d and 234d move relative to each other concurrently and in opposite directions. In present embodiment, the lead screws 244d and 248d are rotated together. However, in other embodiments the lead screws 244d and 248d can be modified to be rotated independently such that independent movement of the first and third portions 228d and 234d can be provided.

[00131] In the present embodiment, the trocar holder 240d is disposed on the first portion 228d. The trocar holder 240d is similar to the trocar holder 240c and is generally configured to support a trocar mount and trocar (not shown).

[00132] Referring to Figure 28, a system 144d for driving the robotic instrument 132d is shown generally at 144d. The system 144d includes a robotic arm 128d, an adapter 200d, a barrier 148d, and a powerpack 140d. The robotic arm 128d includes the rail system 224d described above. The barrier 148d extends from the adapter 200d.

[00133] In the present embodiment, the robotic arm 128d is similar to the robotic arm 128 and is generally configured to support the system 144d and the robotic instrument 132d as shown in Figure 29. In particular, the robotic arm 128d includes a rail system 224d and is mechanically structured to support itself, the adapter 200d, the powerpack 140d, the robotic instrument 132d, and their associated movement. In the present embodiment, the rail system 224d includes first, second, and third portions 228d, 232d and 234d, respectively, which were described above.

[00134] The barrier 148d extends around the robotic arm 128d and is generally configured to separate a first environment 152d from a second environment 156d. In the present embodiment, the robotic arm 128d is in the first environment 152d while the powerpack 140d and the robotic instrument 132d are in the second environment 156d. As shown in Figure 29, in the present embodiment, the adapter 200d is generally configured to be mounted on the third portion 234d of the rail system 224d. In the present embodiment, the rail system 224d includes a trocar holder 240d disposed on the first portion 228d. It is to be understood that holding a trocar (not shown) in the present embodiment involves a trocar mount piercing the barrier 148d in a manner similar to that described in connection with the embodiment shown in Figure 18. In other embodiments, the trocar holder 240d and the barrier 148d can be designed such that it is not necessary to pierce the barrier 148c when holding the trocar.

[00135] Although in the present embodiment shown in Figure 29, the powerpack 140d moves parallel to the axis of the robotic arm 128d, it is to be understood that the rail system 224d can be modified such that it is positioned at any angle relative to the robotic arm 128d to provide linear motion at a different angle.

[00136] It is to be understood that combinations and subsets of the embodiments and teachings herein are contemplated. As a non-limiting example, system 144d can be modified such that no adapter is present resulting in a system for driving a robotic instrument having a rail system, but no adapter.

[00137] As another non-limiting example, referring back to Figures 4 and 6, the motion transfer mechanism 196 is not particularly limited and can include various modifications. For example, the motion transfer mechanism 196 can be modified to include a first rotatable member 196e configured to mate with a second rotatable member 197e on a robotic instrument (not shown) as shown in Figure 30. In this embodiment, the first rotatable member 196e configured to engage the second rotatable member 197e coaxially. For example, the engagement can be through a frictional engagement or some locking mechanism, such as mating pins and holes.

[00138] In another example of a variation, the motion transfer mechanism 196 can be modified to include a first rotatable member 196f configured to mate with a second rotatable member 197f on a robotic instrument (not shown) as shown in Figures 31 to 33. In this embodiment, there is a gap between the first rotatable member 196f and the second rotatable member 197f. In the present embodiment, the first rotatable member 196f includes a first plurality of magnets 304f disposed at pre-determined positions on the first rotatable member as shown in Figure 32. Furthermore, in the present embodiment, the second rotatable member 197f also includes a second plurality of magnets 308f disposed at pre-determined positions on the second rotatable member as shown in Figure 33. Each magnet in the first plurality of magnets 304f is generally configured to engage a corresponding magnet in the second plurality of magnets 308f. In the present embodiment, each plurality of magnets 304f and 308f include four magnets. In other embodiments, the plurality of magnets can have more or fewer magnets. In further embodiments, there can also be a single magnet disposed on each rotatable member 196f and 197f off-axis.

[00139] In yet another example of a variation, the motion transfer mechanism 196 can be modified to include a first rotatable member 196g configured to mate with a second rotatable member 197g on a robotic instrument (not shown) as shown in Figure 34. In this embodiment, there is a gap between the first rotatable member 196g and the second rotatable member 197g. The first rotatable member 196g includes jets 198g for ejecting a fluid, such as air or water, into a corresponding opening 199g defined in the surface of the second rotatable member 197g. Therefore, as the first rotatable member 196g rotates, the second rotatable member 197g would also rotate to keep the jet 198g aligned with the corresponding opening 199g. Furthermore, it will be appreciated that in other embodiments, the jets 198g and openings 199g are modified by interchanging them such that the jets are on the second rotatable member 197g and the openings are on the first rotatable member 196g. In further embodiments, each rotatable member 196g and 197g is modified to include both jets and openings for ejecting and receiving fluid, respectively. In another embodiment of a variation, an additional drive mechanism can be disposed in a powerpack 140h, which is a modification of the powerpack 140. The powerpack 140h includes a motion transfer mechanism 300h as shown in Figure 35. The motion transfer mechanism 300h is generally configured to provide a motion to drive the first and second lead screws (not shown), by rotating them.

[00140] While specific embodiments have been described and illustrated, such embodiments should be considered illustrative only and should not serve to limit the accompanying claims.

What is claimed is:

1. An apparatus for driving a robotic instrument configured to perform medical procedures, the apparatus comprising:

   a housing;

   a first mount disposed on the housing, the second mount configured to mount the robotic instrument;

   a second mount disposed on the housing, the first mount configured to mount the housing on a robotic arm; and

   a drive unit disposed at least partially in the housing, the drive unit configured to provide a motion for driving the robotic instrument.

2. The apparatus of claim 1, further comprising a motion transfer mechanism for transferring the motion provided by the drive unit to the robotic instrument.

3. The apparatus of claim 2, wherein the motion transfer mechanism comprises a first rotatable member configured to mate with a second rotatable member disposed on the robotic instrument.

4. The apparatus of claim 3, wherein the first rotatable member is configured to engage the second rotatable member coaxially.

5. The apparatus of claim 3, wherein the first rotatable member is configured to frictionally engage the second rotatable member.

6. The apparatus of claim 3, wherein the first rotatable member is configured to magnetically engage the second rotatable member.

7. The apparatus of claim 3, wherein the first rotatable member is configured to engage the second rotatable member via a fluid.

8. The apparatus of claim 7, wherein the fluid is air.

9. The apparatus of claim 1, further comprising a rotatable gear configured to transfer the motion to the robotic instrument.

10. The apparatus of claim 9, wherein the rotatable gear is configured to mate with a drive gear of the robotic instrument.

11. The apparatus of claim 1, wherein the first mount is configured to be mounted on a barrier, the barrier configured to separate a non-sterile environment from a sterile environment.

12. The apparatus of claim 11, wherein the apparatus is disposed in the sterile environment.

13. The apparatus of claim 12, wherein the first mount is configured to engage an adapter having a sterile side within the sterile environment and a non-sterile side within the non-sterile environment, the sterile side configured to engage the second mount and the non-sterile side configured to engage the robotic arm.

14. The apparatus of claim 1, further comprising an electrical connector configured to receive electrical signals.

15. The apparatus of claim 14, wherein the electrical connector is disposed on the first mount.

16. The apparatus of claim 14, wherein the electrical signals are for controlling the drive unit.

17. The apparatus of claim 14, wherein the electrical signals are for transferring data.

18. The apparatus of claim 17, wherein the data includes information related to a state of the robotic instrument.

19. The apparatus of claim 9, wherein the electrical signals are for supplying power to the drive unit.

20. The apparatus of claim 10, wherein the electrical connector is a male connector.

21. The apparatus of claim 10, further comprising an adapter, wherein the electrical connector is configured to connect to the adapter, the adapter configured to transfer electrical signals between a non-sterile environment and a sterile environment.

22. The apparatus of claim 1, wherein the second mount is configured to releasably connect with the robotic instrument.

23. The apparatus of claim 1, further comprising a second drive unit disposed in the housing, the second drive unit configured to provide a second motion for moving the apparatus along the robotic arm.

24. The apparatus of claim 23, wherein the second motion is for driving a lead screw to move a portion of a rail system.

25. The apparatus of claim 1, further comprising a second drive unit disposed in the housing, the second drive unit configured to provide a second motion for moving the robotic instrument relative to the housing.

26. The apparatus of claim 1, wherein the first mount is configured to releasably mount on a rail system of the robotic arm.

27. The apparatus of claim 1, wherein the drive unit is a motor.

28. A rail system for providing linear motion, the rail system comprising:

a first portion mounted on a robotic arm;

a second portion slidably connected to the first portion; and

a drive unit configured to move the first portion relative to the second portion.

29. The rail system of claim 28, further comprising a third portion slidably connected to the second portion, the drive unit further configured to move the third portion relative to the second portion.

30. The rail system of claim 29, wherein the drive unit is disposed on the second portion.

31. The rail system of claim 29 or 30, wherein the first and second portion move in a first motion relative to each other.

32. The rail system of claim 31, wherein the second and third portion move in a second motion relative to each other.

33. The rail system of claim 32, wherein the first motion and the second motion are concurrent and opposite in direction.

34. The rail system of claim 28, further comprising a trocar holder disposed on the first portion, the trocar holder configured to hold a portion of a trocar.

35. The rail system of claim 33, wherein the third portion is configured to mount a barrier, the barrier configured to separate a non-sterile environment from a sterile environment.

36. The rail system of claim 35, wherein the apparatus is disposed in the non-sterile environment.

37. The rail system of claim 35, wherein the trocar holder is disposed in the non-sterile environment, the trocar holder configured to hold a portion of a trocar piercing through the barrier.

38. The rail system of claim 28, wherein the third portion is configured to engage an adapter having a sterile side within a sterile environment and a non-sterile side within a non-sterile environment, the sterile side configured to engage a power pack and the non-sterile side configured to engage the third portion.

39. A system for driving a robotic instrument, the system comprising:

a robotic arm;

a barrier disposed on the robotic arm, the barrier configured to separate a non-sterile environment from a sterile environment such that the robotic arm is in the non-sterile environment; and

a powerpack disposed on the robotic arm such that the powerpack is in the sterile environment, the powerpack configured for driving a robotic instrument.

40. The system of claim 39, wherein the powerpack includes a rotatable gear configured to transfer a motion to the robotic instrument.

41. The system of claim 40, wherein the rotatable gear is configured to mate with a drive gear of the robotic instrument.

42. The system of claim 39, further comprising an adapter having a sterile side within the sterile environment and a non-sterile side within the non-sterile environment, the sterile side configured to engage the powerpack and the non-sterile side configured to engage the robotic arm.

43. The system of claim 39, wherein the powerpack includes an electrical connector configured to receive electrical signals.

44. The system of claim 43, wherein the electrical signals are for controlling the drive unit.

45. The apparatus of claim 39, wherein the electrical signals are for transferring data.

46. The apparatus of claim 45, wherein the data includes information related to a state of the robotic instrument.

47. The system of claim 43, wherein the electrical signals are for supplying power to the drive unit.

48. The system of claim 43, wherein the electrical signals are received from a signal source in the non-sterile environment.

49. The system of claim 43, wherein the electrical connector is a male connector.

50. The system of claim 43, further comprising an adapter, wherein the electrical connector is configured to connect to the adapter, the adapter configured to transfer electrical signals between a non-sterile environment and a sterile environment.

51. The system of claim 39, wherein the robotic arm includes a rail system having a first portion and a second portion, the barrier being disposed on the second portion.

52. The system of claim 51, wherein the powerpack includes a second drive unit, the second drive unit configured to provide a second motion for moving a first portion of the rail system relative to a second portion of the rail system.

53. The system of claim 51, wherein the powerpack is configured to releasably mount on the rail system.

54. The system of claim 51, further comprising a trocar holder disposed on the rail system, the trocar holder configured to hold a portion of a trocar.

55. The system of claim 54, wherein the trocar holder is disposed in the non-sterile environment, the trocar holder configured to hold a portion of a trocar piercing through the barrier.

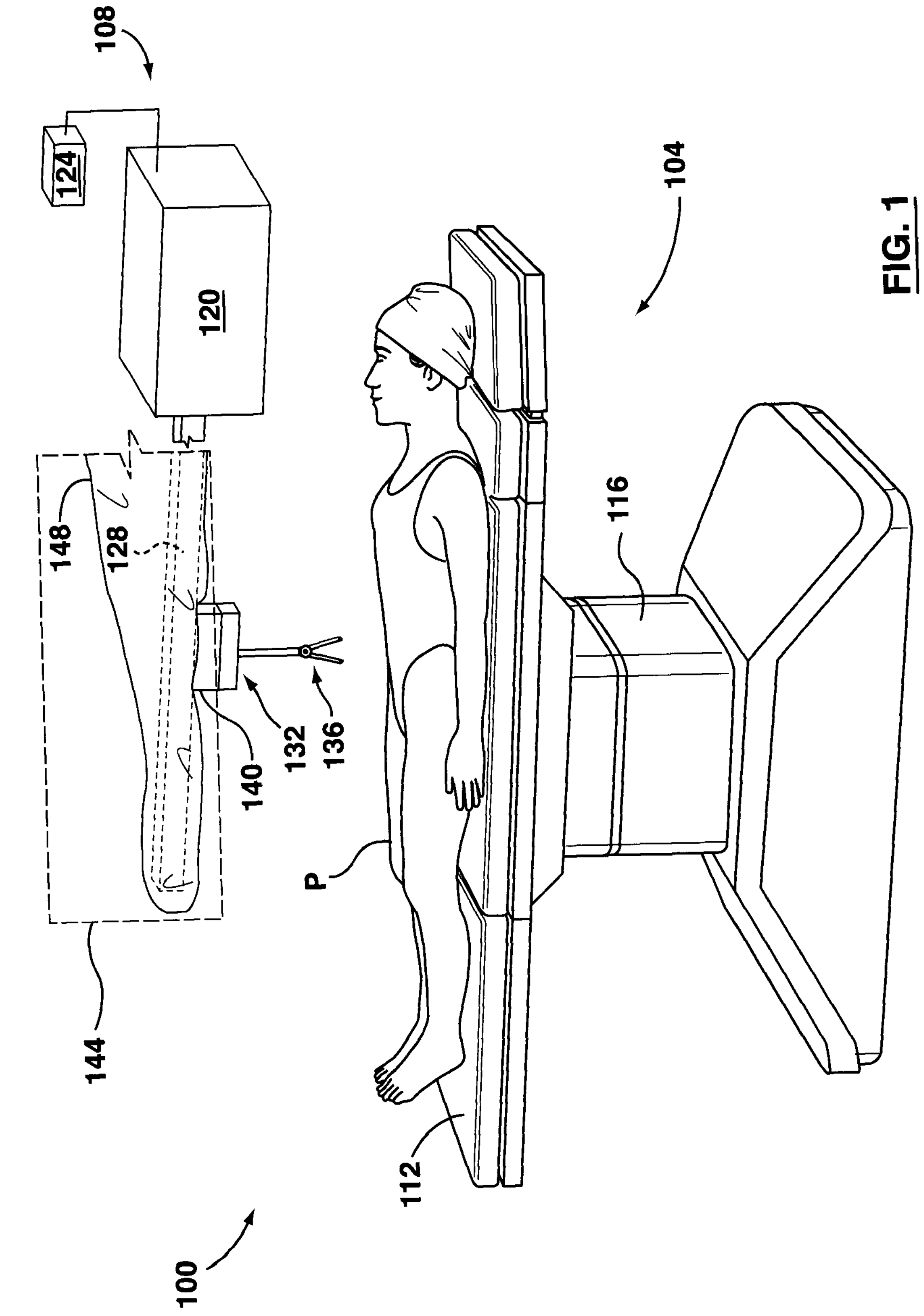


FIG. 1

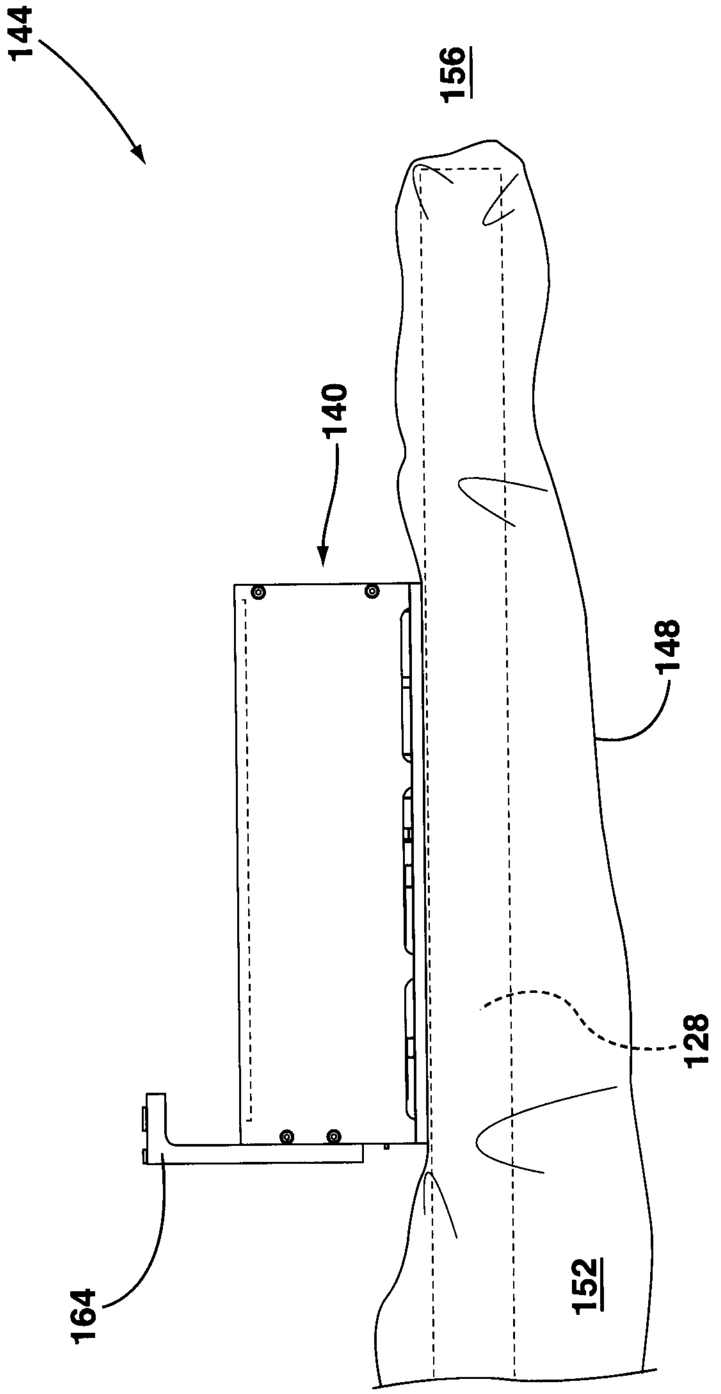


FIG. 2

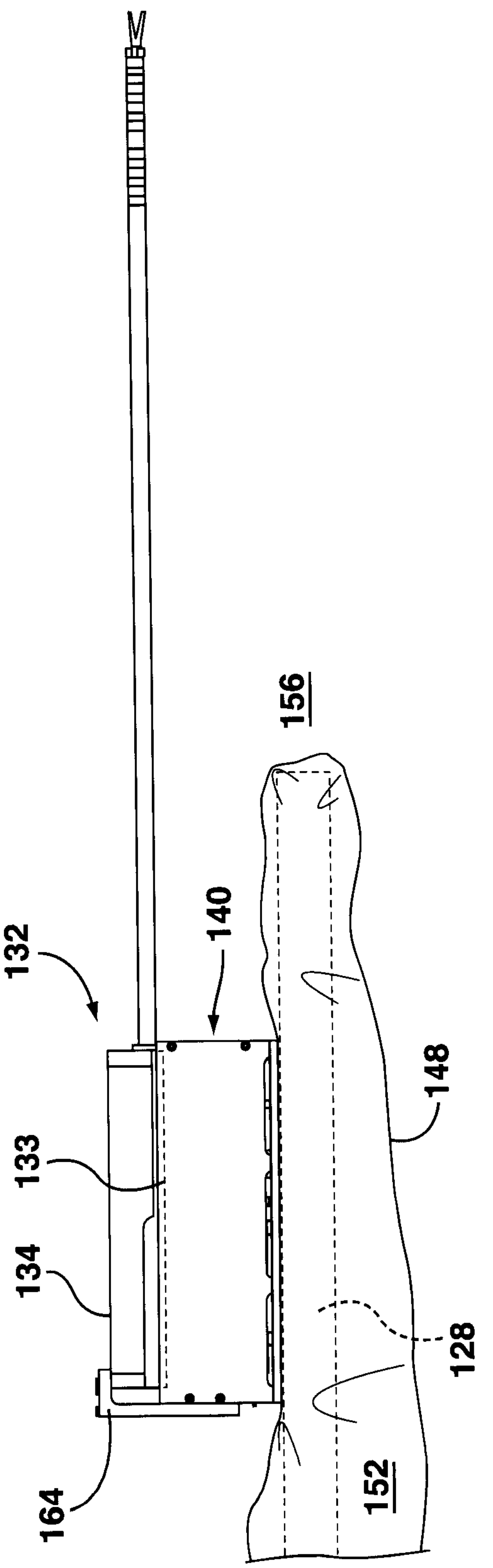
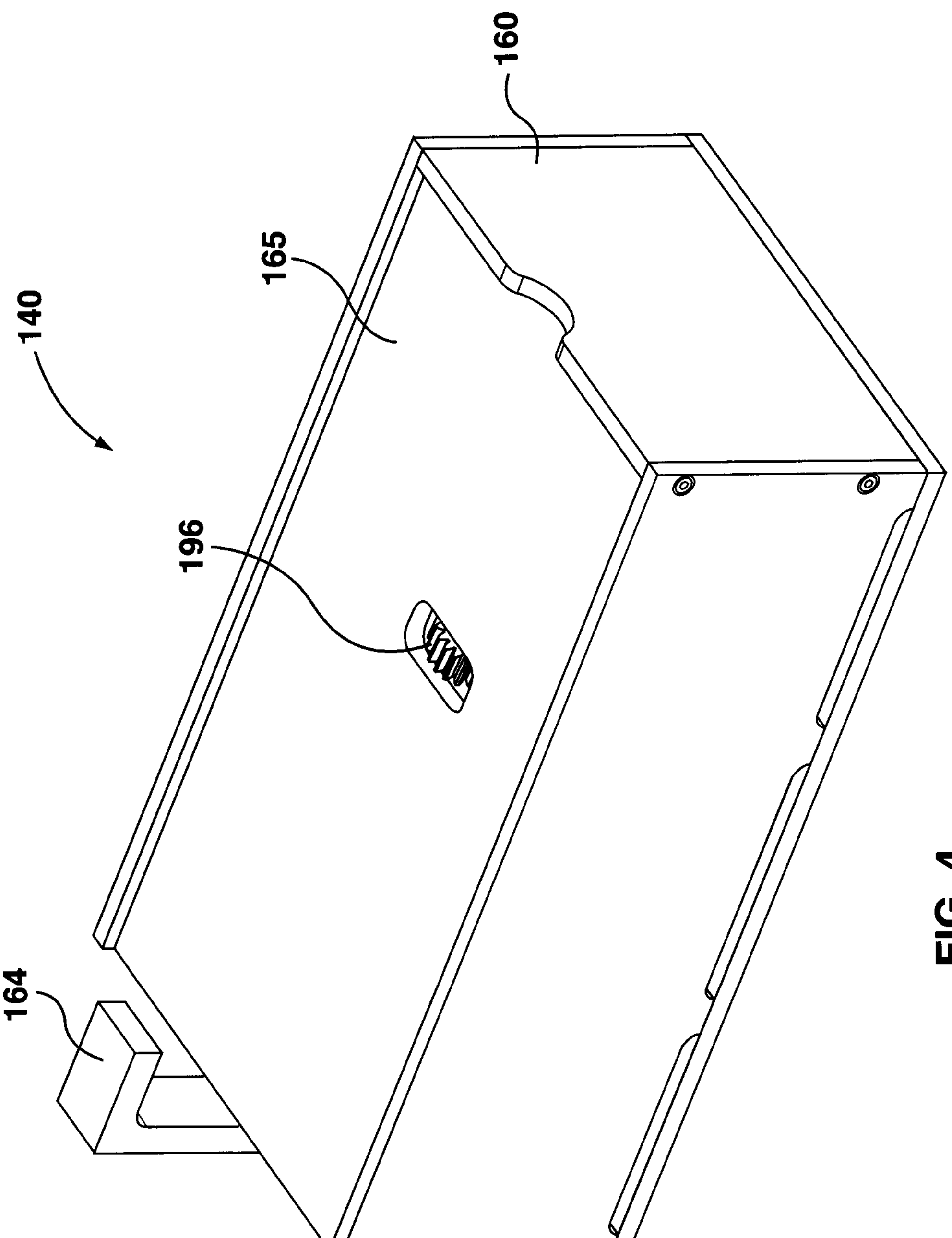


FIG. 3



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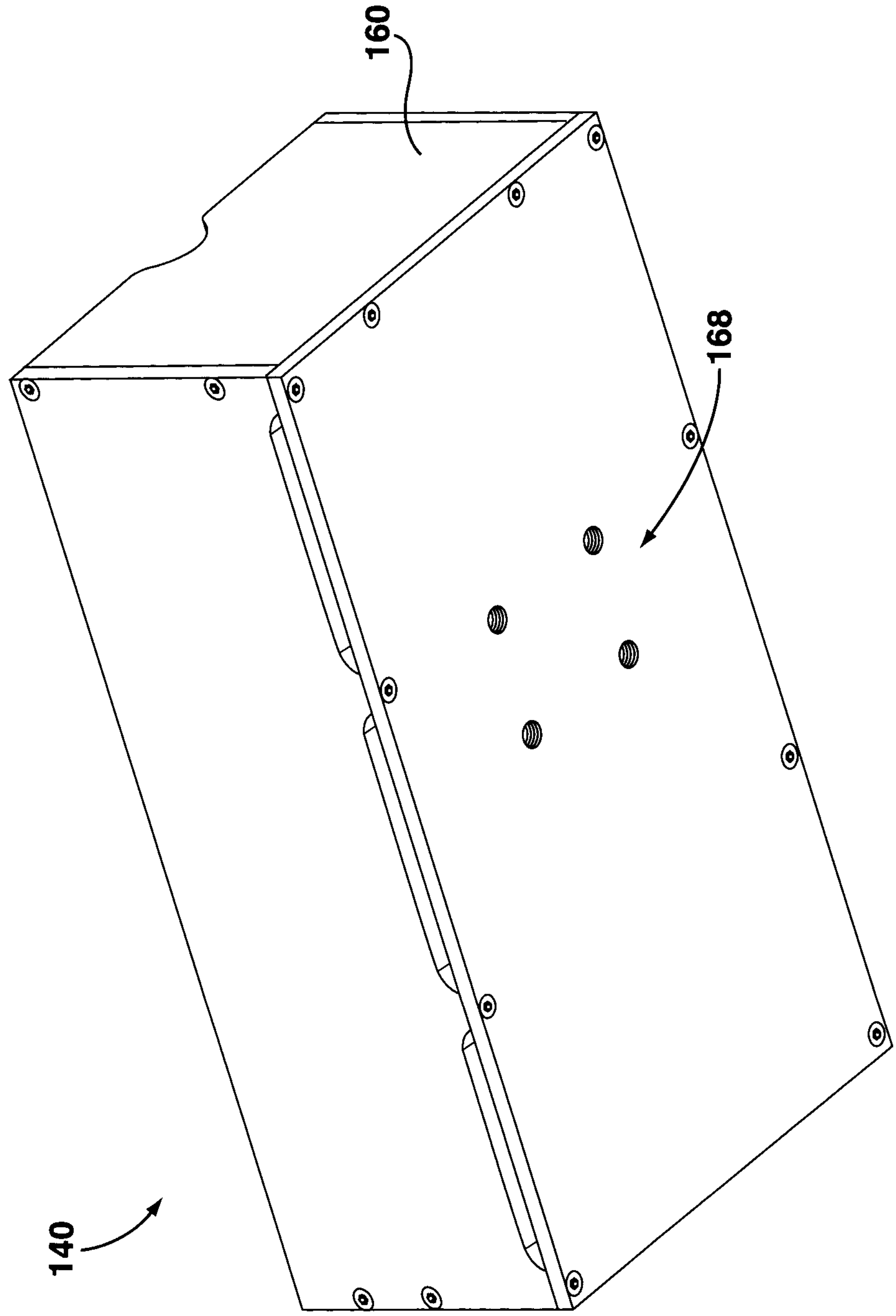


FIG. 5

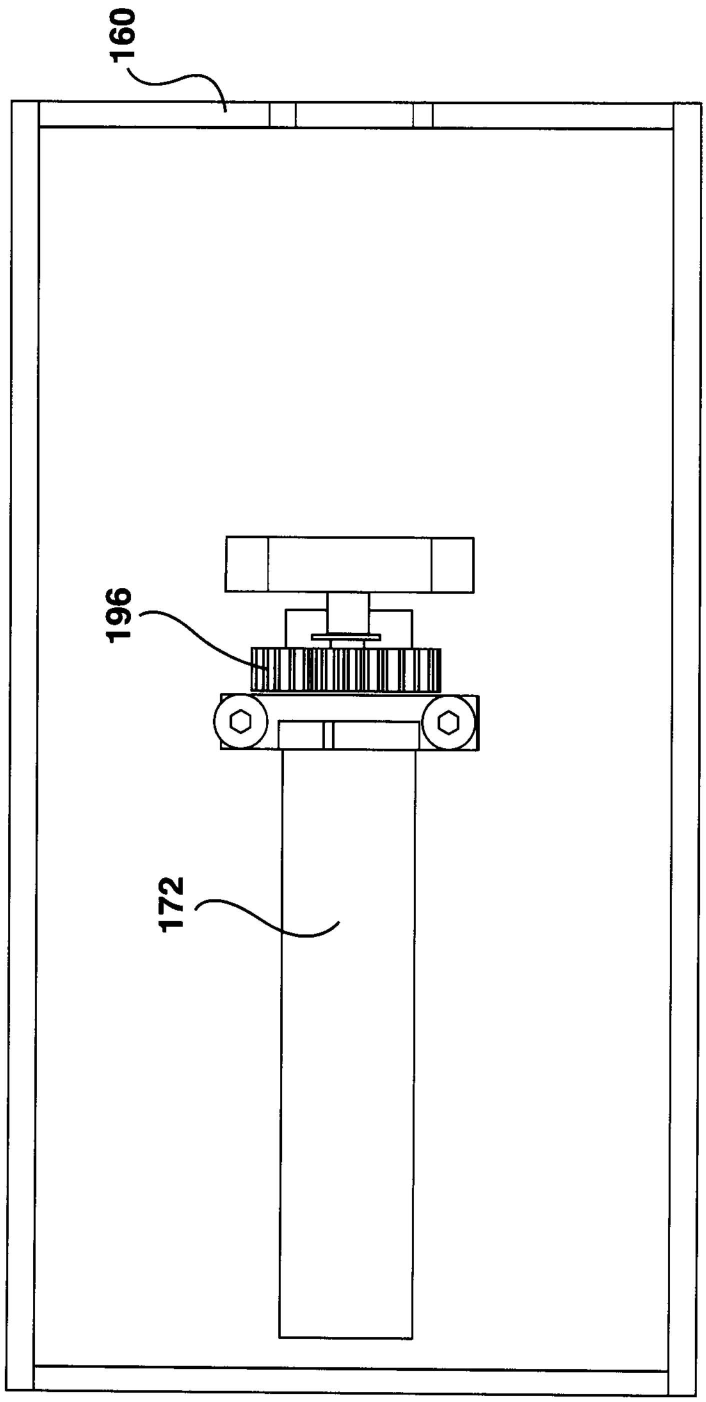


FIG. 6

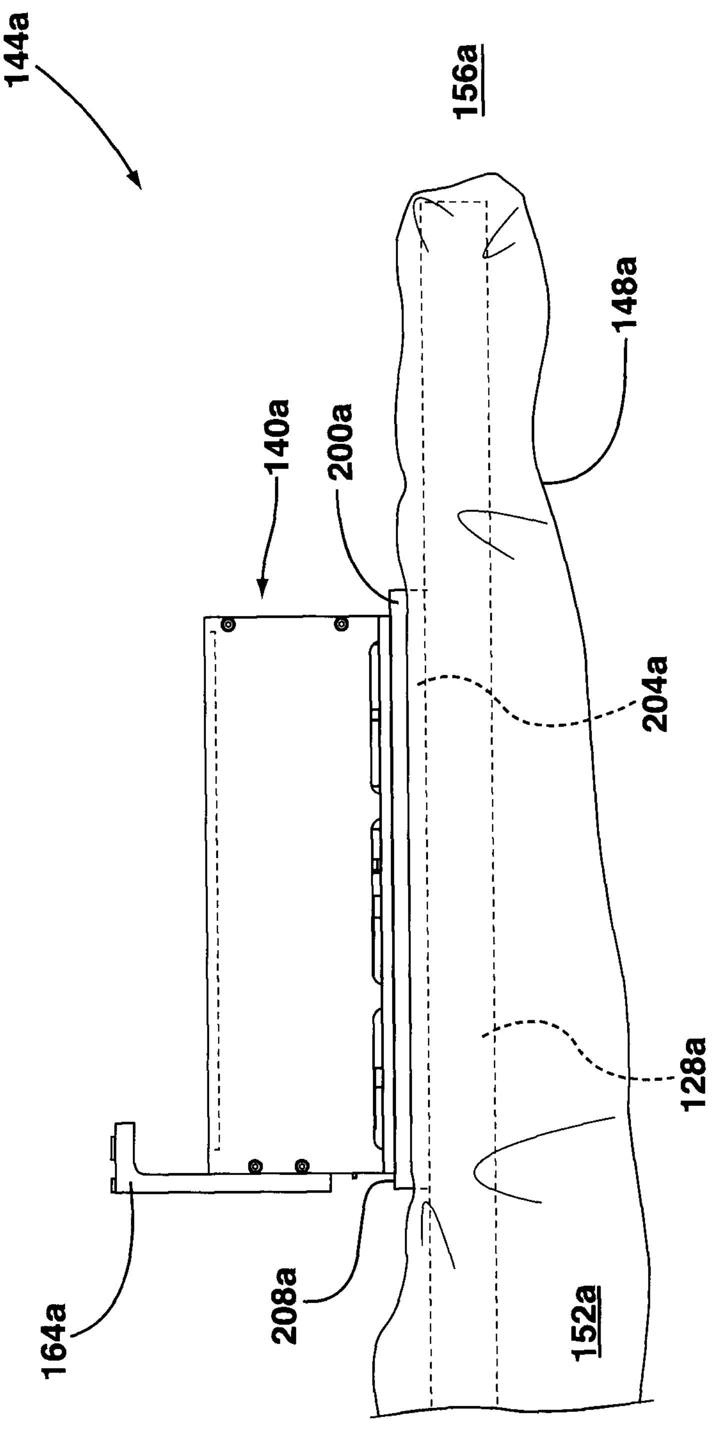


FIG. 7

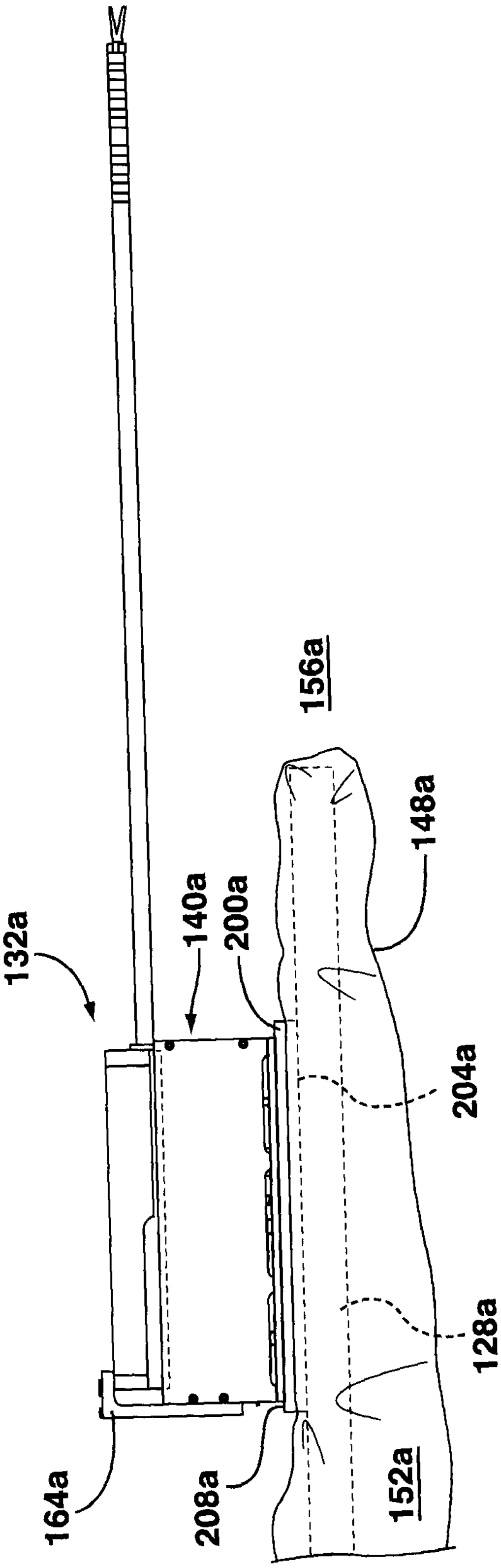


FIG. 8

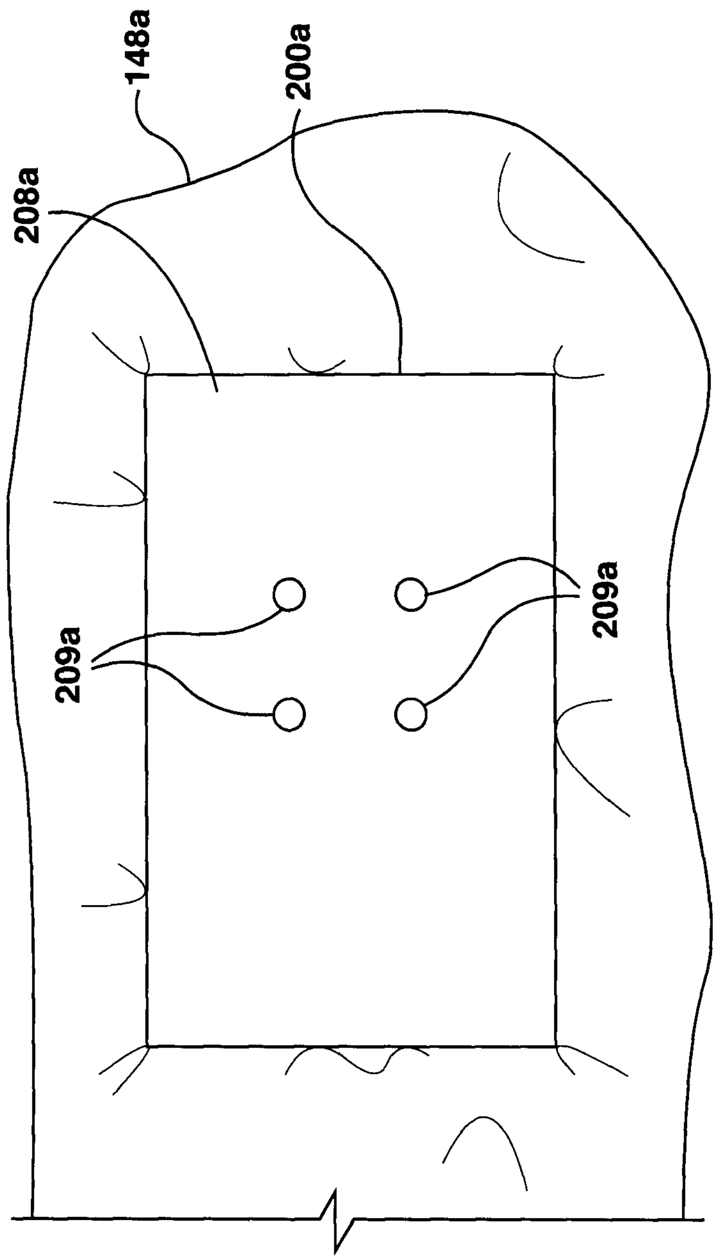


FIG. 9

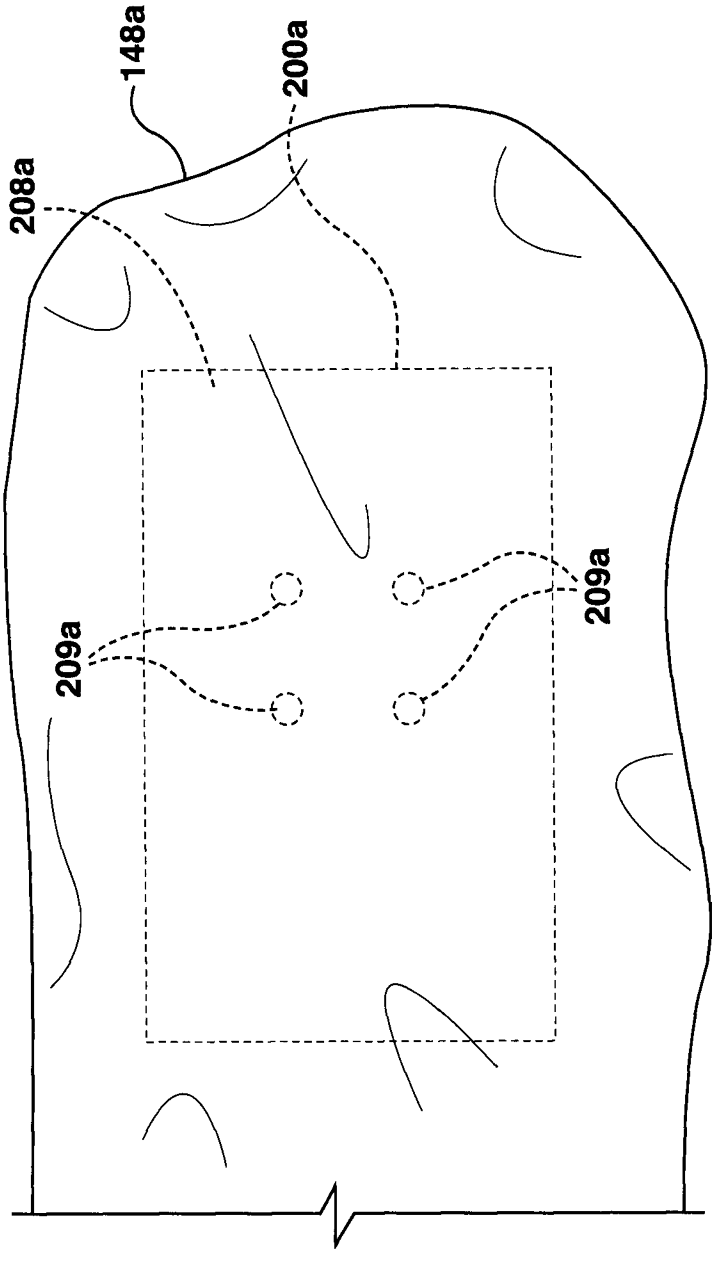


FIG. 10

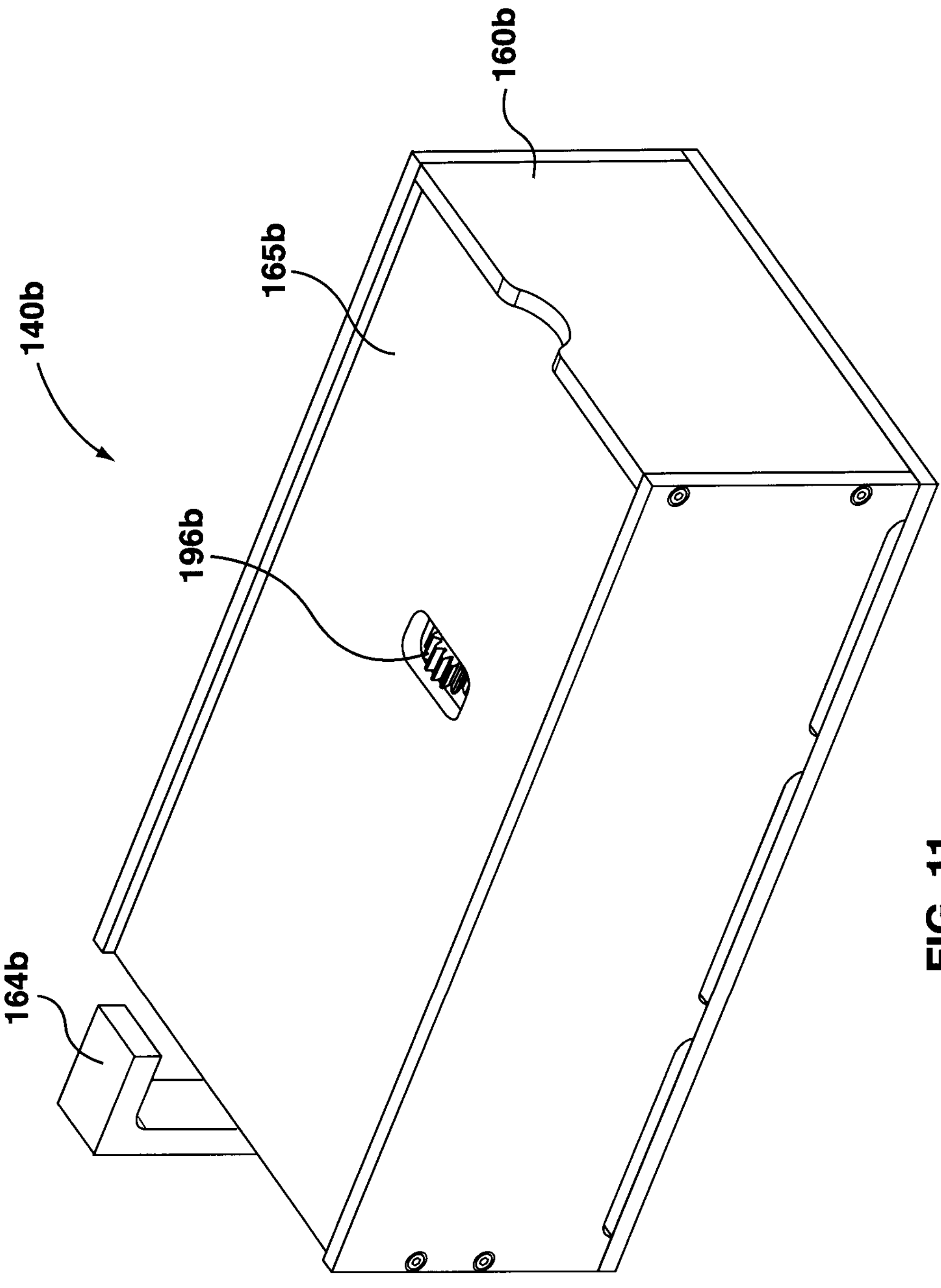
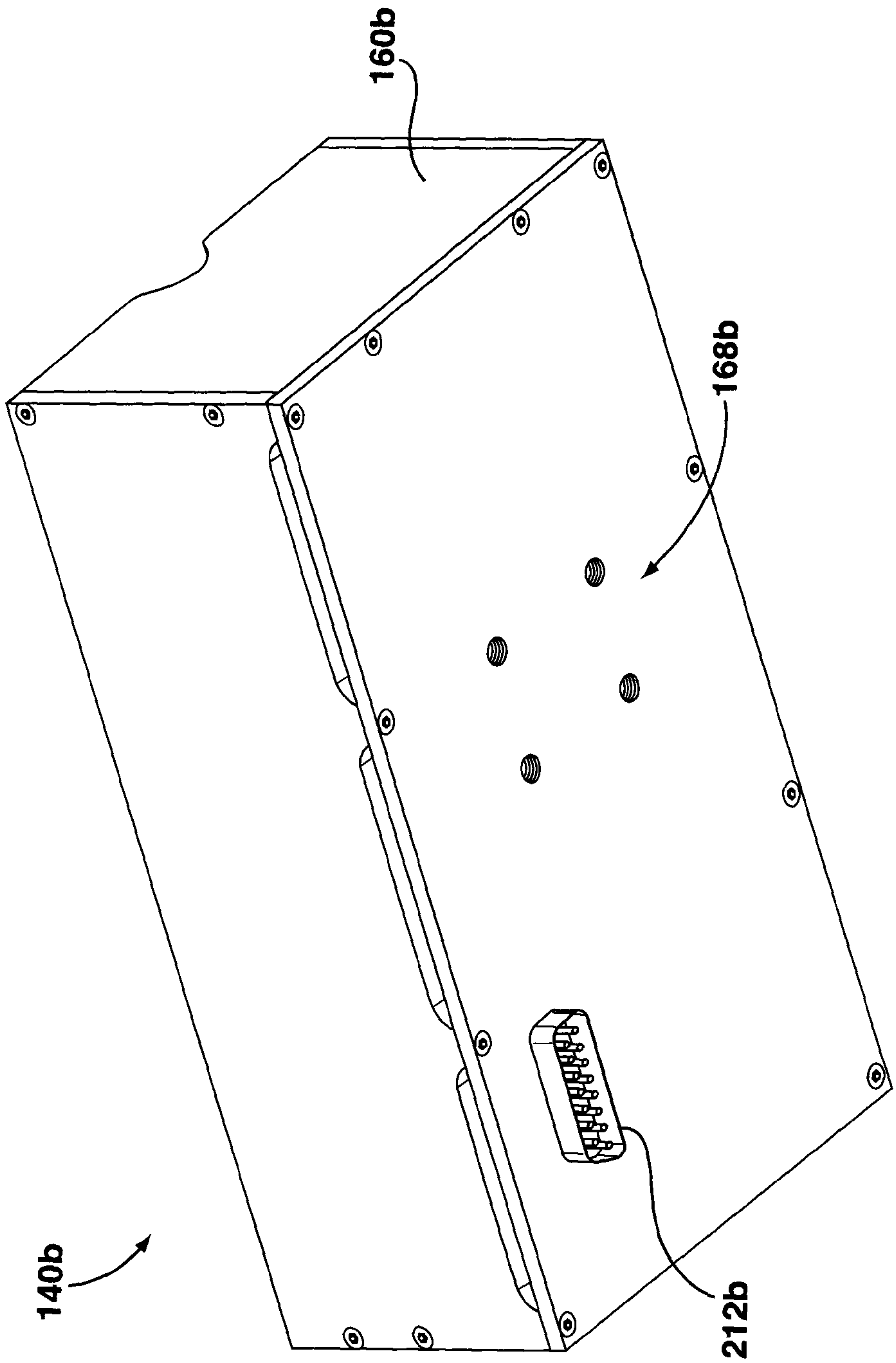


FIG. 11



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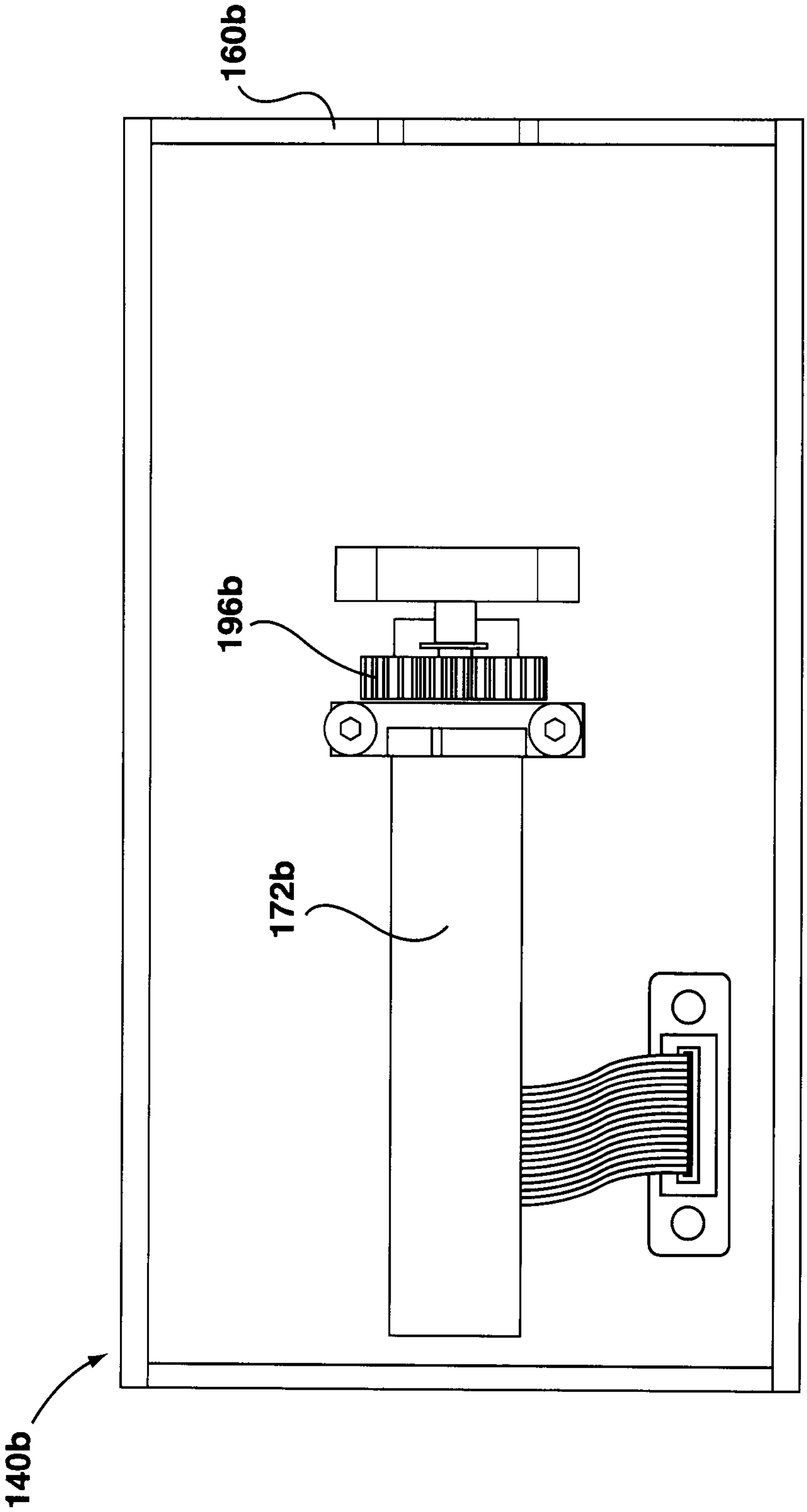


FIG. 13

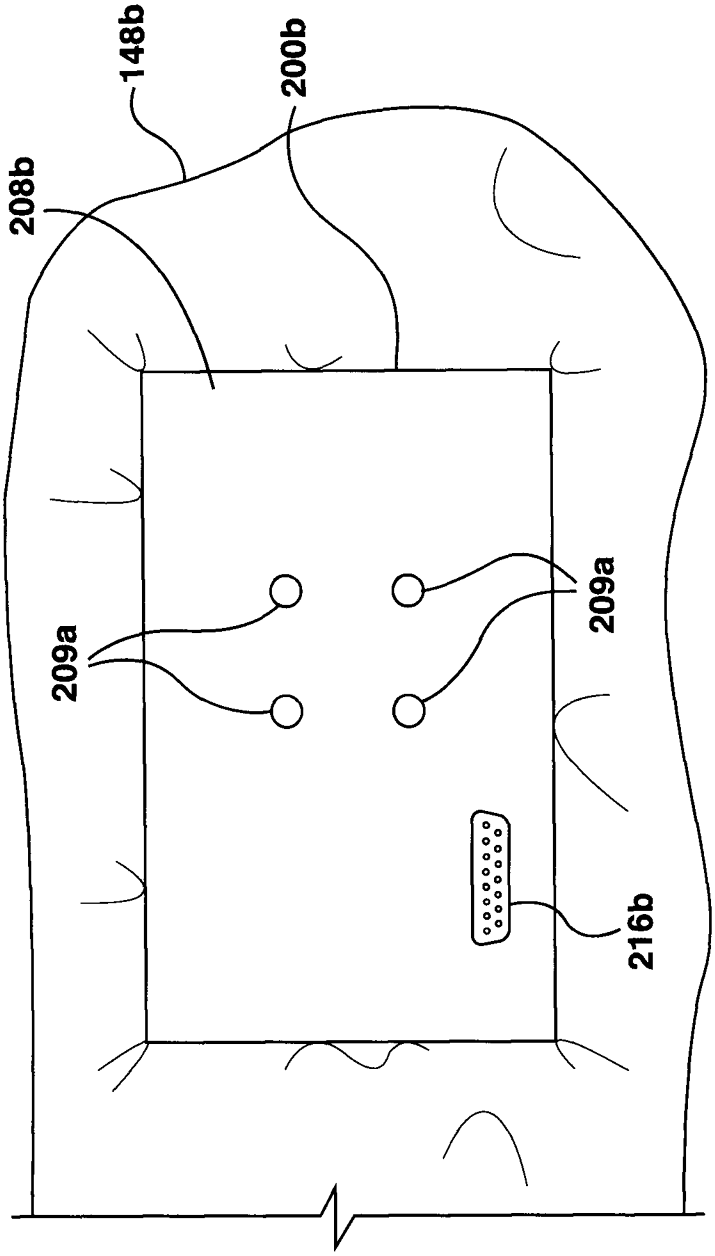


FIG. 14

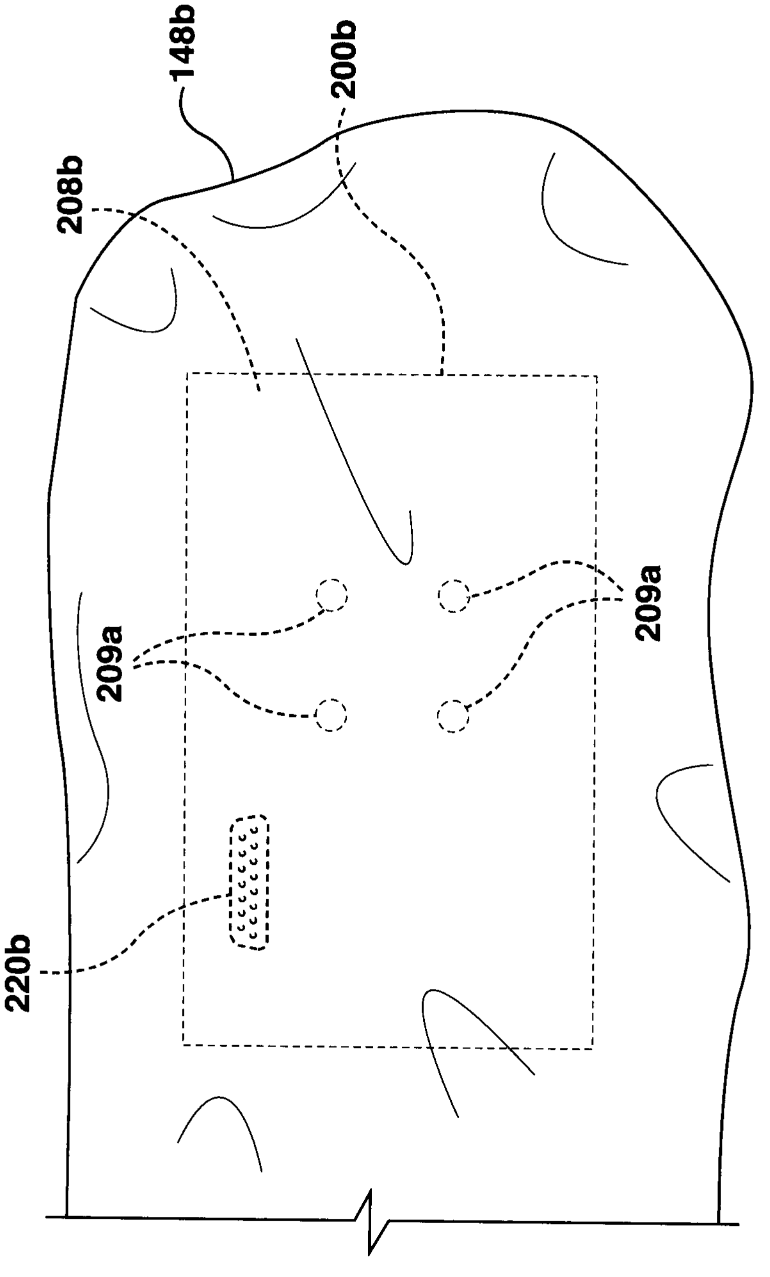


FIG. 15

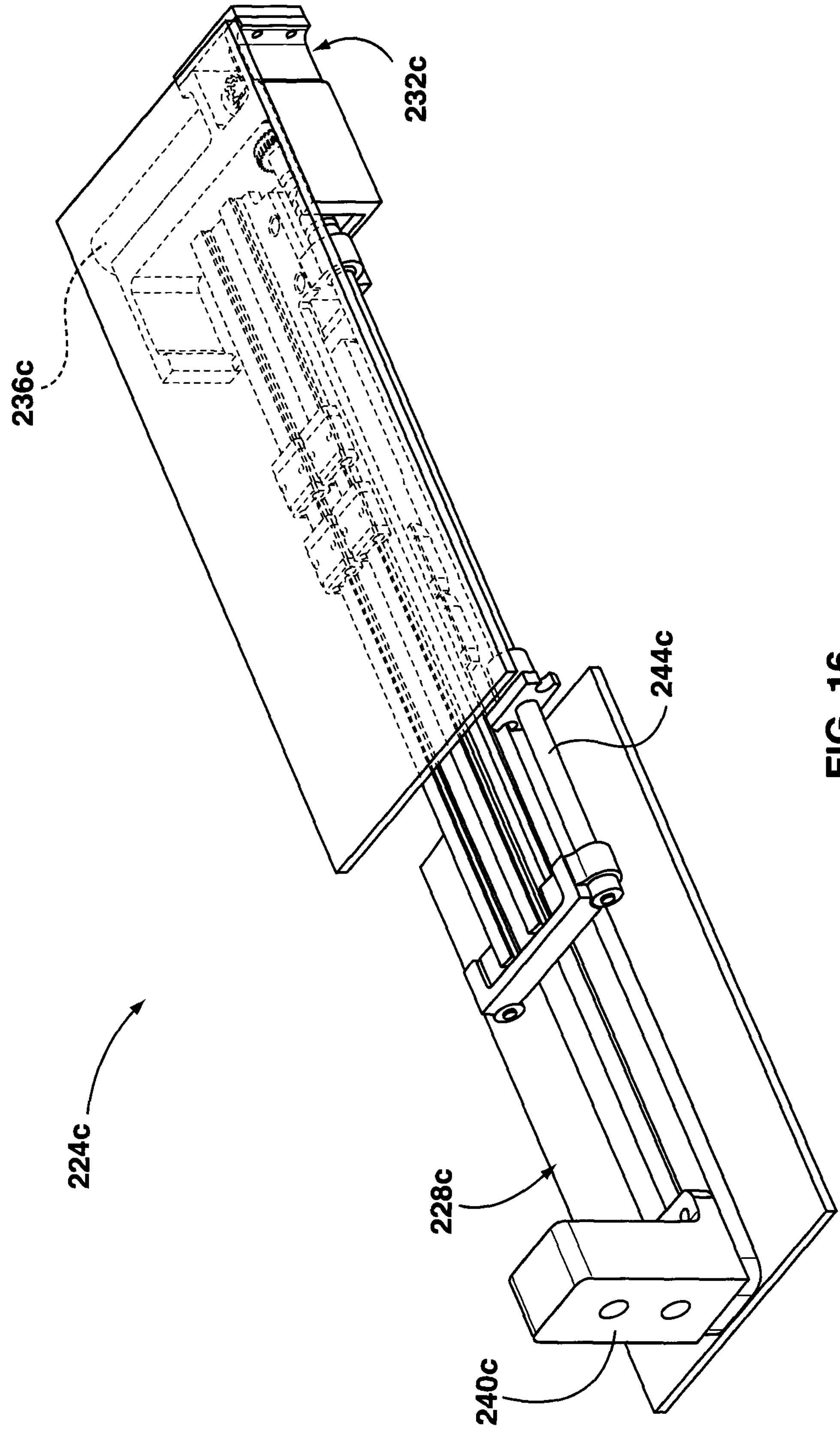


FIG. 16

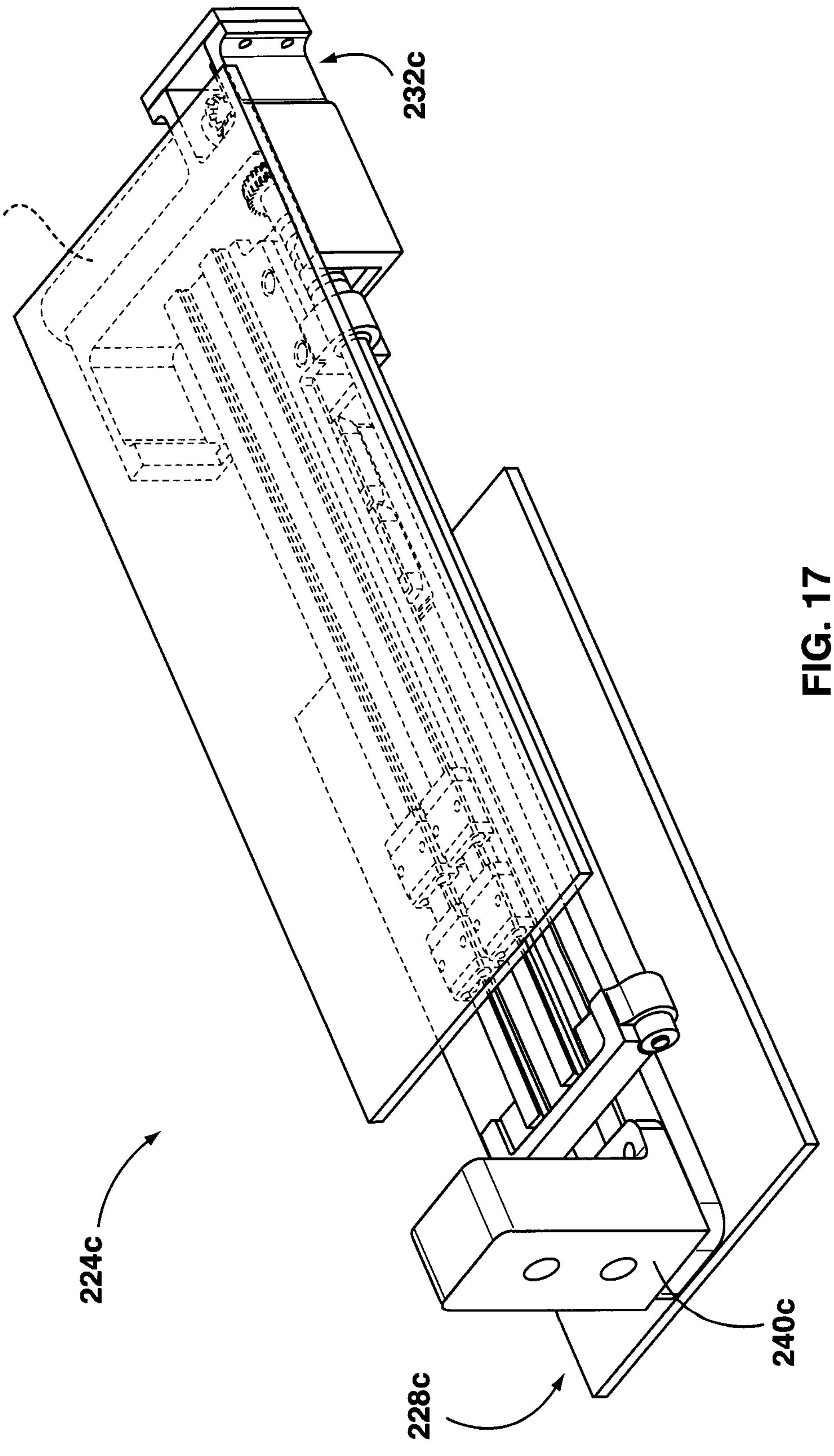


FIG. 17

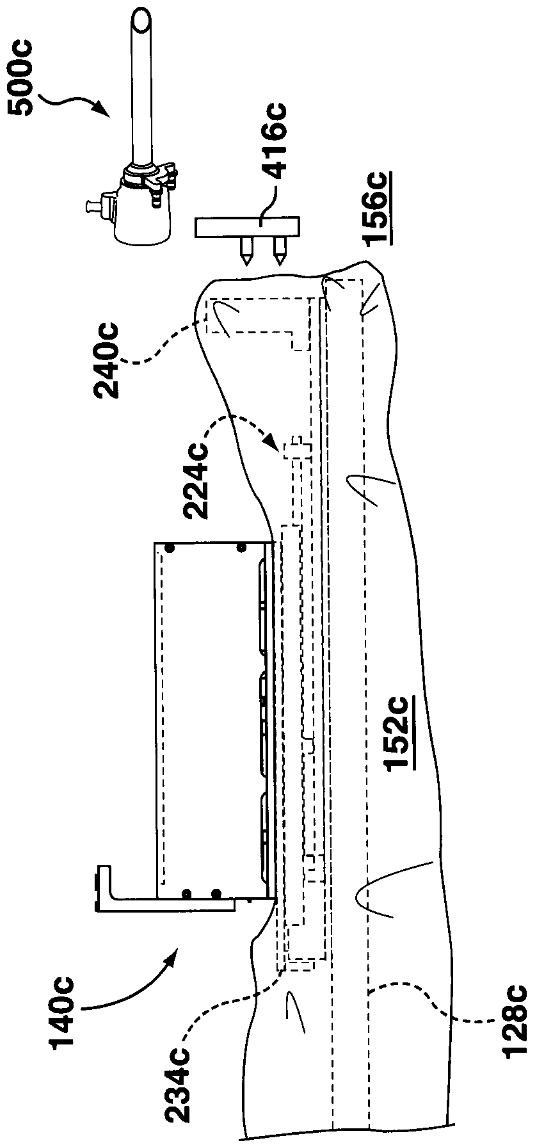


FIG. 18

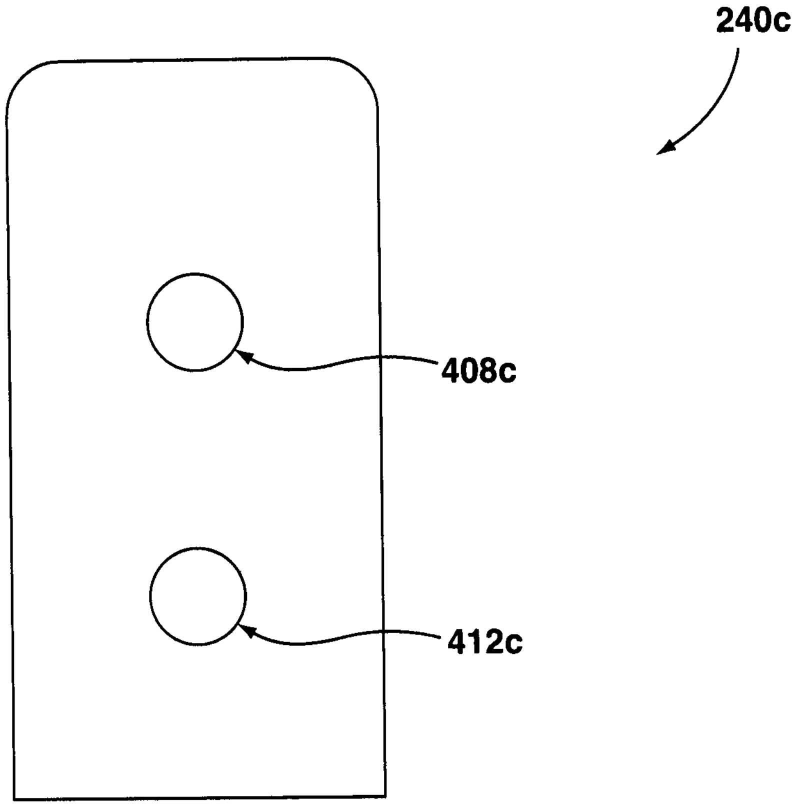


FIG. 19

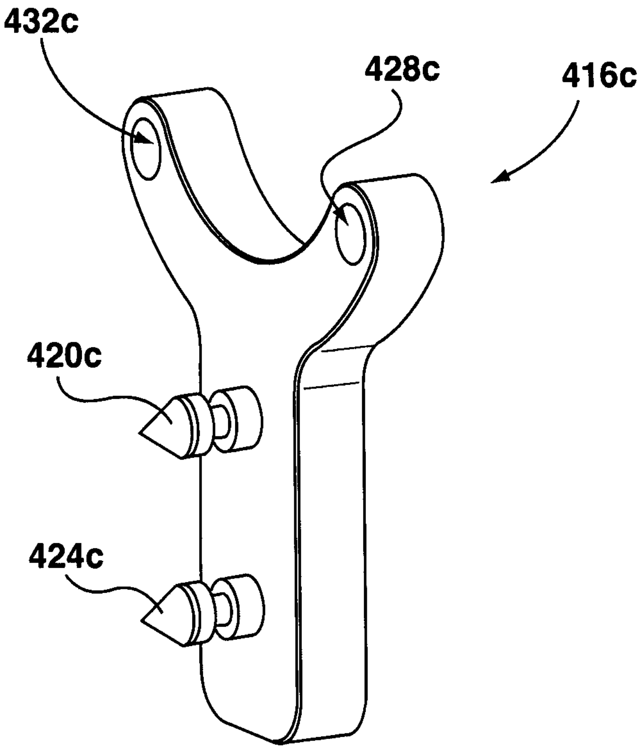
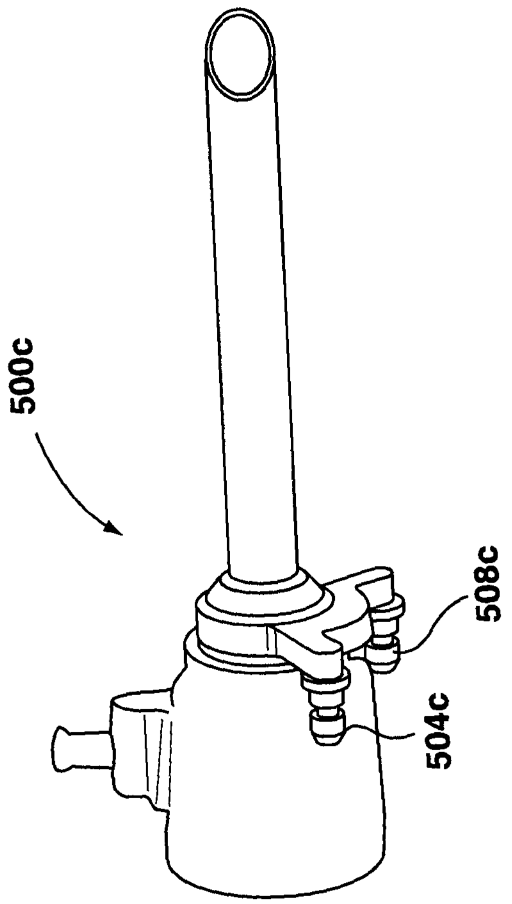


FIG. 20



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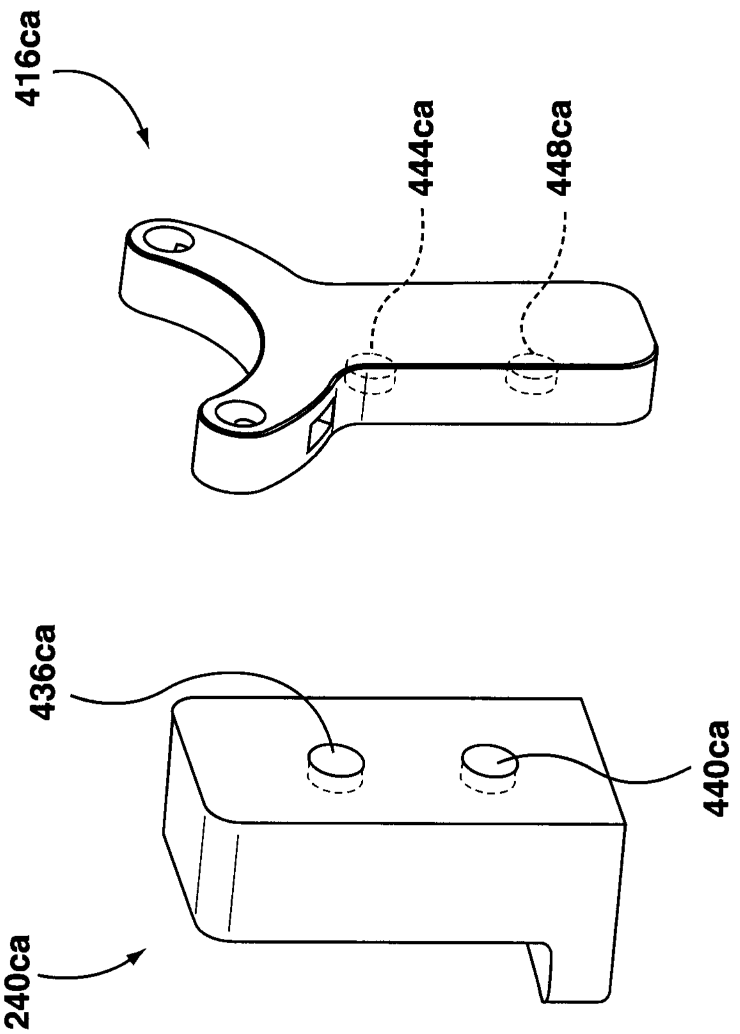

FIG. 22

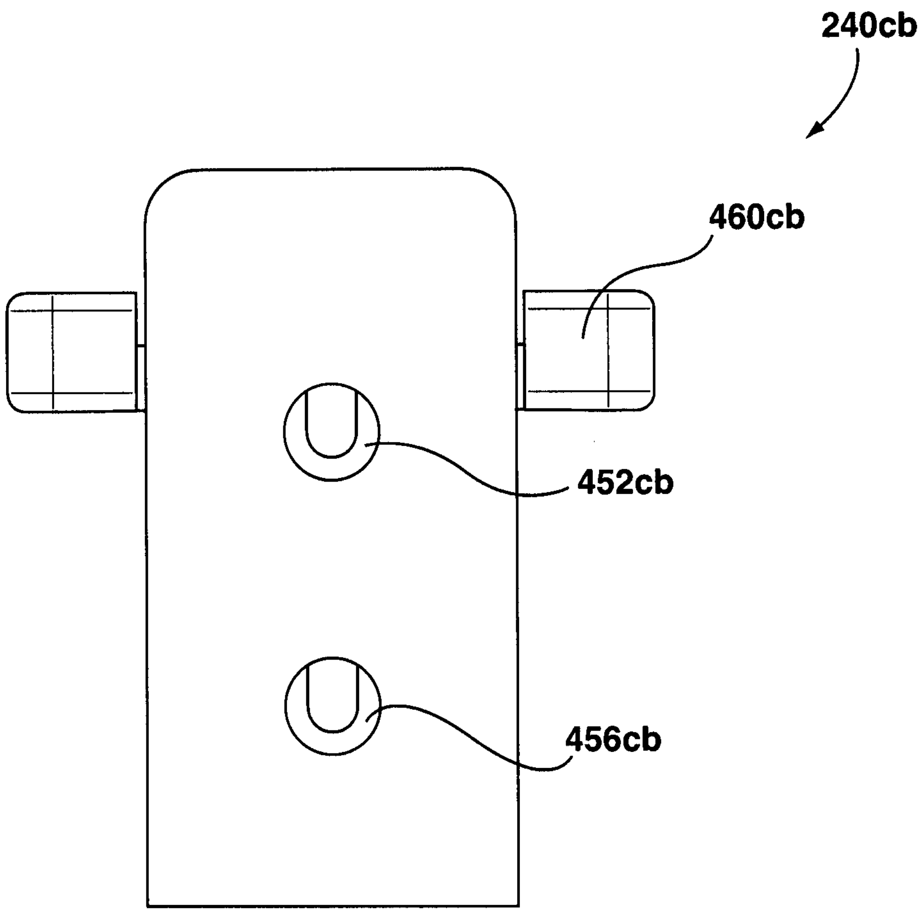

FIG. 23

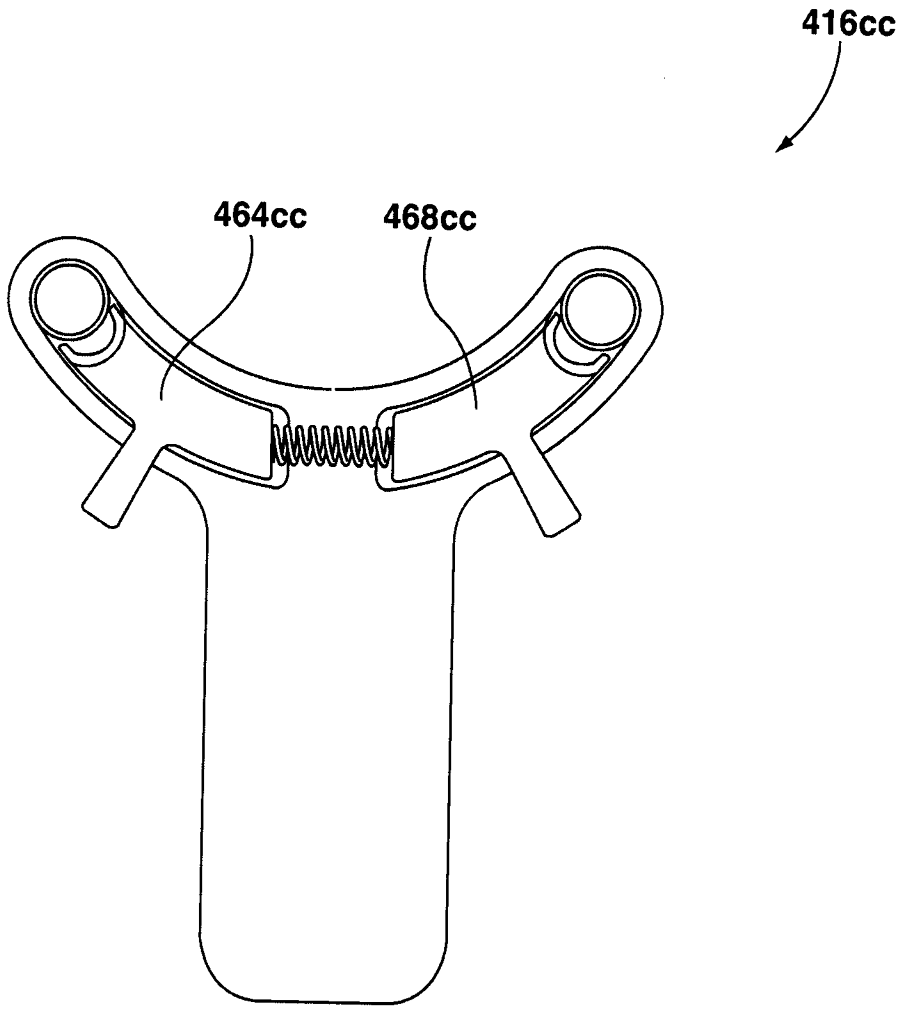

FIG. 24

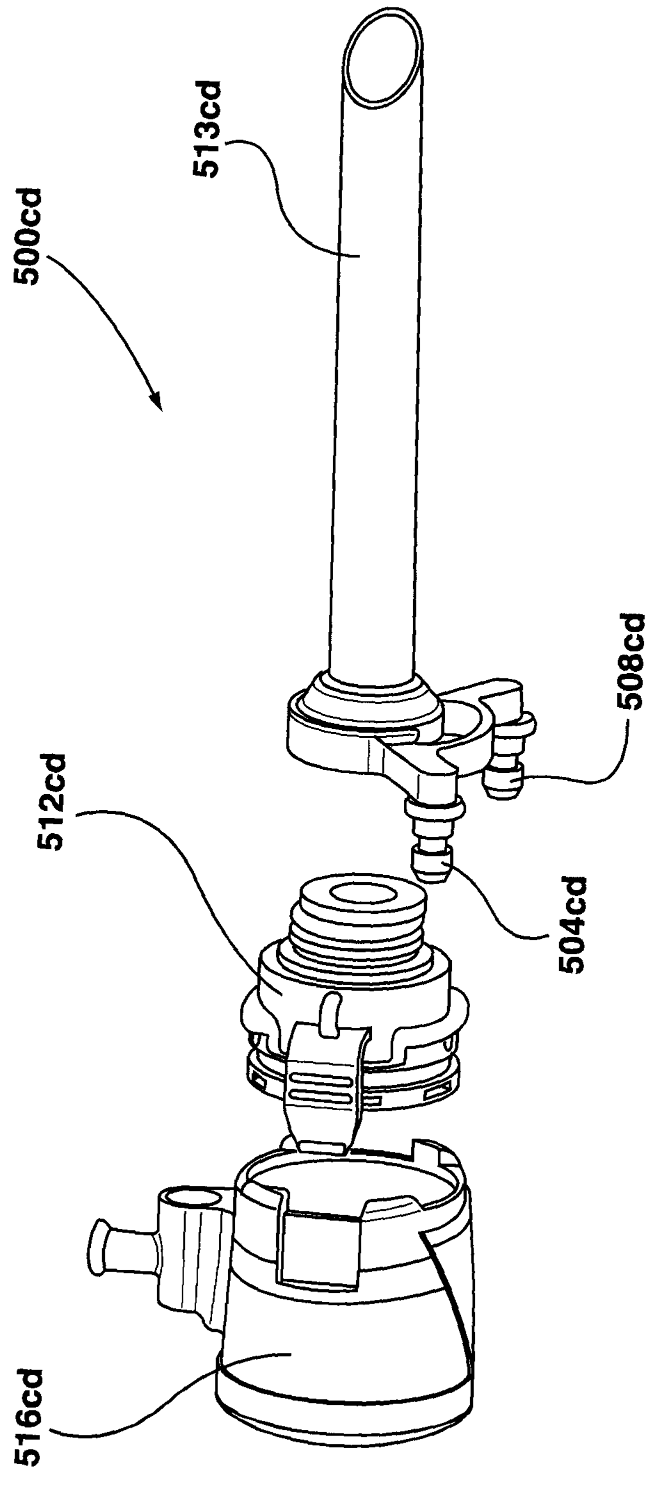

FIG. 25

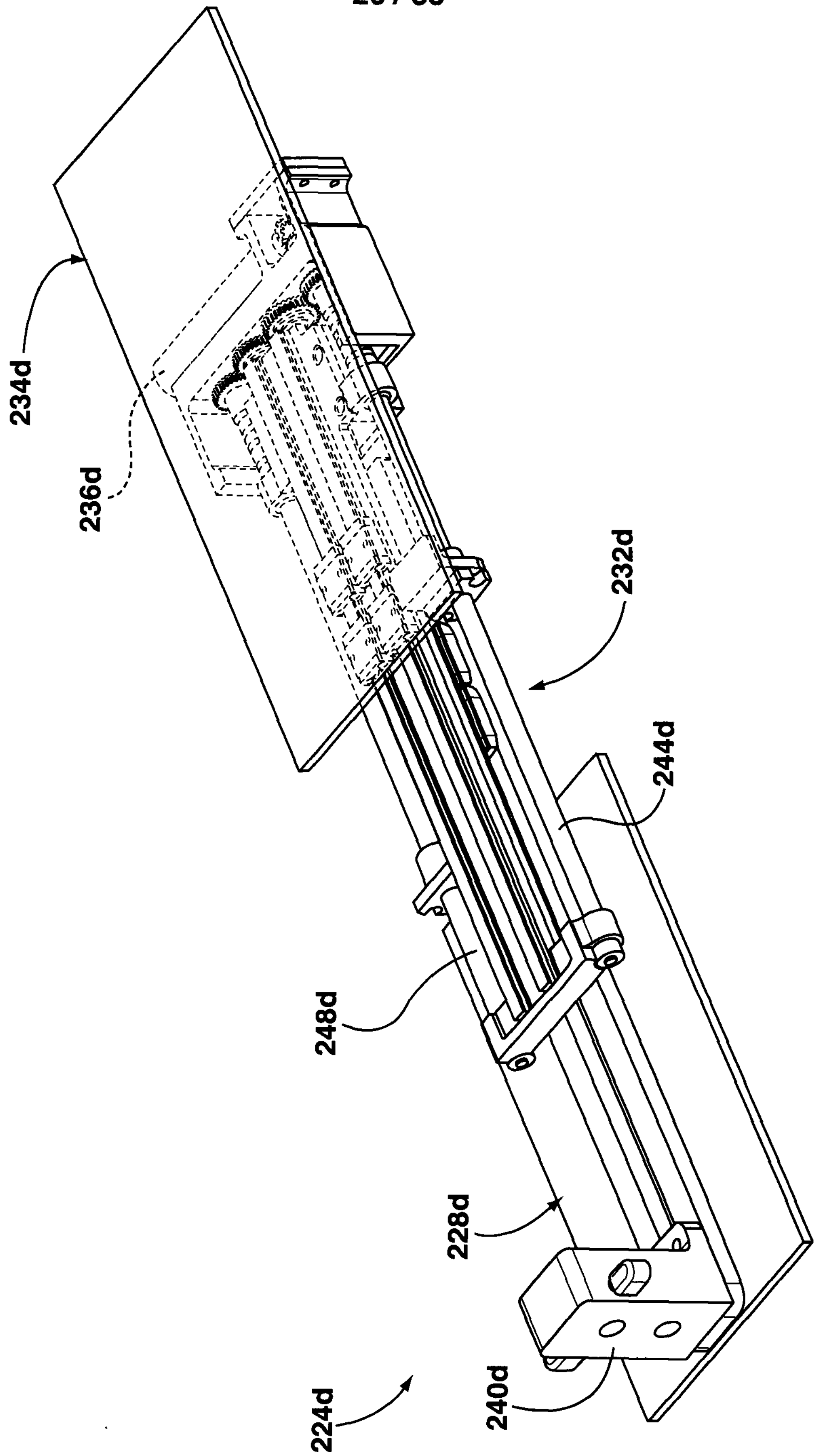

FIG. 26

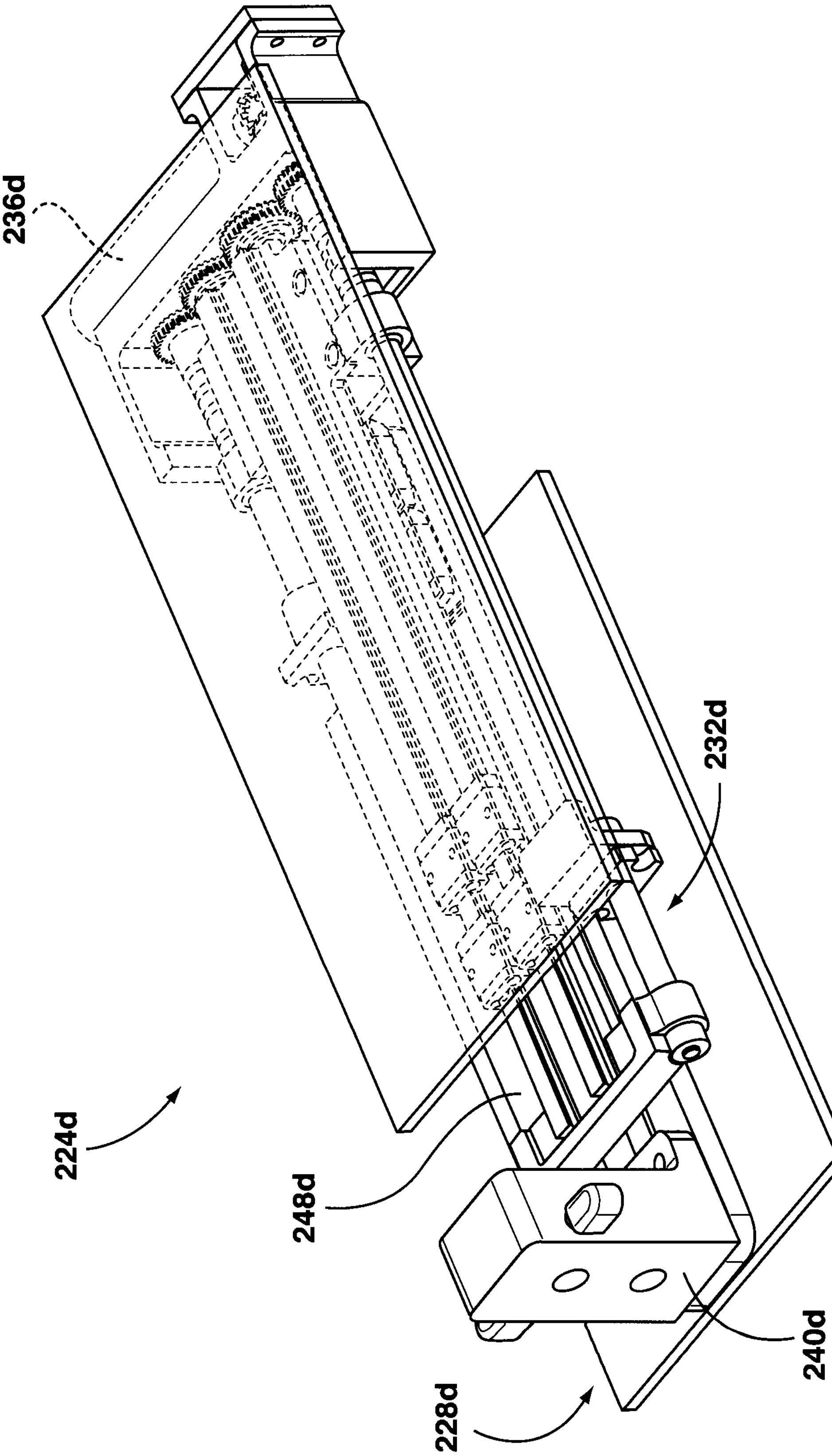

FIG. 27

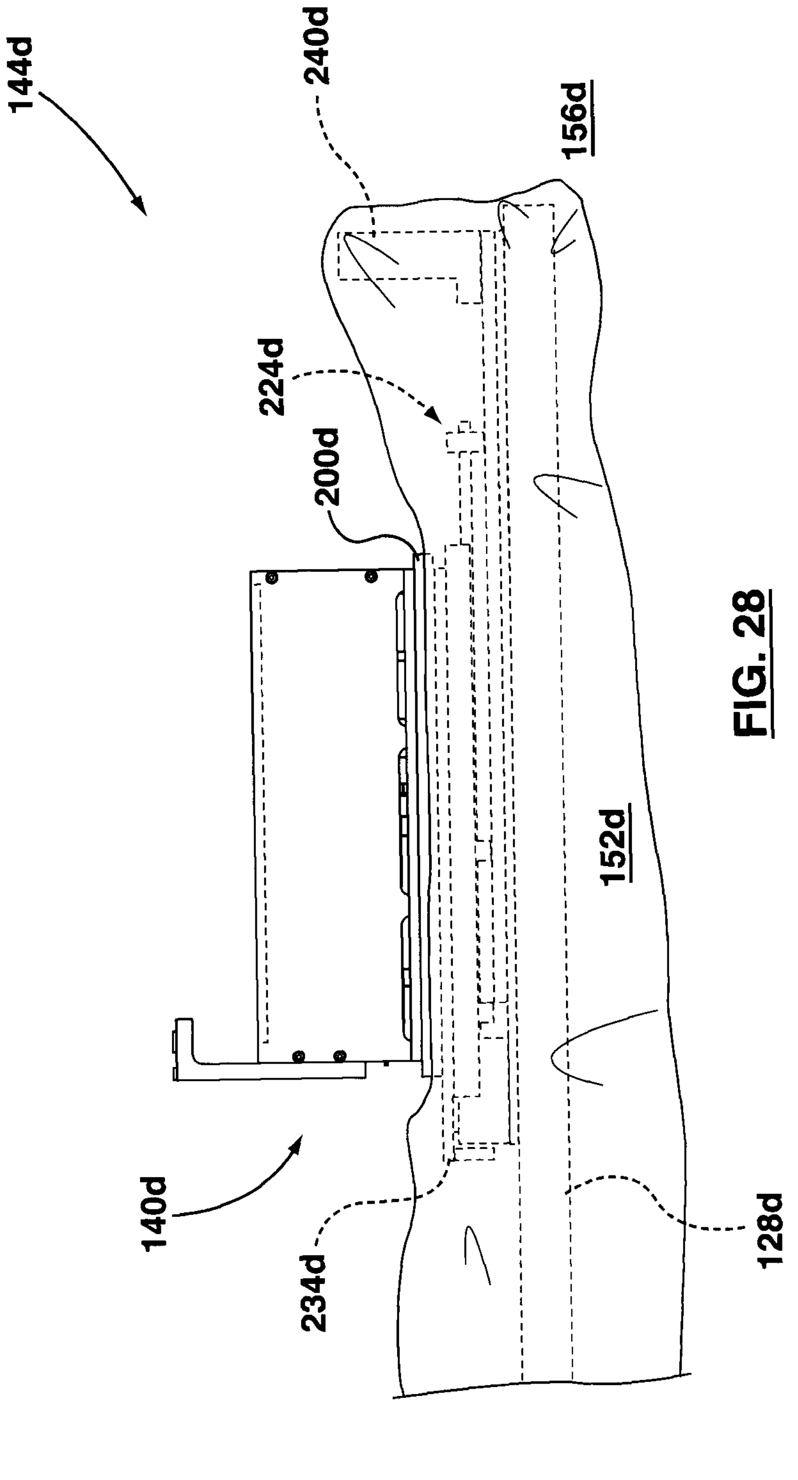

FIG. 28

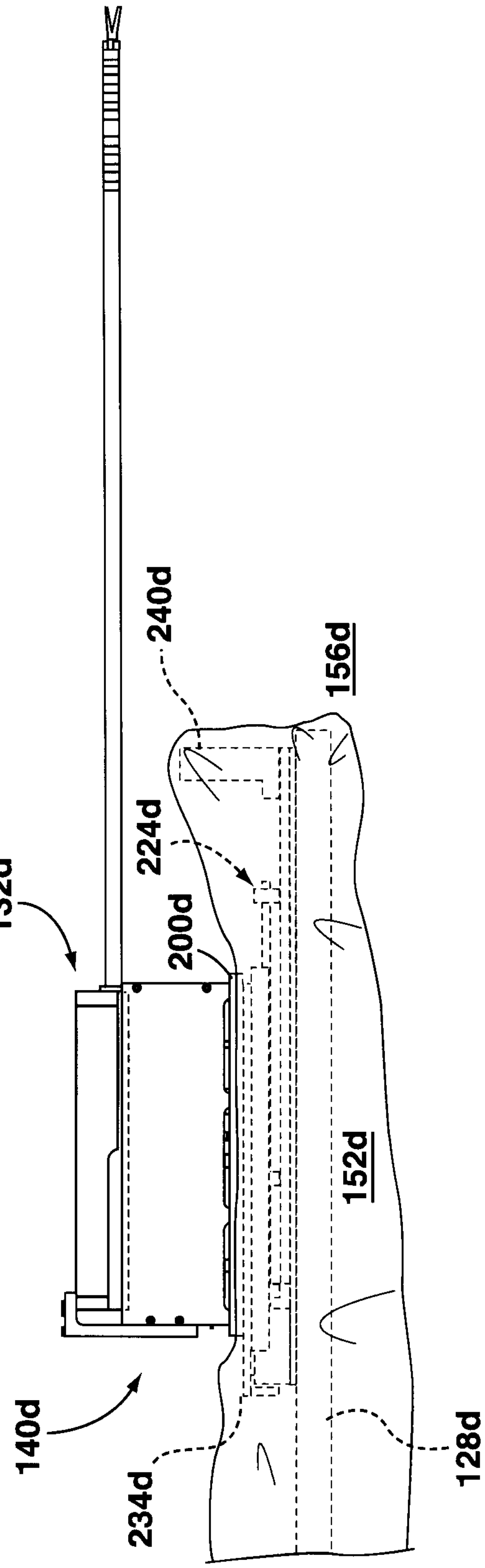

FIG. 29

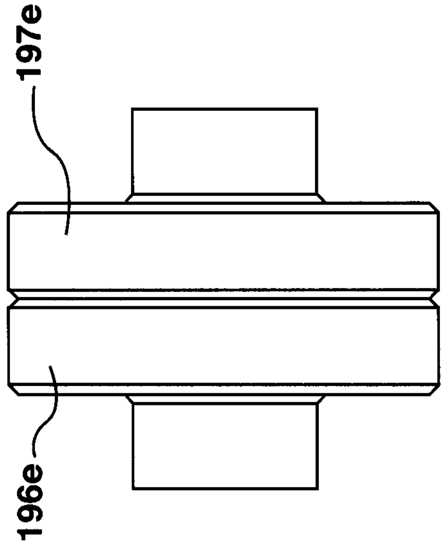

FIG. 30

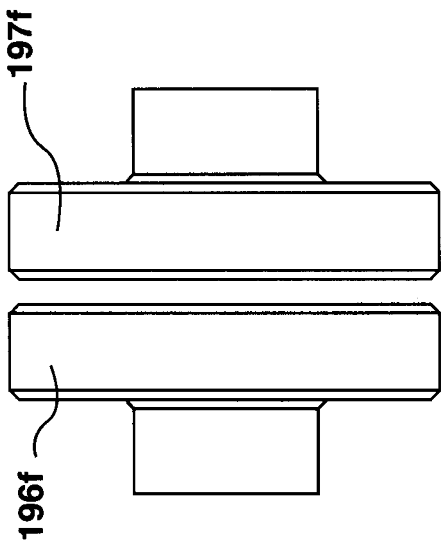

FIG. 31

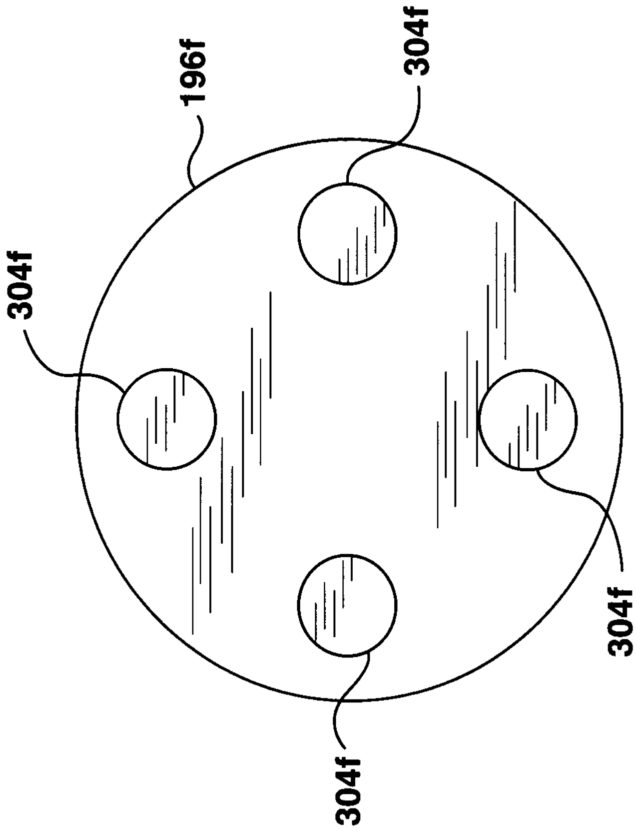

FIG. 32

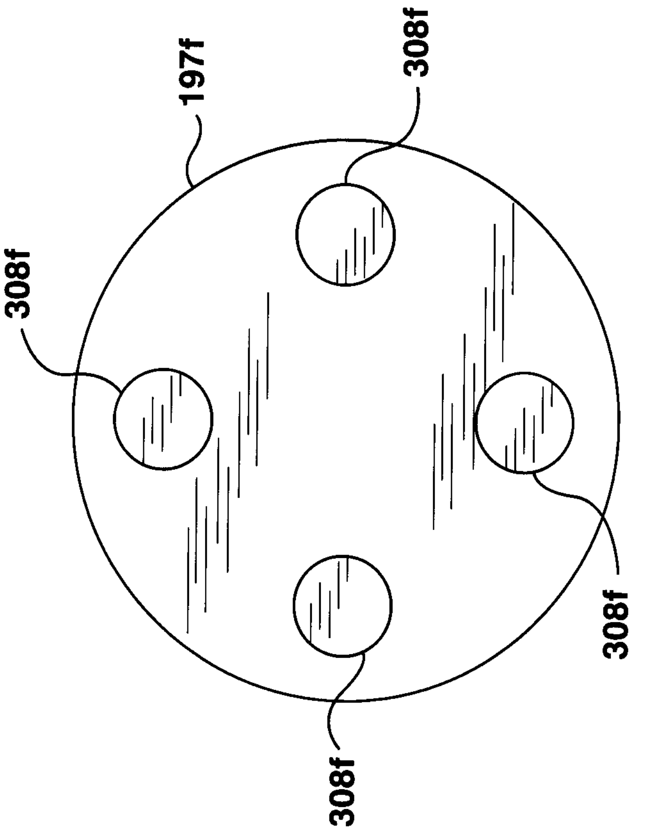

FIG. 33

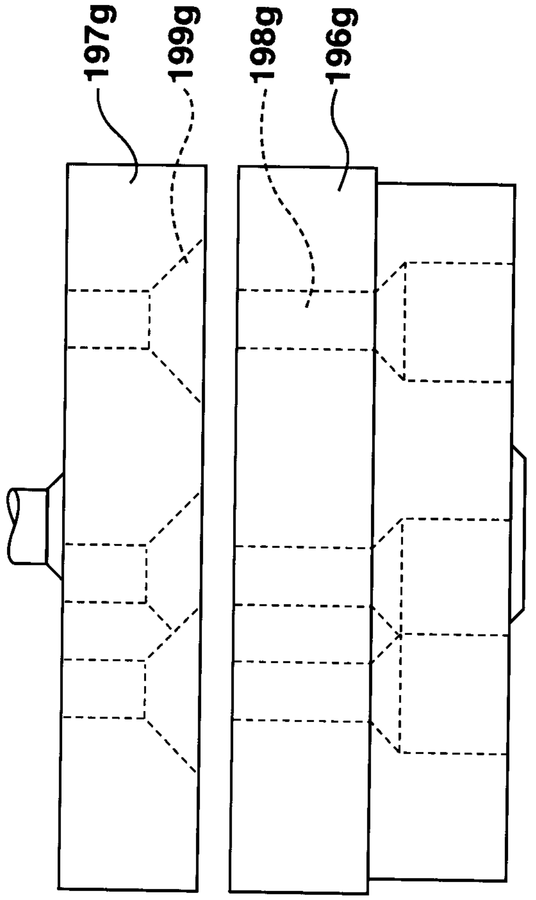

FIG. 34

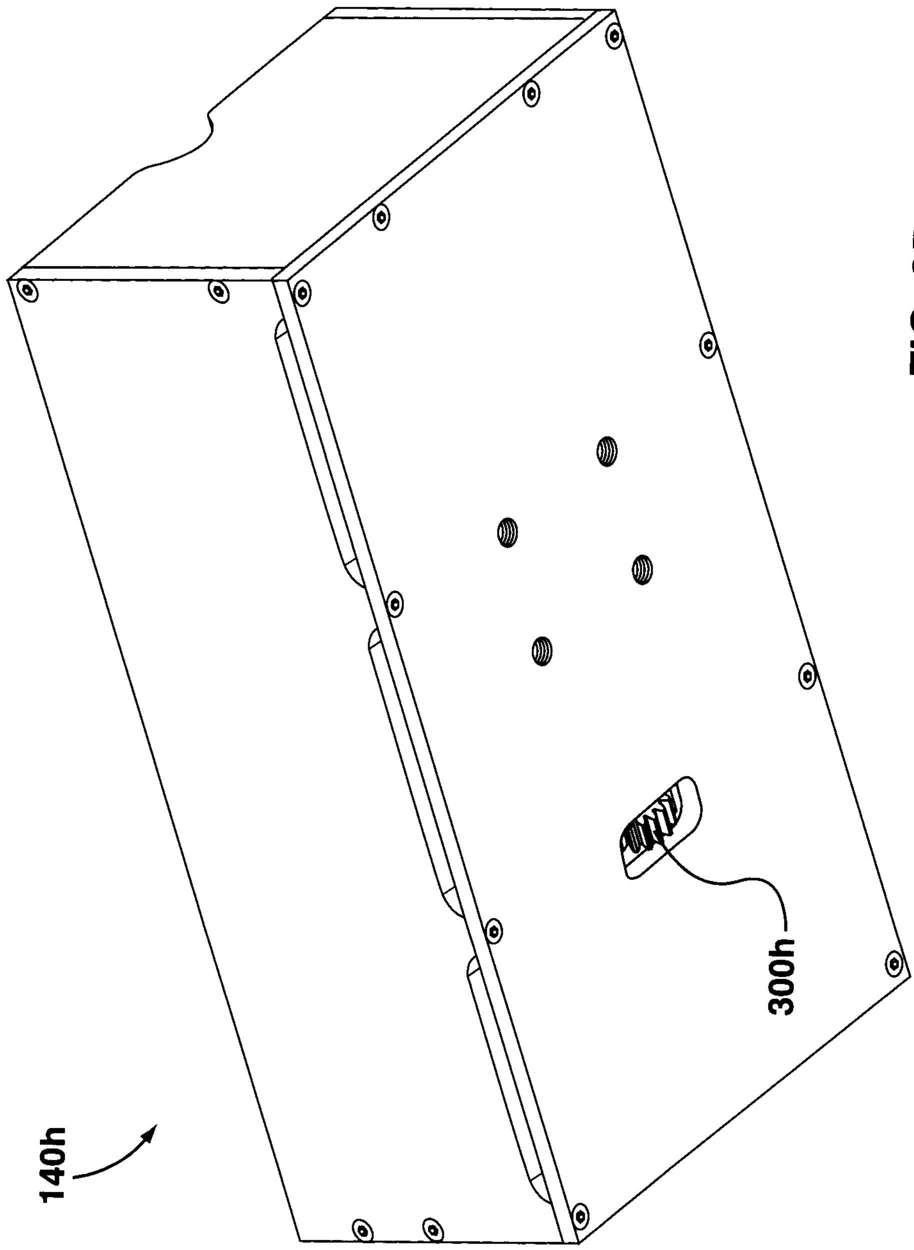

FIG. 35

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2011/001302

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B25J 9/10*** (2006.01) , ***B25J 19/00*** (2006.01) , ***B25J 3/04*** (2006.01) , ***B25J 5/02*** (2006.01) , ***B25J 9/00*** (2006.01) , ***B25J 9/16*** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: **B25J 9/10** (2006.01) , **B25J 19/00** (2006.01) , **B25J 3/04** (2006.01) , **B25J 5/02** (2006.01) , **B25J 9/00** (2006.01) , **B25J 9/16** (2006.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Data Bases: Canadian Patent Database, Total Patent, Epoque. **Search Terms Used:** robotic, automatic, instrument, housing, drive, arm, sterile, linear, translation, adaptor, electrical, data, signal, cables, power.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	CA2222150C (SRI INTERNATIONAL) 16 September 2008 (16-09-2008)	1- 4, 25 and 27 5- 24, 26
Y	US2007/00883340A1 (HANSEN MEDICAL INC) 19 April 2007 (19-04-2007)	11- 22
Y	US2009/0248039A1 (COOPER ET AL) 01 October 2009 (01-10-2009)	11- 22
Y	WO9825666 (INTUITIVE SURGICAL INC) 18 June 1998 (18-06-1998)	11-22
Y	US2006/0235436A1 (INTUITIVE SURGICAL INC) 19 October 2006 (19-10-2006)	11- 22
Y	WO0030548A1 (INTUITIVE SURGICAL INC) 2 June 2000 (02-06-2000)	23, 24, 26
Y	US5382885 (SALCUDEAN ET AL) 17 January 1995 (17-01-1995)	23, 24, 26
A	CA1239167 (MOSHER) 12 July 1988 (12-07-1988)	1-27

[ ] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
22 August 2012 (22-08-2012)

Date of mailing of the international search report
31 August 2012 (31-08-2012)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
Place du Portage I, C114 - 1st Floor, Box PCT
50 Victoria Street
Gatineau, Quebec K1A 0C9
Facsimile No.: 001-819-953-2476

Authorized officer
Charles W. Wootton (819) 997-2763

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of the first sheet)

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

1. [ ] Claim Nos. :
because they relate to subject matter not required to be searched by this Authority, namely :

2. [ ] Claim Nos. :
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically :

3. [ ] Claim Nos. :
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. [ ] As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claim Nos. :
4. [X] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim Nos. : 1- 27.

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

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
CA2222150C	16 September 2008 (16-09-2008)	None	
US20070088334A1	19 April 2007 (19-04-2007)	None	
US20090248039A1	01 October 2009 (01-10-2009)	None	
WO9825666A1	18 June 1998 (18-06-1998)	AT155059T	15 July 1997 (15-07-1997)
		AT215430T	15 April 2002 (15-04-2002)
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