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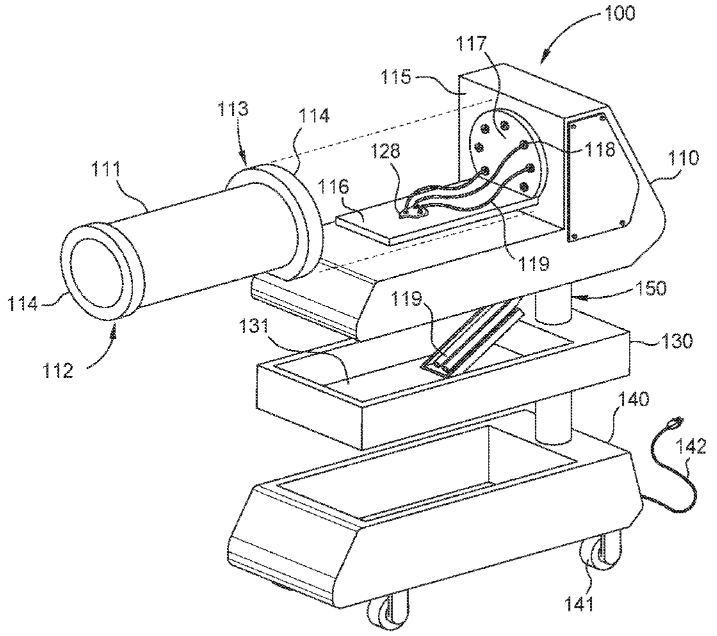

FIG. 1

(57) Abstract: The present disclosure provides a modular system for preserving and transporting living organs extracorporeally, comprising an organ monitoring and support module configured to engage with a removable chamber for housing an organ to be transplanted at a pressure of greater than or equal to two to three bars atmospheric, a fluid module configured to store for supply to the organ monitoring and support module one or more fluids, and a power module for supplying power to the organ monitoring and support module and the fluid module. The organ monitoring and support module, the fluid module, and the power module are movably coupled to each other. The disclosed system allows for control of pressure, temperature, and fluid management in the environment surrounding the organ.

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MODULAR HYPERBARIC ORGAN PRESERVATION AND TRANSPORT SYSTEM

INTRODUCTION

FIELD

[0001] This disclosure relates to modular systems for the preservation and transport of living organs and tissues extracorporeally such as is required pending transplantation of organs from one being to another. The disclosed system allows for control of pressure, temperature, and fluid management in the environment surrounding the organ. The present disclosure refers generally to “organs;” however, the present disclosure contemplates that the disclosed systems are useful for preservation and transportation of organs as well as other body tissues.

BACKGROUND

[0002] Organ transplantation and preservation is a field of increasing importance due to the advances in the medical arts and sciences related to organ transplants, which have made it possible to transplant a variety of living tissues and organs. It is generally recognized in the art that preservation of living tissue is most effective if the tissue is immersed in a perfusate, nutrient liquid, and is maintained in a thermally-controlled, hyperbaric environment.

[0003] It has been found to be desirable for effective preservation and transport to provide a chamber wherein the temperature is typically near freezing (e.g., 2-8 degrees C) and the pressure is from two to three bars or more above ambient atmospheric pressure. Furthermore, it is desirable to perfuse the organ with plasma or other similar fluid, which provides the necessary nutrients and oxygen to the organ. This perfusate may also contain additives such as hormones, steroids, penicillin, antibiotics or the like to treat specific conditions found in the organ being preserved. Prior art systems generally provided a hyperbaric chamber for storing the organ under the prescribed environmental conditions and a closed, pressurized reservoir and conduit system as a source of perfusate.

[0004] When an organ is being preserved in this manner, the attending physician may require that the perfusate be modified as, for example, to include additives or change the basic composition of the fluid. In the past, the perfusate and the preservation chamber were maintained at equilibrium pressures, either both under hyperbaric conditions or both at ambient pressure. Since it is desirable to provide a hyperbaric environment for the organ, prior preservation systems were closed, pressurized systems, wherein both the perfusate and the preservation chamber were maintained at elevated pressures. In these past systems, it is generally necessary to depressurize the entire system, including the organ preservation chamber, in order to change or modify the perfusate.

[0005] It is well known that depressurization of the organ must be done carefully to avoid creating gassy embolisms in the organ tissues. These past systems all lacked modularity and suffered from the highly undesirable requirement of having to follow carefully prescribed and time consuming procedures for depressurizing the preservation system each time it was necessary or desired to modify or test the perfusate. The past systems were not configured to allow for control of pressure, temperature, and fluid management in the environment surrounding the organ.

SUMMARY

[0006] The present disclosure provides a modular system for preserving and transporting living organs extracorporeally, comprising an organ monitoring and support module configured to engage with a removable chamber for housing an organ to be transplanted at a pressure of greater than or equal to two to three bars atmospheric, a fluid module configured to store for supply to the organ monitoring and support module one or more fluids, and a power module for supplying power to the organ monitoring and support module and the fluid module. The organ monitoring and support module, the fluid module, and the power module are movably coupled to each other.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] So that the manner in which the above-recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only exemplary embodiments and are therefore not to be considered limiting of its scope, which may admit to other equally effective embodiments.

[0008] FIG. 1 illustrates a first perspective view of a modular hyperbaric organ preservation and transportation system, according to certain embodiments of the present disclosure.

[0009] FIG. 2 illustrates a second perspective view of the modular hyperbaric organ preservation and transportation system in FIG. 1, according to certain embodiments of the present disclosure.

[0010] FIG. 3 illustrates a cross-sectional side view of a portion of the modular hyperbaric organ preservation and transportation system in FIGs. 1 and 2, according to certain embodiments of the present disclosure.

[0011] FIG. 4A illustrates a side schematic view of a portion of the modular hyperbaric organ preservation and transportation system in FIGs. 1 and 2, according to certain embodiments of the present disclosure.

[0012] FIG. 4B illustrates a perspective view of the portion of the modular hyperbaric organ preservation and transportation system in FIG. 4A, according to certain embodiments of the present disclosure.

[0013] FIG. 5 illustrates a perspective view of a portion of the modular hyperbaric organ preservation and transportation system in FIGs. 1 and 2, according to certain embodiments of the present disclosure.

[0014] FIG. 6 illustrates a cross-sectional side view of a portion of the modular hyperbaric organ preservation and transportation system in FIGs. 1 and 2, according to certain embodiments of the present disclosure.

[0015] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0016] FIGs. 1 and 2 depict perspective views of a modular hyperbaric organ preservation and transportation system 100 (sometimes referred to herein as “system 100”) for transporting and storing an organ (shown as 128 in FIG. 1) under pressure, which enables the organ 128 to reside extracorporeally for an increased period of time relative to an organ not stored under pressure. By increasing the time the organ 128 can remain viable extracorporeally, the organ 128 can be transported greater distances and thus may be available to a wider range of individuals awaiting a necessary organ transplant. In use, medical personnel generally place an organ in the modular hyperbaric organ preservation and transport system 100 and then apply pressure to the organ. In some embodiments, the pressure profile to be applied to the organ is established before the organ is placed in the system 100. Next, medical personnel generally treat the organ, for example by administering fluids to the organ, and/or monitor the organ, during, e.g., transport. Then, at the appropriate time, medical personnel carefully decompress the modular hyperbaric organ preservation and transport system 100, remove the organ from the system 100, and proceed to place the organ in the patient, if appropriate.

[0017] The modular hyperbaric organ preservation and transportation system 100 includes an organ monitoring and support module 110, a fluid module 130, and a power module 140. As shown in FIGs. 1 and 2, each of the modules (110, 130, and 140) is coupled to a support column 150 at different positions along a length of the support column 150. The support column 150 may be a single unitary piece or multiple, separable pieces. In some embodiments, the support column 150 is telescoping such that when extended, each of the modules 110, 130, and 140 is separated a distance apart for easy access to each of the modules. In some embodiments, each of the modules 110, 130, and 140 is rotatable around the support column 150 for easy access to each of the modules. Moreover, each of the modules 110, 130, and 140 may be detached from the modular hyperbaric organ preservation and transportation system 100 to operate independently.

[0018] Generally, the various components of the modular hyperbaric organ preservation and transportation system 100 are formed of robust and lightweight materials that facilitate easy transfer of the system into and out of, e.g., vehicles, and therefore facilitate easy transportation of the system between distant locations. Examples of such materials include lightweight metals, ceramics, polymers, and composites. In some embodiments, the materials of one or more components of the modular hyperbaric organ preservation and transportation system 100 are configured to be sterilized or chemically treated to allow the system to be transported into healthcare environments with reduced the risk of contamination. Components of the modular hyperbaric organ preservation and transportation system 100 that may come into contact with the organ 128 are constructed of suitable biocompatible materials, such as medical grade thermoplastics, so that the environment for the organ 128 will not be contaminated.

[0019] The organ monitoring and support module 110 is designed to support and engage a pressure-tight pressure module 111 for storing the organ 128 at pressure. In some embodiments, the pressure module 111 comprises a cylindrical container, or chamber, manufactured from a rigid and transparent or translucent material capable of withstanding interior pressures around two to three bars or more above ambient atmospheric pressure, including but not limited to acrylic, so that the organ 128 disposed therein is viewable. The pressure module 111 is configured to engage with the body 115 of the organ monitoring and support module 110, as well as an interface manifold plate 117. In one embodiment, the pressure module 111 includes rails attached thereto that slidingly engage with one or more tracks in the body 115 of the organ monitoring and support module 110.

[0020] The pressure module 111 includes a first end 112 and a second end 113, each of which may be reinforced with an aluminum ring 114 for mechanical support. The first end 112 and the second end 113 are configured to sealingly engage with the container of the pressure module 111 to maintain the targeted pressure in the pressure module 111. The second end 113 is designed to further engage interface manifold plate 117 and/or body 115. In some embodiments, the first end 112 and/or the second end 113 are removable such that the organ 128 may be easily put into, removed from, or manipulated within the pressure module 111. In some embodiments, the first end 112 or the second end 113 includes a transparent plate that is connected to the remainder of the container of pressure module 111 with one or more hinges such that the first end 112 or the second end 113 can be opened, like a door, for easy access to an organ disposed in the pressure module 111.

[0021] Generally, the pressure module 111 slides onto the body 115 to engage with the organ monitoring support module 110. When placed thereon, the pressure module 111 surrounds an organ support tray 116 and the second end 113 engages with the interface manifold plate 117, which serves as the system manifold. In some embodiments, the organ support tray 116 may removably couple to the interface manifold plate 117, the body 115, and/or the pressure module 111. Similarly, the interface manifold plate 117 may removably couple to the body 115. The organ support tray 116 and connection plate 118 may be formed of any suitable rigid and biocompatible materials configured to be thermally and/or chemically sterilized.

[0022] The interface manifold plate 117 includes one or more ports 118 through which one or more cables and/or lines may be sealingly disposed for supplying the pressure module 111 and the organ 128 with fluids during operation, as well as for providing power and/or electrical signals to one or more sensors and/or other electronics within the pressure module 111. For example, the ports 118 may facilitate extension of one or more fluid lines 119 from an environment external to the pressure module 111 to an environment within the pressure module 111 when the pressure module 111 is engaged with the interface manifold plate 117. The fluid lines 119 are configured to deliver liquids and/or gasses to the organ 128 in the pressure module 111. The fluid lines 119 extend through the ports 118 and down into the fluid module 130, where they may removably couple to one or more liquid and/or gas sources for supplying the liquids and/or gasses. The ports 118 may comprise one or more self-sealing features, thereby enabling the fluid lines 119 to be extended through the ports 118 one at a time during use.

[0023] Generally, the fluid lines 119 may be formed of any suitable flexible and biocompatible materials. In some embodiments, the fluid lines 119 are disposable and may be configured for single use. In some embodiments, the fluid lines 119 are disposed within protective sleeving to enable manipulation of the lines without causing damage or creasing thereto. Examples of suitable types of protective sleeving include tube sleeving, braided sleeving, corrugated sleeving, spiral sleeving, wraparound sleeving, and drag chain sleeving. The interchangeability and disposability of these components of the system 100 beneficially reduce the need for system downtime to clean the components.

[0024] As shown in FIG. 2, the organ monitoring and support module 110 further includes a dashboard 120 (e.g., a user interface) which may include a display screen 121, buttons or knobs 122, and keys 123 (or other user input devices or mechanisms) for monitoring and controlling parameters of the modular hyperbaric organ preservation and transportation system 100, such as pressure, temperature, fluids, and gasses. Handles 124 may also be included to facilitate navigating the modular hyperbaric organ preservation and transportation system 100 when it is being transported.

[0025] The organ monitoring and support module 110 also includes a monitoring tray 125 with a cavity 126 that facilitates mounting and support/storage for various monitoring devices, such as fluid and oxygen sensors or other devices for monitoring the condition of the organ 128. The monitoring devices may be wired or wirelessly coupled to probes disposed within the pressure module 111 during operation, which may provide to the monitoring devices analogue or digital electrical signals indicative of organ environmental conditions such as organ temperature, transcutaneous gas pressure, and tissue oxygen partial pressure. Data collected by the monitoring devices supported on monitoring tray 125 may be displayed for a user on the display screen 121.

[0026] Like the dashboard 120, the monitoring tray 125 includes handles 127 such that the monitoring tray 125 may be pulled out of and pushed into the organ monitoring and support module 110, similar to a drawer, for space optimization and compactness of the organ monitoring and support module 110 during transport.

[0027] The fluid module 130 includes a cavity 131 for storing fluid sources (e.g., liquid and gas sources), as well as portions of the fluid lines 119 to supply the stored fluids to the organ monitoring and support module 110. The cavity 131 may be temperature controlled, via a refrigeration unit, to accommodate the fluids being used. This provides for improved thermal regulation of the organ 128 by enabling control of the temperature of the fluids in which the organ 128 is immersed. The refrigeration unit may include any suitable regulated fluid refrigeration apparatus which uses a coolant such as Freon circulated through a heat exchanger to effect and control the temperature of fluids in the cavity 131. The refrigeration unit includes a temperature-sensing element to sense the temperature of fluids, such as perfusate, and a suitable thermostat to form a temperature control signal to maintain the temperature of fluids within a prescribed range. The refrigeration unit may be any suitable refrigeration system such as are known in the art which is capable of maintaining the temperature of fluids near freezing (e.g., 2-8 degrees C) at ambient pressure. If desired, the heat exchanger of the refrigeration unit can be mounted on the body 115 and configured to be disposed within the pressure module 111 during operation rather than the cavity 131, since the object and function of the refrigeration unit is to maintain the temperature of the organ 128 indirectly by cooling the fluids the organ 128 is immersed in.

[0028] Gas sources of the fluid module 130 may include any suitable apparatus for providing regulated high-pressure gas, such as oxygen, as is known in the art. In some embodiments, the gas sources include a source of high-pressure gas, such as a gas canister, a regulator, gas supply conduit, and gas vent conduit. The regulator may include any suitable pressure gauges and control mechanisms to enable the operator to set, adjust and monitor the gas pressure in the pressure module 111 when engaged with the body 115.

[0029] The cavity 131 includes a fluid receptacle for perfusate constructed of any suitable material and in any particular shape or configuration as desired. In some embodiments, the fluid receptacle is constructed with material having a low thermal conductivity to facilitate the refrigeration of perfusate. Thus, the temperature-sensing element of the refrigeration unit described above can alternatively be mounted within the cavity 131 or within/adjacent to the organ 128. The fluid receptacle of the cavity 131 is provided with an outlet and a return inlet suitably located below the normal perfusate level to permit perfusate to circulate from the fluid receptacle to the pressure module 111 and back to the fluid receptacle via the fluid lines 119.

[0030] It is contemplated that the modular hyperbaric organ preservation and transportation system 100 will include a supply system comprising at least two fluid and/or gas supply loops: one loop for managing fluid and/or gas supply to the organ 128, and one loop for managing fluid and/or gas supply to the environment surrounding the organ 128 within the pressure module 111. Generally, the supply system of the modular hyperbaric organ preservation and transportation system 100 includes one or more pumps, check valves, backpressure regulators, and the fluid lines 119. The pumps provide fluid pressure to circulate fluids, such as perfusate, from the fluid sources in the fluid module 130 to the pressure module 111 and may include any suitable pumps capable of providing sufficient fluid pressure to deliver fluids the pressure module 111 when the pressure module 111 is pressurized from around two (2) to three (3) bars or more above the ambient pressure of the fluid sources of the fluid module 130. In some embodiments, the pumps provide a steady flow of fluids to the pressure module 111, but other types of pumps can be used to provide pulsating flow of fluids if desired. Selection of the particular type of pumps to be used is dependent upon the volume of fluids that is necessary to circulate via the fluid lines 119, as well as other factors that are known to those of ordinary skill in the art and thus need not be described herein.

[0031] The fluid lines 119 are in fluid communication with the fluid sources in the cavity 131 via one or more outlets and return inlets, and with the pressure module 111 via one or more check valves and the ports 118 of the interface manifold plate 117. The check valves and ports 118 allow unidirectional flow of fluids, such as perfusate, from the fluid lines 119 into pressure module 111 in response to fluid pressure provided by the one or more pumps of the supply system. The check valve(s) prevent fluid flow from the pressure module 111 and thus isolate hyperbaric pressure module 111 from the ambient pressure of the fluid sources in the fluid module 130.

[0032] The backpressure regulators may include any suitable pressure regulators and relief valve mechanisms which sense the pressure in the pressure module 111 and open to maintain a prescribed fluid pressure differential between pressure module 111 and the fluid sources in the fluid module 130. The backpressure regulators permit return circulation of effluent fluids to the fluid module 130 via the fluid lines 119, the ports 118 in the interface manifold plate 117, and inlets of the fluid sources. If desired, a filter unit or filtration means may be included interposed between the fluid lines 119 and the fluid sources to remove organ by-products and impurities from effluent fluids. Thus, the backpressure regulators and fluid lines 119 form a perfusate return means of the present disclosure. Alternatively, the perfusate return means may include fixed or variable in-line orifices that may be mounted in flow communication with the fluid lines 119 for providing backpressure control, eliminating the need for backpressure regulators if desired. Filters may be any suitable gas or liquid filters, such as plasma filters, as are commonly available. Furthermore, flow meters are positioned in fluid communication with the fluid lines 119 for determining the volumetric amount of fluid, such as perfusate (hence the quantity of additives such as vitamins, minerals, antibiotics and all types of metabolic additives), available to the organ 128.

[0033] The power module 140 includes a power supply for the modular hyperbaric organ preservation and transportation system 100. In some embodiments, the power supply may be a battery, including but not limited to a rechargeable battery such as a lithium ion battery. In some embodiments, the modular hyperbaric organ preservation and transportation system 100 is AC/DC-powered and the power module 140 includes an AC/DC adapter or converter that may be plugged into an outlet via a power cord 142. It is further contemplated that the modular hyperbaric organ preservation and transportation system 100 may be both battery and AC/DC-powered. In the embodiments of FIGs. 1 and 2, the power module 140 is supported on a plurality of wheels 141, which enable rolling of the modular hyperbaric organ preservation and transportation system 100 for easy transport thereof.

[0034] In one embodiment, one or more gases to be supplied to the system 100 may be stored in the power module 140. For example, the power module 140 may store one or more oxygen tanks.

[0035] Turning to FIG. 3, a cross-sectional side view of the pressure module 111 and organ support tray 116 is illustrated, according to certain embodiments of the present disclosure. As shown, the organ support tray 116 may removably couple to the pressure module 111 and/or the interface manifold plate 117. The organ support tray 116 may include any suitable type of receptacle formed of rigid and biocompatible materials for supporting the organ 128 and/or a bath of perfusate 132, within which the organ 128 may be disposed. In some embodiments, the organ support tray 116 comprises a bin or tub having a horizontal bottom wall 160 sealingly coupled to one or more vertical side walls 161 for supporting the organ 128 in the bath of perfusate 132. The perfusate 132 may be supplied via the internal fluid lines 119, which may have distal or terminal ends disposed within the organ support tray 116 during use.

[0036] FIGS. 4A and 4B illustrate various views of the organ monitoring and support module 110, including the monitoring tray 125, according to certain embodiments of the present disclosure. As noted above, the monitoring tray 125 includes a cavity 126 for mounting and support/storage of various monitoring devices 154 for monitoring the condition of the organ 128. The monitoring devices 154 may be wired or wirelessly coupled to one or more probes 152 configured to be disposed within the pressure module 111 during operation of the modular hyperbaric organ preservation and transportation system 100. Such probes 152 may include, for example, oxygen and other fluid sensors.

[0037] In FIGS. 4A and 4B, the monitoring devices 154 are coupled to probes 152 via cables 153 extending between the monitoring devices 154 and probes 152 and through the ports 118 in the interface manifold plate 117. The cables 153 sheathe electrical wiring for transmitting signals between the probes 152 and monitoring devices 154. The cables 153 may be formed of suitable biocompatible materials. To facilitate sliding of the monitoring tray 125 into/from the body 115 of organ monitoring and support module 110, the cavity 126 may include one or more cable management devices 155 for facilitating organization and extension/collapse of the cables 153 when sliding the monitoring tray 125. The cables 153 may also be disposed within sleeving, such as collapsible drag chain sleeving, to prevent damage to the cables 153 as the monitoring tray 125 is extended from or retracted into the body 115. For easy access to the cables 153 and setup/connection thereof to the ports 118 and/or monitoring devices 154, the body 115 of the organ monitoring and support module 110 may include removable side panels 151.

[0038] In some embodiments, other support systems and devices, such as pumps, check/relief valves, and backpressure regulators, may also be mounted and/or stored in the cavity 126 of monitoring tray 125. For example, in some embodiments, the fluid lines 119 may be operably coupled with pumps, check/relief valves, and/or backpressure regulators within the monitoring tray 125.

[0039] As shown in FIG. 5, the system 100 may also be configured to support a robotic arm 170 having an end effector 171. The robotic arm 170 may be removably coupled to the interface manifold plate 117 and/or the body 115 of organ monitoring and support module 110. The end effector 171 may comprise any suitable end effector device for interacting with the organ 128, such as jaws, claws, grippers (e.g., Bernouilli grippers), or the like. In operation, the robotic arm 170 can be used to stabilize, manipulate, or stimulate an organ disposed in the system 100 for preservation and transportation. The robotic arm 170 is generally configured for at least rotational movement and lateral movement. For example, in certain embodiments, the robotic arm 170 comprises a serial robotic arm having a plurality of links 172 movably coupled by linear and/or revolute joints 174. In certain embodiments, the linear and/or revolute joints 174 may linearly translate along and/or rotate about one or more axes, including horizontal axis Z and vertical axis Y shown in FIG. 5, to facilitate 1-DOF, 2-DOF, 3-DOF, 4-DOF, 5-DOF, and/or 6-DOF for the robotic arm 170.

[0040] In certain embodiments, a fluid line 176 having a nozzle 178 at a terminal end thereof is coupled to, and in some examples, extends along, the robotic arm 170. The fluid line 176 may be fluidically coupled, through a port 118 in the interface manifold plate 117, to a fluid source in the fluid module 130 for supplying and delivering one or more fluids to the organ 128 through the nozzle 178. Such fluids may be utilized for stimulation of one or more tissues of the organ 128 during preservation and transport thereof.

[0041] Turning now to FIG. 6, a cross-sectional side view of the organ monitoring and support module 110 is shown, according to certain embodiments of the present disclosure. As mentioned above, the interface manifold plate 117 includes one or more ports 118 through which fluid lines 119 and cables 153 may be sealingly disposed for supplying the pressure module 111 and the organ 128 with fluids during operation, as well as for providing power and/or electrical signals to one or more probes 152 and/or other electronics within the pressure module 111. Each of the ports 118 may comprise a self-sealing feature that fluidically seals the respective port 118 with or without a fluid line 119 or cable 153 disposed therethrough. The self-sealing features facilitate an airtight seal around the environment within the pressure module 111, thus enabling the pressure module 111 to be maintained at elevated pressures (e.g., two (2) to three (3) bars or more) during use. In certain embodiments, the self-sealing features comprise taper seal connections 180, and/or the like. In certain embodiments, the self-sealing features comprise gland-type connections 182, and/or the like. In still further embodiments, the self-sealing features comprise push-in connectors, plugs, O-ring seals, sleeves, and/or the like.

[0042] In summary, the modular hyperbaric organ preservation and transportation system 100 provides a controlled hyperbaric environment for oxygen preservation wherein the organ 128 is bathed in fluids, including perfusate, provided from one or more ambient pressure fluid sources. In operation, the organ 128 is placed on organ support tray 116 and the pressure module 111 is slid over and engaged with organ monitoring and support module 110. A bath of perfusate may then be supplied to the organ support tray 116 and/or pressure module 111 from the fluid module 130 via fluid lines 119, and the organ 128 immersed in perfusate, which is generally life sustaining artificial blood plasma or similar liquid circulated from the fluid module 130 to the organ monitoring and support module 110. The pressure module 111 is then pressurized via supply of gasses from the fluid module 130 to provide a prescribed, hyperbaric environment for the organ 128. One or more regulators maintain the pressure inside the pressure module 111 at the prescribed level. In one embodiment, the pressure module 111 is maintained at a pressure of at least three (3) bars, which enhances preservation of the organ 128. The perfusate is circulated under pressure from the fluid module 130 to the pressure module 111 to provide oxygen, nutrients, and treatment to the organ 128 as is required. The temperature of the organ 128 is also controlled indirectly by controlling the temperature of the perfusate and/or other fluids supplied to the pressure module 111. These and other conditions of the organ 128 may be monitored via the dashboard 120.

[0043] Medical personnel may determine it is necessary to add, remove, or modify the constituents of the perfusate bath in which the organ 128 is immersed. Since fluid sources in the fluid module 130 are maintained at ambient pressure, the attendant need not depressurize any part of the modular hyperbaric organ preservation and transportation system 100 and in particular need not depressurize the pressure module 111. The modular hyperbaric organ preservation and transportation system 100 is thus a significant advance in the art which eliminates the need for time consuming depressurizing procedures and avoids difficulties such as the development of gassy embolisms when a modification of the perfusate is desired.

[0044] The embodiments of the system 100 disclosed herein are configured to allow for easy accessibility and interchangeability of various components thereof making the disclosed system 100 beneficial not only in terms of organ preservation and transportation, but also in terms of ease of use for medical professionals operating under high stress conditions during organ transplant procedures. System downtime is significantly reduced as a result of the accessibility and interchangeability of many components of the system 100.

[0045] While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. A modular system for preserving living organs extracorporeally, comprising:

an organ monitoring and support module configured to engage with a removable chamber for housing an organ to be transplanted at a pressure of greater than or equal to two bars atmospheric;

a fluid module configured to store for supply to the organ monitoring and support module one or more fluids; and

a power module for supplying power to the organ monitoring and support module and the fluid module, the organ monitoring and support module, the fluid module, and the power module being movably coupled to each other.

2. The modular system of claim 1, wherein the organ monitoring and support module comprises an interface manifold plate.

3. The modular system of claim 2, wherein the interface manifold plate has one or more ports through which one or more cables may be disposed for supplying fluids or gases from the fluid module to the organ housed in the removable chamber.

4. The modular system of claim 3, wherein the one or more cables are further coupled to the fluid module.

5. The modular system of claim 2, wherein removable chamber includes one or more sensors.

6. The modular system of claim 5, wherein the interface manifold plate further comprises one or more ports through which one or more cables may be disposed for supplying power or electrical signals to the one or more sensors.

7. The modular system of claim 2, wherein the removable chamber is a cylindrical chamber with a first end and a second end.

8. The modular system of claim 7, wherein the second end is configured to engage with the interface manifold plate.

9. The modular system of claim 7, wherein the cylindrical chamber is manufactured from a rigid and transparent or translucent material.

10. The modular system of claim 7, wherein the cylindrical chamber is configured to slidingly engage with the organ monitoring and support module via one or more rails attached to the removable chamber that engage with one or more tracks in the organ monitoring and support module.

11. The modular system of claim 1, wherein the organ monitoring and support module, the fluid module, and the power module being are movably coupled to a support column.

12. An organ monitoring and support module, comprising:

a body configured to couple to a removable chamber for housing an organ to be transplanted;

an organ support tray disposed on the body and configured to support the organ within the removable chamber when the removable chamber is coupled to the body; and

an interface manifold plate coupled to the body and comprising at least one port, the port configured to receive a fluid line for extension of the fluid line into the removable chamber when the removable chamber is coupled to the body.

13. The organ monitoring and support module of claim 12, further comprising the removable chamber.

14. The organ monitoring and support module of claim 13, wherein the removable chamber comprises a transparent or translucent chamber.

15. The organ monitoring and support module of claim 14, wherein:

the removable chamber comprises a first end and a second end, and

at least one of the first end and the second end can be opened to facilitate access to an interior of the removable chamber.

16. The organ monitoring and support module of claim 15, wherein at least one of the first end and the second end are reinforced with an aluminum ring.

17. The organ monitoring and support module of claim 13, wherein the removable chamber is configured to slide onto the body to couple to the body and surround the organ support tray.

18. The organ monitoring and support module of claim 12, wherein the port comprises a self-sealing port configured to provide an airtight seal around the fluid line.

19. The organ monitoring and support module of claim 12, further comprising an extendable tray for storing one or more electrical organ monitoring devices.

20. A method for preserving living organs extracorporeally, comprising:

placing an organ in a removable chamber for housing the organ that is coupled to an organ monitoring and support module;

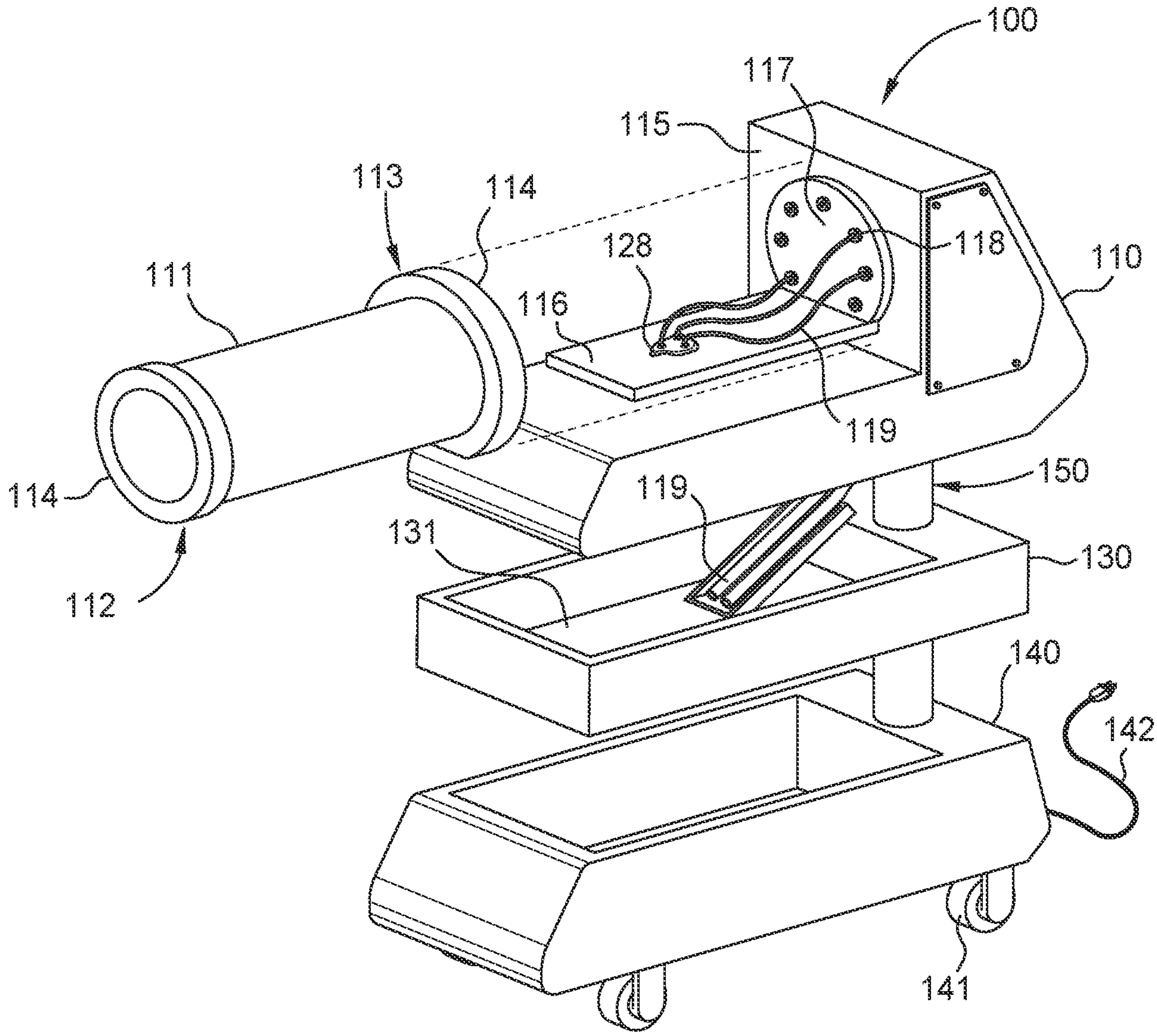
applying a pressure of greater than or equal to two bars atmospheric to the removable chamber;

supplying fluids or gases to the organ in the removable chamber;

monitoring the organ in the removable chamber;

carefully decompressing the removable chamber; and

removing the organ from the removable chamber.


100
117
115
113
114
118
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128
111
116
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114
150
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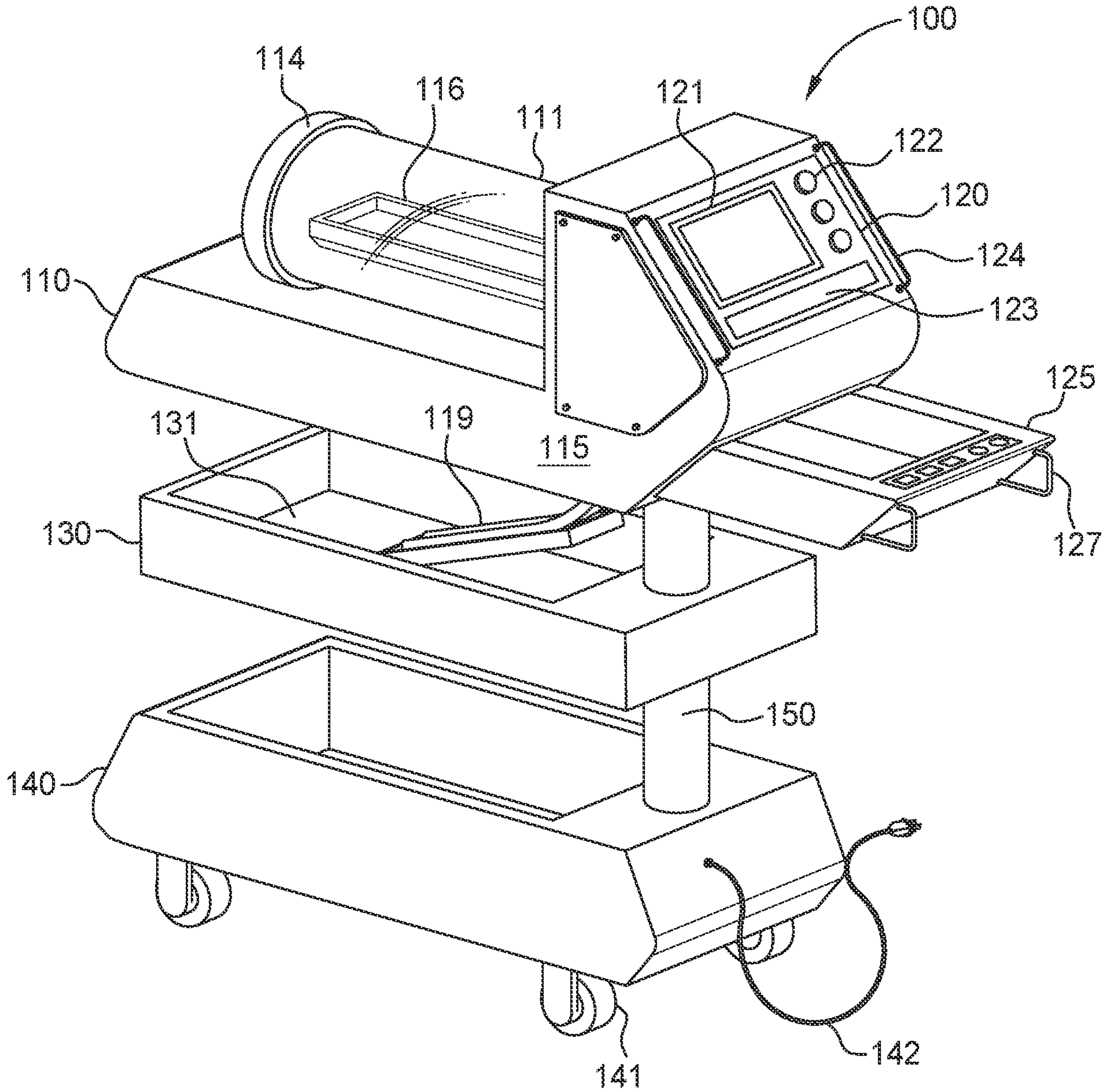
131
130
112
140
142
141

FIG. 1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150
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142
141

FIG. 2

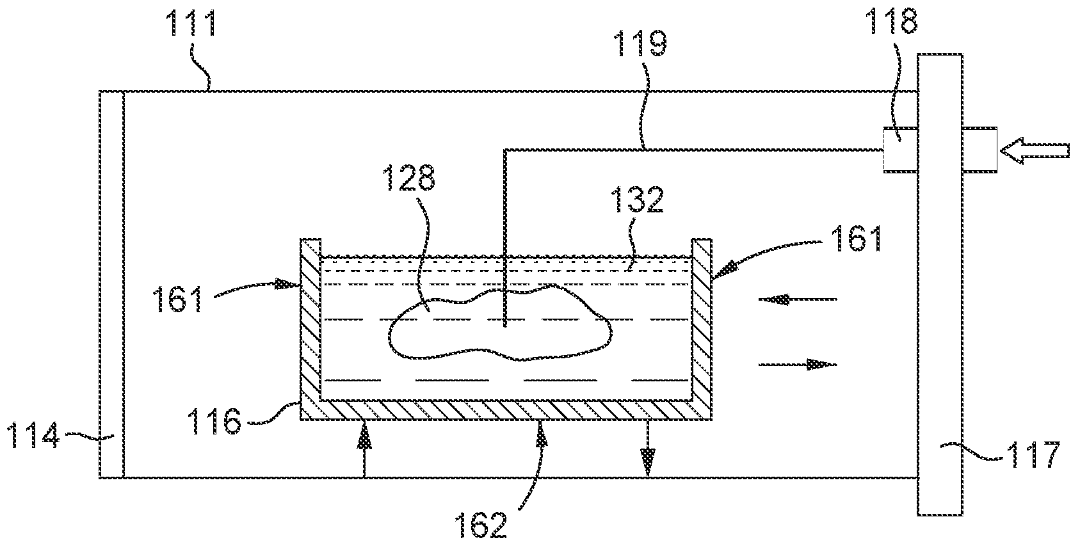
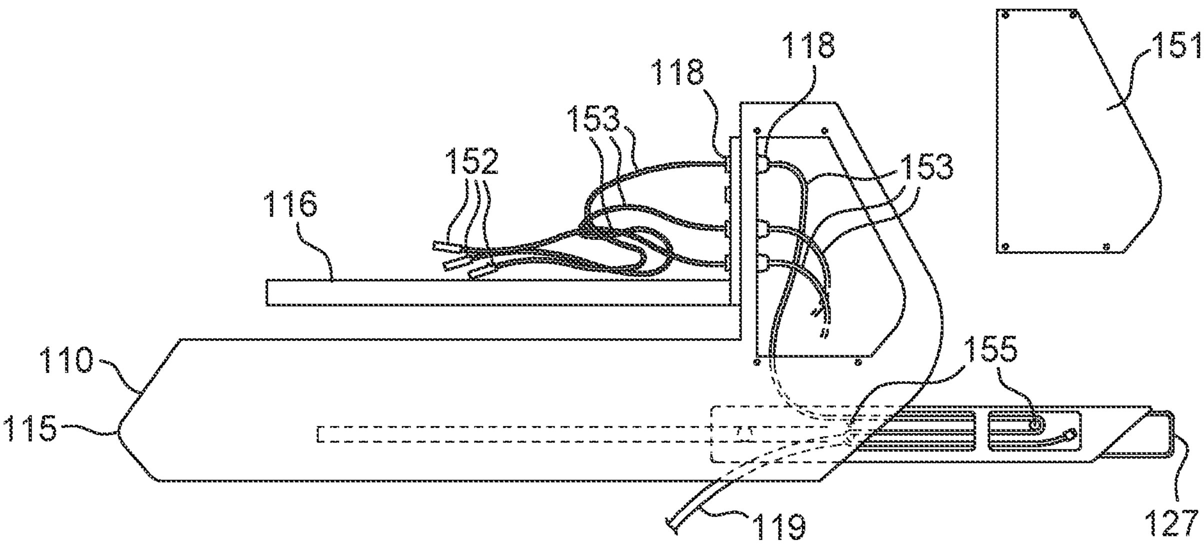


FIG. 3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152
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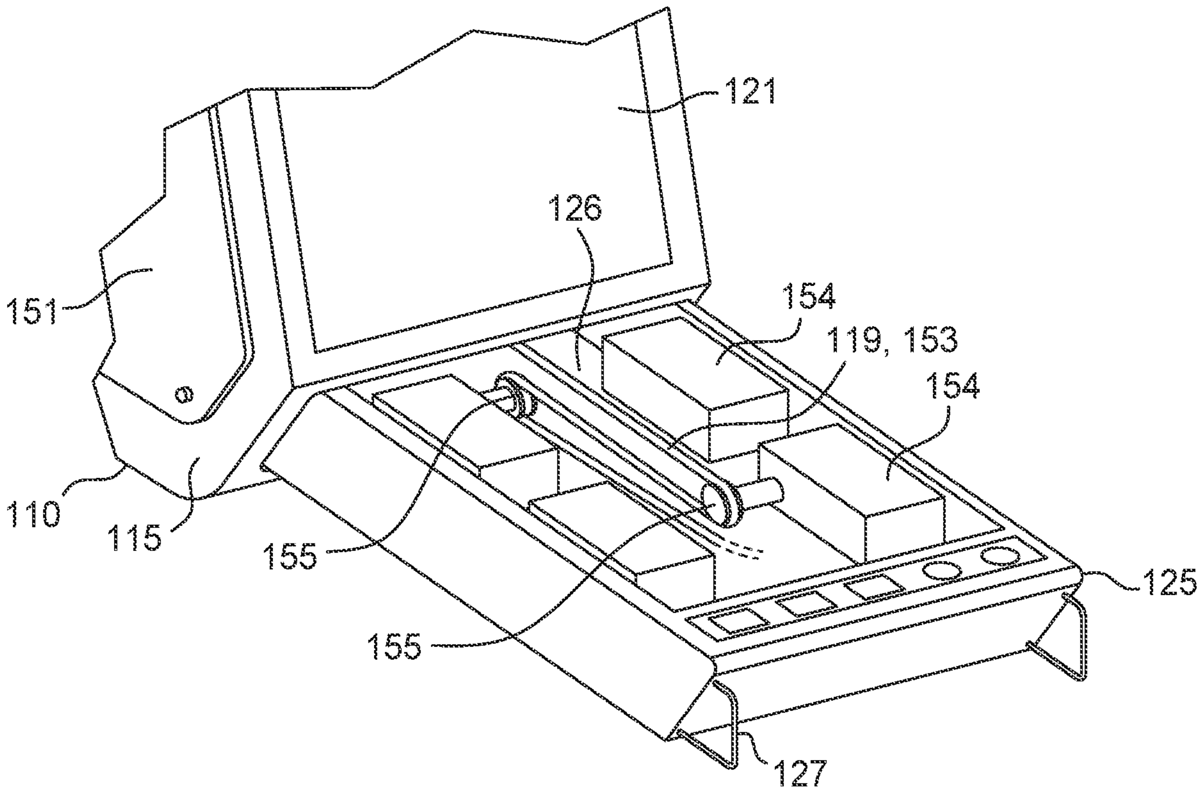
116
153
110
155
115
119
127

FIG. 4A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119, 153
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115
155
125
155
127

FIG. 4B

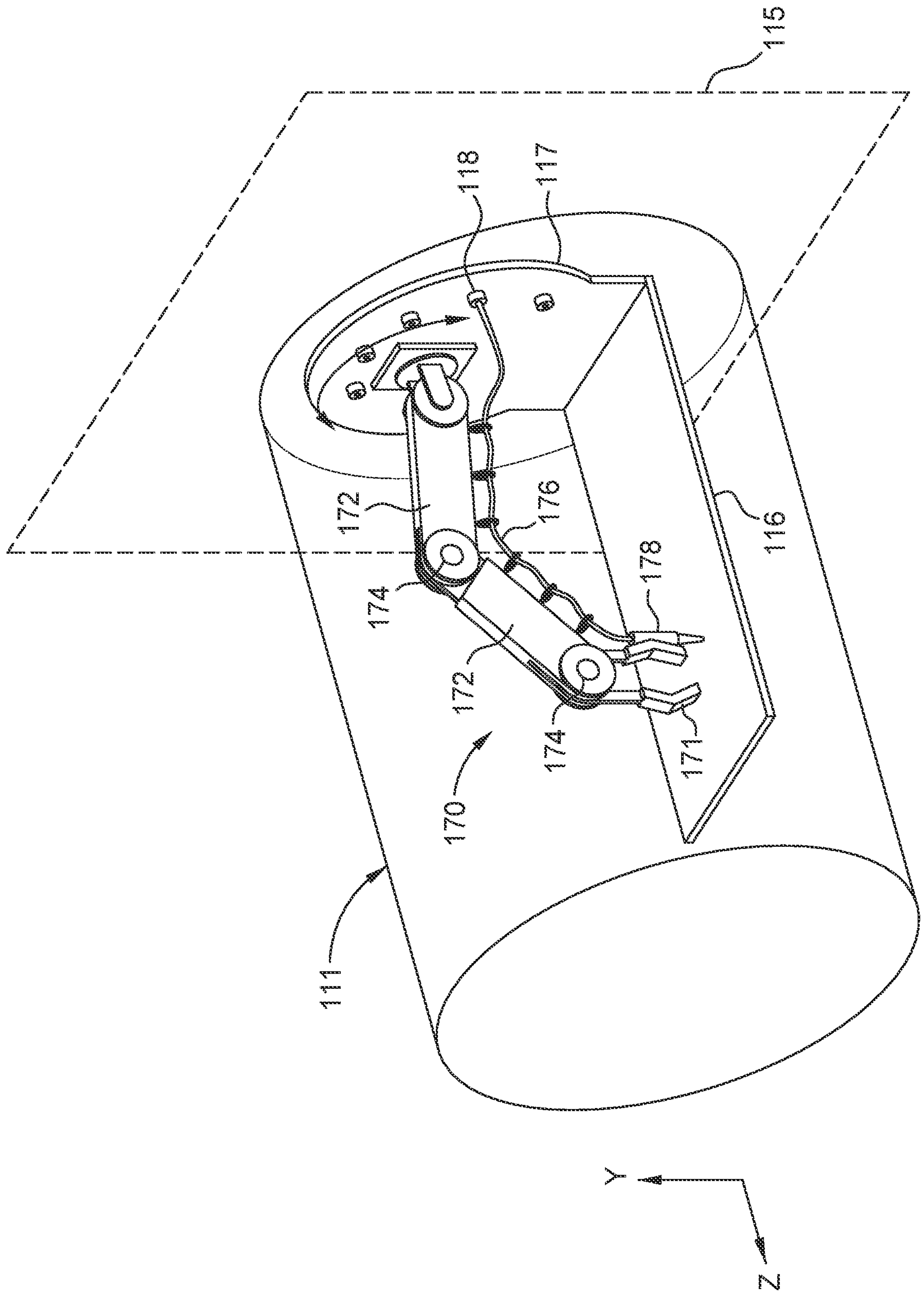

FIG. 5

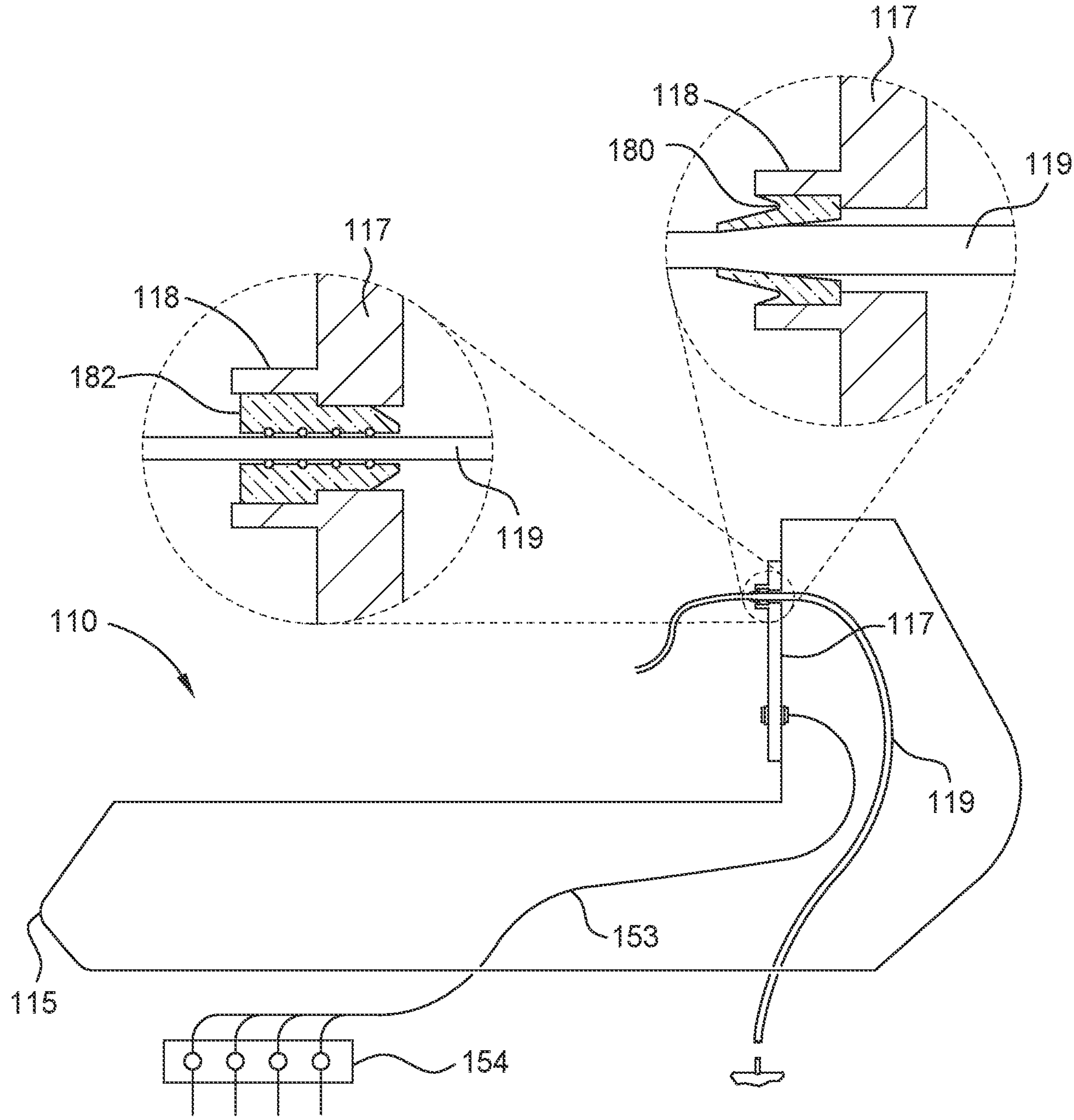

FIG. 6