

(51) International Patent Classification:
A61M 5/14 (2006.01)(21) International Application Number:
PCT/US2014/042310(22) International Filing Date:
13 June 2014 (13.06.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/835,131 14 June 2013 (14.06.2013) US
61/840,818 28 June 2013 (28.06.2013) US(71) Applicant: **BAYER MEDICAL CARE INC.** [US/US]; 1
Bayer Drive, Indianola, Pennsylvania 15051 (US).(72) Inventors: **RHINEHART, Edward, J.**; 1780 McClure
Road, Monroeville, Pennsylvania 15146 (US). **BERRY,
David, H.**; 277 Ping Wing Hollow Road, Kittanning,
Pennsylvania 16201 (US). **HOFFMAN, Raymond, C.**;
204 MacDuff Court, Gibsonia, Pennsylvania 15044 (US).
COWAN, Kevin; 4242 Estates Court, Allison Park,
Pennsylvania 15101 (US). **MCCOPPIN, Kathy**; 158 Eck-
stein Road, Renfrew, Pennsylvania 16053 (US). **REILLY,****David, M.**; 146 Wescott Drive, Pittsburgh, Pennsylvania
15237 (US). **TROCKI, Mark**; 130 Reaghard Drive,
Cheswick, Pennsylvania 15024 (US). **TROMBLEY, Fre-
derick, W., III**; 5750 Phillips Road, Gibsonia,
Pennsylvania 15044 (US). **TUCKER, Barry, L.**; 219 Mc-
Gregor Drive, Verona, Pennsylvania 15147 (US). **UBER,
Arthur, E., III**; 7426 Ben Hur Street, Pittsburgh,
Pennsylvania 15208 (US).(74) Agents: **SCHUSTER, Christian, E.** et al.; One Gateway
Center, 420 Fort Duquesne Boulevard, Suite 1200, Pitts-
burgh, Pennsylvania 15222 (US).(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.

[Continued on next page]

(54) Title: PORTABLE FLUID DELIVERY SYSTEM

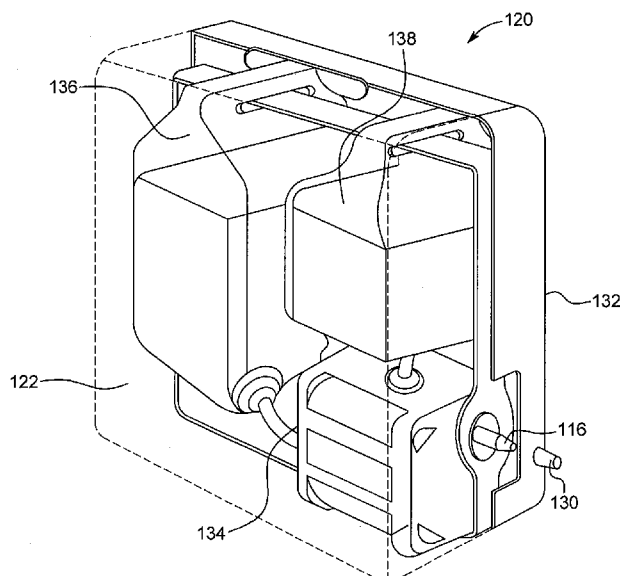


FIG. 6A

(57) Abstract: A fluid delivery system includes a first container configured for storing a first fluid therein and a second container configured for storing a second fluid therein, wherein the second fluid is different from the first fluid. The fluid delivery system further includes at least one pump configured for delivering under pressure one or both of the first and second fluids. At least one valve is provided for selectively delivering one or both of the first and second fluids to the pump. The first and second containers, the pump, and the valve are contained within a cartridge that is removably insertable into a cartridge carrier of the fluid delivery system.



(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,

SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

PORTABLE FLUID DELIVERY SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Patent Application No. 61/835,131, entitled "Portable Fluid Delivery System", filed on June 14, 2013, and U.S. Provisional Patent Application No. 61/840,818, entitled "Sterility Retaining Medical Connector Assembly and Method", filed on June 28, 2013, the disclosures of which is incorporated herein in their entirety.

BACKGROUND OF THE DISCLOSURE

Field of the Disclosure

[0002] The present disclosure is directed to medical fluid delivery applications and, particularly, to a portable fluid delivery system for delivering one or more medical fluids and a connector assembly therefor.

Description of Related Art

[0003] Current medical imaging practice uses a combination of a medical fluid injector and an imaging device to visualize the inside of a patient's body. In certain procedures, a physician maneuvers a catheter to a desired blood vessel, and electromagnetic-absorbing or radiation emitting contrast solution is injected so that the contrast solution, commonly referred to as "contrast", becomes clearly visible against the background of the surrounding tissue.

[0004] Using the resultant image, a physician makes a diagnosis and determines appropriate treatment. In interventional procedures, treatment is performed using injection catheters, atherectomy devices, stents, or any one of many interventional devices. Often, the interventional treatment is performed during the angiographic procedure, although sometimes treatment is performed at a later time.

[0005] During certain procedures, in addition to contrast, it is common to inject saline to flush the contrast from the catheter. This keeps the catheter lumen open (unclotted), and/or acts as a fluid path for measuring blood pressure. In certain embodiments, the physician performs the injections by hand. However, it may be difficult for a human to inject a fluid at a steady rate, especially for slow rates (ml/min) extending more than a minute. Motion at a slow rate suffers from stick-slip friction in the syringe, and it takes prolonged concentration to maintain a steady

injection rate for extended time periods during the procedure. There is significant risk of accidental jerking or bolus injection that either wastes drug or causes it to reflux into the aorta and travel elsewhere in the body. Also, as syringes are connected and disconnected, the plunger can be unintentionally bumped and a bolus of drug injected into the patient or expelled into the environment. Additionally, the changeover time from drug syringe to saline syringe causes an uncontrolled break in therapy injection. As the drug is susceptible to clump formation or crystallization if agitated, manually connecting and disconnecting the syringe provides opportunities for agitation and clumping/crystallizing.

[0006] For certain procedures, powered injectors are used to inject the contrast because of its high viscosity and the high pressures required to drive contrast through small catheter diameters. Powered injectors can, for example, develop pressures up to 1200 psi in such injections. The pressure range used in such injections is well above the pressure a person can practically develop via hand injection. U.S. Patent Nos. 5,494,036, 6,339,718, 5,843,037, 5,840,026, 5,806,519, 5,739,508, and 5,569,181, assigned to the assignee of the present disclosure, which are incorporated herein by reference, disclose the use of powered injector systems that are capable of injecting contrast, saline, and other fluids, either at the same time or in sequence.

[0007] One difficulty with such currently available powered injectors is that they require a complex fluid path set to deliver the one or more fluids from a storage container to the patient. Typically, such a fluid path set includes a plurality of fluid lines that are interconnected by one or more connectors and valves. In many cases, a new fluid path set must be assembled for each new patient. Additionally, one or more fluid storage containers are separately provided to the fluid delivery device and must be connected therewith prior to the injection procedure. The assembly process is laborious and time consuming, and increases the risk that some of the fluid may be spilled, aerosolized, or otherwise contaminated. Conventional medical connectors for use with powered injectors require the user to ensure that proper sterilization precautions are taken each time a new connection is made. There exists a significant risk of contamination due to human error in handling the connectors. Furthermore, because conventional medical connectors for use with powered injectors do not have reusable components, large stockpiles of medical connectors must be kept on premises, which increases storage costs and per procedure costs. Accordingly, a need exists for an improved fluid delivery system and a connector assembly therefor.

SUMMARY OF THE DISCLOSURE

[0008] While manual and powered injectors are known in the medical field, improved fluid delivery systems are desired. In view of certain disadvantages of the existing manual and powered injection mechanisms, there is a need in the art for an injection device that enables precise dosing of contrast and/or saline. There is an additional need for an injection system having a simplified connection with a fluid path set for delivering the fluid to the patient. A further need exists in the art for an injection system that reduces the risk that some of the fluid may be spilled, aerosolized, or otherwise contaminated. An additional need exists for a portable fluid delivery system having one or more of the above-noted advantages.

[0009] In accordance with one embodiment, a cartridge for a fluid delivery system is provided where the cartridge may include a first fluid container configured for storing a first fluid therein and a second fluid container configured for storing a second fluid therein, where the second fluid may be different from the first fluid. The cartridge may further include at least one pump configured for delivering under pressure one or both of the first fluid and the second fluid, and at least one valve configured for selectively delivering one or both of the first fluid and the second fluid to the pump. The first and second containers, the at least one pump, and the at least one valve may be received within an outer shell of the cartridge. The cartridge may be removably engagable with the fluid delivery system.

[0010] In accordance with a further embodiment, the at least one pump further may include a first pump in fluid communication with the first fluid container for delivering under pressure the first fluid and a second pump in fluid communication with the second fluid container for delivering under pressure the second fluid. Additionally, the at least one valve may have a plurality of states for selectively allowing a flow of the first fluid, the second fluid or both the first fluid and the second fluid through the at least one valve. In one embodiment, the at least one valve may include (1) a first state where the flow of the first fluid and the second fluid through the at least one valve is closed, (2) a second state where the flow of the first fluid through the valve is open and the flow of the second fluid through the valve is closed, (3) and a third state where the flow of the first fluid and the second fluid through the valve is open.

[0011] In accordance with yet another embodiment, the cartridge may include a first fluid line in fluid communication with the first fluid container and a second fluid line in fluid communication with the second fluid container. A third fluid container may optionally be

provided for storing a third fluid therein. The third fluid container may be in fluid communication with at least one of the first fluid line and the second fluid line. In one embodiment, the third fluid may be a disinfectant configured for disinfecting at least one of the first fluid line and the second fluid line.

[0012] At least one sterilization device may be in communication with at least one of the first fluid line and the second fluid line. In one embodiment, the sterilization device may be fluid communication with and configured to inject vaporized fluid into at least one of the first fluid line and the second fluid line. In another embodiment, the sterilization device may be configured to irradiate at least a portion of at least one of the first fluid line and the second fluid line, and any fluid contained therein with electromagnetic energy. The electromagnetic energy may be ultraviolet radiation.

[0013] In accordance with a further embodiment, the cartridge may include at least one fluid level indicator configured for indicating a volume of at least one of the first fluid inside the first fluid container and the second fluid inside the second fluid container. At least one viewing window may be provided on at least one of the first fluid container or the second fluid container. The at least one viewing window may be configured for providing visual access to an interior of the at least one of the first fluid container and the second fluid container. At least one refilling port may be in fluid communication with at least one of the first fluid container and the second fluid container for refilling the at least at least a portion of at least one of the first fluid container with the first fluid and the second fluid container with the second fluid. In some embodiments, at least a portion of the second fluid container may be received within an interior of the first fluid container, or alternatively at least a portion of the first fluid container may be received within an interior of the second fluid container. At least one sampling chamber may be in fluid communication with and optionally removable from at least one of the first fluid container and the second fluid container. The at least one sampling chamber may be configured to selectively draw a sample of at least the first fluid from the first fluid container and the second fluid from the second fluid container. A power source may be received within the cartridge for providing power to at least one of the at least one pump and the at least one valve. In one embodiment, the first fluid is saline and the second fluid is contrast.

[0014] In accordance with a further embodiment, a fluid delivery system is provided where the fluid delivery system may include a cartridge carrier and a cartridge configured for being

removably engagable with the cartridge carrier. The cartridge may include a first fluid container configured for storing a first fluid therein and a second fluid container configured for storing a second fluid therein, where the second fluid is different from the first fluid. The cartridge may further include at least one pump configured for delivering under pressure one or both of the first fluid and the second fluid, and at least one valve configured for selectively delivering one or both of the first fluid and the second fluid to the pump. The first and second containers, the at least one pump, and the at least one valve may be received within an outer shell of the cartridge. At least one multi-patient connector may be configured for fluidly connecting the cartridge to a single-patient connector. Engaging the cartridge with the fluid delivery system places various components of the cartridge, such as the first fluid container, the second fluid container, the at least one pump, and/or the at least one valve, in fluid communication with the fluid delivery system, the at least one multi-patient connector, and/or the single-patient connector.

[0015] In accordance with another embodiment, a medical connector assembly may include a multi-patient connector and one or more single-patient connectors removably engagable with the multi-patient connector to establish a fluid path therethrough. Each single-patient connector may include a housing having a proximal end opposite a distal end with a central fluid path extending therebetween, a flange extending around the distal end, and a cap removably engaged to the flange. A sterility-maintaining arrangement may be configured for slidably or otherwise removing the cap from the one or more single-patient connectors without exposing the distal end of the one or more single-patient connectors to contamination.

[0016] These and other features and characteristics of the portable fluid delivery system and the connector assembly therefor, as well as the methods of operation and functions of the related elements of structures and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims with reference to the accompanying drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the disclosure. As used in the specification and the claims, the singular form of “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a perspective view of a portable fluid delivery system in accordance with one embodiment.

[0018] FIG. 2 is a perspective view of a portable fluid delivery system in accordance with another embodiment.

[0019] FIG. 3 is a detailed perspective view of a connection interface of the portable fluid delivery system shown in FIG. 1.

[0020] FIG. 4 is a perspective view of a cartridge being loaded into to the portable fluid delivery system shown in FIG. 1.

[0021] FIG. 5 is a detailed view of connection interface of the cartridge.

[0022] FIG. 6A is a partial transparent view of an arrangement of first and second fluid containers within the cartridge in accordance with a first embodiment.

[0023] FIG. 6B is a schematic representation of an arrangement of first and second fluid containers within the cartridge in accordance with a second embodiment.

[0024] FIG. 7A is a schematic representation of the cartridge in accordance with a one embodiment.

[0025] FIG. 7B is a schematic representation of the cartridge in accordance with another embodiment.

[0026] FIG. 7C is a schematic representation of the cartridge in accordance with another embodiment.

[0027] FIG. 7D is a schematic representation of the cartridge in accordance with another embodiment.

[0028] FIG. 7E is a schematic representation of the cartridge in accordance with another embodiment.

[0029] FIG. 7F is a schematic representation of the cartridge in accordance with another embodiment.

[0030] FIG. 7G is a schematic representation of the cartridge in accordance with another embodiment.

[0031] FIG. 7H is a schematic representation of the cartridge in accordance with another embodiment.

[0032] FIG. 8A is a perspective view of a connector assembly in accordance with one embodiment.

[0033] FIG. 8B is a perspective view of a connector assembly in accordance with another embodiment.

[0034] FIG. 8C is a perspective view of a connector assembly in accordance with another embodiment.

[0035] FIG. 8D is a perspective view of a connector assembly in accordance with another embodiment.

[0036] FIG. 9 is a perspective view of a connector assembly in accordance with another embodiment.

[0037] FIG. 10 is a front view of the connector assembly shown in FIG. 9.

[0038] FIG. 11 is a rear view of the connector assembly shown in FIG. 9.

[0039] FIG. 12 is a side view of the connector assembly shown in FIG. 9.

[0040] FIG. 13 is a top view of the connector assembly shown in FIG. 9.

[0041] FIG. 14 is a cross-sectional view of the connector assembly taken along line A-A shown in FIG. 12.

[0042] FIG. 15 is a cross-sectional view of the connector assembly taken along line B-B shown in FIG. 13.

[0043] FIG. 16 is a front perspective view of a single-patient connector configured for use with the connector assembly shown in FIG. 9.

[0044] FIG. 17 is a front perspective view of a fluid path connector of the single-patient connector shown in FIG. 16.

[0045] FIG. 18 is a front perspective view of a housing of the single-patient connector shown in FIG. 17.

[0046] FIG. 19 is a rear perspective view of the housing shown in FIG. 18.

[0047] FIGS. 20A-20F are perspective views of various stages of connecting a single-patient connector to a multi-patient connector.

[0048] FIG. 21A is a perspective view of a single-patient connector in accordance with another embodiment.

[0049] FIG. 21B is a perspective view of a multi-patient connector configured for use with the single-patient connector shown in FIG. 21A.

[0050] FIGS. 22A-22C are perspective views of various stages of connecting the single-patient connector of FIG. 21A to the multi-patient connector of FIG. 21B.

[0051] FIG. 23A is a schematic view of a first variation of a fluid outlet line of the multi-patient connector in accordance with a further embodiment.

[0052] FIG. 23B is a schematic view of a second variation of a fluid outlet line of the multi-patient connector.

[0053] FIG. 24 is a schematic view of a connection member for use with the multi-patient connector shown in FIG. 23B in accordance with another embodiment.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0054] For purposes of the description hereinafter, spatial orientation terms shall relate to the referenced embodiment as it is oriented in the drawing figures. However, it is to be understood that the various embodiments may assume alternative variations and step sequences, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification, are simply exemplary embodiments. Hence, specific dimensions and other physical characteristics related to the embodiments disclosed herein are not to be considered as limiting.

[0055] Referring to the drawings in which like reference characters refer to like parts throughout the several views thereof, the present disclosure is generally directed to a portable fluid delivery system and a connector therefor configured for connection to a fluid path set used in an injection procedure.

[0056] Referring initially to FIG. 1, an embodiment of a portable fluid delivery system 100 (hereinafter referred to as “fluid delivery system 100”) is shown. The fluid delivery system 100, as described herein, is intended for delivering one or more medical fluids, such as contrast and saline, to a patient as will be readily apparent to those skilled in the medical art. The fluid delivery system 100 includes a frame 102 supported on a base 104. One or more wheels 106 movably support the base 104 and facilitate movement of the fluid delivery system 100 across a floor surface. The fluid delivery system 100 further includes a cartridge carrier 108 connected to the frame 102. In some embodiments, the cartridge carrier 108 removably receives and engages a cartridge having at least one pump, at least one valve, and one or more fluid storage containers for storing medical fluids, as will be described in detail hereinafter. The cartridge carrier 108 includes a connection interface 110 for establishing a fluid connection between the cartridge and

a fluid path set **114** (shown in **FIG. 3**) that delivers fluid from the fluid delivery system **100** to the patient. In some embodiments, the fluid delivery system **100** may include a self-contained power system, such as a battery pack, or it may be connected to an external power source, such as an external power outlet or battery.

[0057] With continued reference to **FIG. 1**, a user interface **112** may be provided to control the operation, receive input from a user, and monitor the performance of the fluid delivery system **100**. In one embodiment, the user interface **112** may be in the form of a touch-sensitive display capable of receiving tactile input from the user, may be in the form of a keyboard, or may be designed to receive voice command input. The input from the user may be in the form of an operational command or a status inquiry. For example, the user interface **112** may be used to define the desired injection protocol, including at least one of the injection volume, pressure, and duration. One of ordinary skill in the art will understand that the user interface **112** may be embodied as any type of a control console capable of controlling the operation and monitoring the performance of the fluid delivery system **100**.

[0058] With reference to **FIG. 2**, an alternative embodiment of the fluid delivery system **100** is shown. Rather than being attached to a movable base **104**, as the embodiment shown in **FIG. 1**, the embodiment in **FIG. 2** includes a frame **103** that is fixedly mounted. For example, the frame **103** shown in **FIG. 2** may be mounted to the wall, floor, table, or the ceiling of a room. The remaining components of the fluid delivery system **100** shown in **FIG. 2**, including the cartridge carrier **108**, connection interface **110**, and the user interface **112**, are substantially identical to the components discussed above with reference to **FIG. 1**.

[0059] Referring to **FIG. 3**, a detailed view of the connection interface **110** is illustrated. The connection interface **110** is configured for fluidly connecting the fluid delivery system **100** to the fluid path set **114**, such as a catheter, a pressure tube, or a connector tube, for delivering one or more fluids from the fluid delivery system **100** to the patient. Desirably, the fluid path set **114** is configured to be discarded after a single use. In one embodiment, the connection interface **110** may include a multi-patient connector **116** in the form of a male connector on the fluid delivery system **100** and a corresponding single-patient connector **118** in the form of a female connector on the fluid path set **114**. Alternatively, the multi-patient connector **116** may be in the form of a female connector and the single-patient connector **118** may be in the form of a male connector. In some embodiments, as will be described hereinafter, the multi-patient connector

116 is a multi-patient connector such that it can be used with multiple single-patient fluid path sets **114**. The multi-patient connector **116** and the single-patient connector **118** may be embodied as any type of a mechanical connector known in the medical arts. Various non-limiting embodiments of the connectors will be described hereinafter with reference to **FIGS. 8A-22C**.

[0060] Referring to **FIG. 4**, a cartridge **120** having one or more fluid storage containers is removably insertable into and engagable with the cartridge carrier **108**. The cartridge **120** is removable from the cartridge carrier **108** so that the cartridge **120** may be replaced after the one or more medical fluids stored within the cartridge **120** are depleted. At least a portion of the cartridge **120** has a rigid sidewall that is dimensionally stable to protect the cartridge **120** and its contents. The cartridge carrier **108** defines an interior compartment **122** configured for receiving the cartridge **120**. At least a portion of the cartridge **120**, such as the portion of the cartridge **120** proximate to the connection interface **110**, may be exposed to facilitate connection with the single patient fluid path set **114** (shown in **FIG. 3**). A door **124** is secured to the cartridge carrier **108** for enclosing the interior compartment **122** after the cartridge **120** is inserted therein. The interior compartment **122** may be dimensioned such that the cartridge **120** may be inserted in only one direction in order to prevent erroneous insertion of the cartridge **120** into the interior compartment **122**. In another embodiment, the cartridge **120** may be secured directly to the frame **102** shown in **FIG. 1** or frame **103** shown in **FIG. 2**.

[0061] As shown in **FIG. 5**, the cartridge **120** includes a handle **126** to facilitate the carrying of the cartridge **120** and insertion thereof into the interior compartment **122** of the cartridge carrier **108** or placement on the frame **102** or frame **103**. The cartridge **120** may further include a flap **128** that covers at least a portion of the multi-patient connector **116** when the cartridge **120** is not in use. For example, the flap **128** may be movable between an open orientation where the multi-patient connector **116** is exposed and a closed configuration where the multi-patient connector **116** is concealed. In some embodiments, the flap **128** may be removed from the cartridge **120** prior to the initial use of the cartridge **120**. In other embodiments, the flap **128** may have a breakable membrane that is pierced or otherwise broken prior to the initial use of the cartridge **120**. The multi-patient connector **116** may include a cover or cap **130** that covers the multi-patient connector **116** prior to the initial use. The cover **130** is removed prior to connecting the multi-patient connector **116** and the single-patient connector **118** of the fluid path

set 114 (shown in FIG. 3), for example, after insertion of cartridge 120 into interior compartment 122.

[0062] With reference to FIG. 6A, a partial transparent view of the cartridge 120 is illustrated in accordance with a first embodiment. The cartridge 120 includes an outer shell 132 that defines an outer shape of the cartridge 120. The outer shell 132 defines a hollow interior volume that receives a pump 134, such as a high-pressure peristaltic pump and one or more fluid containers. A power source 156, such as a battery (shown in FIG. 6B), may be provided within the outer shell 132 of the cartridge 120 for powering the at least one pump 134 and/or the at least one valve 140 (shown in FIG. 6B). In some embodiments, the at least one pump 134 and/or the at least one valve may be provided externally from the outer shell 132 of the cartridge 120. In the embodiment shown in FIG. 6A, the cartridge 120 includes a first fluid container 136 for receiving a first fluid, such as saline, and a second fluid container 138 for receiving a second fluid, such as contrast. One or both of the first and second fluid containers 136, 138 may be refillable or disposable containers. In some embodiments, at least one of the first and second fluid containers 136, 138 may have a refilling port (shown in FIG. 6B) for refilling the contents of the first and second fluid containers 136, 138 once at least a portion of the first and second fluids has been depleted therefrom. The cartridge 120 may further comprise one or more electrical contacts for establishing electrical communication with the user interface 112 and/or other components of the fluid delivery system 100.

[0063] The first and second fluid containers 136, 138 may have the same or different shapes and/or volumes. In some embodiments, the first and second fluid containers 136, 138 may have a flexible sidewall. For example, at least one of the first and second fluid containers 136, 138 may have a collapsible structure, such as a bellows arrangement, that collapses as fluid is delivered from the first and/or second fluid containers 136, 138. In this manner, the void left by the fluid delivered from the first and/or second fluid containers 136, 138 does not have to be replaced with air to prevent a vacuum from being formed within the first and/or second fluid containers 136, 138. In other embodiments, the first and second fluid containers 136, 138 may have rigid sidewalls. The first and second fluid containers 136, 138 may be made from any medical-grade material, such as medical-grade plastic. The first and second fluid containers 136, 138 are secured within the hollow interior volume of the outer shell 132 of the cartridge 120 to prevent movement of the first and second fluid containers 136, 138 within the cartridge 120. The

first and second fluid containers **136**, **138** may be permanently or removably connected to the cartridge **120**. In one embodiment, the first and second fluid containers **136**, **138** are removably connected to the cartridge **120** such that one or both of first and second fluid containers **136**, **138** may be replaced and the cartridge **120** and other components thereof can be reused. In another embodiment, the first and second fluid containers are permanently connected within the cartridge **120** such that the entire cartridge **120**, along with the first and second containers **136**, **138**, must be replaced after use. In specific embodiments, the at least one pump **134** may be removable from cartridge **120** and may be used in additional cartridges after disposal of the first cartridge. In an embodiment where the first and second fluid containers **136**, **138** are refillable, the cartridge **120** may be reused after refilling at least one of the first and second containers **136**, **138**. In other embodiments, more than two fluid containers may be provided within the hollow interior volume of the cartridge **120**.

[0064] With reference to **FIG. 6B**, a schematic representation of the cartridge **120** is illustrated in accordance with a second embodiment. The cartridge **120** includes an outer shell **132** that defines an outer shape of the cartridge **120**. The outer shell **132** defines a hollow interior compartment **122** that receives one or more fluid containers. In the embodiment shown in **FIG. 6B**, the cartridge **120** includes a first fluid container **136** for receiving a first fluid, such as saline, and a second fluid container **138** for receiving a second fluid, such as contrast. One or both of the first and second fluid containers **136**, **138** may be refillable containers, or they may be disposable containers. For example, first and second refilling ports **152**, **154** may be provided for refilling the contents of the first and second fluid containers **136**, **138** once at least a portion of the first and second fluids has been depleted therefrom.

[0065] The second fluid container **138** may be received within at least a portion of the first fluid container **136**. In one embodiment, the second fluid container **138** is received entirely within the first fluid container **136**. In some embodiments, the first and second fluid containers **136**, **138** may have a flexible sidewall. In other embodiments, the first and second fluid containers **136**, **138** may have rigid sidewalls. In embodiments where the second container **138** is constructed from a material that allows gas and water vapor transmission from the interior of the second container **138** to the exterior thereof, the rate of gas and water vapor transmission can be reduced by surrounding the second container **138** with the first fluid within the first fluid container **136** instead of air. One or both of the first and second fluid containers **136**, **138** are

secured within the hollow interior compartment 122 of the outer shell 132 of the cartridge 120 to prevent the movement of the first and/or second fluid containers 136, 138 within the cartridge 120. In one embodiment, the first fluid container 136 may be removably connected to the cartridge 120 such that the first fluid container 136, and the second fluid container 138 received therein, may be replaced. In one embodiment, the first fluid container 136 and/or the second fluid container 138 may be removably connected to the cartridge 120 such that the first fluid container 136 and/or the second fluid container 138 may be replaced. In another embodiment, the first container 136 is permanently connected within the cartridge 120 such that the entire cartridge 120 must be replaced after use. In an embodiment where the first and second fluid containers 136, 138 are refillable, the cartridge 120 may be reused after refilling at least one of the first and second containers 136, 138. In other embodiments, more than two fluid containers may be provided within the hollow interior volume of the cartridge 120 and, in certain embodiments, more than one fluid container may be contained within the first and/or the second fluid containers 136, 138. The first and second fluid containers 136, 138 are connected to a valve 140 (shown in FIGS. 7A-7H) that delivers at least one of the first and second fluids from the first and second containers 136, 138 to at least one pump 134, as will be described hereinafter. The first and second fluid containers 136, 138 are connected to the valve 140 (shown in FIGS. 7A-7H) via first and second fluid lines 142, 144, respectively.

[0066] With continued reference to FIG. 6B, a viewing port 133 may be provided on the outer shell 132 of the cartridge 120. The viewing port 133 may be configured to provide a visual indication of a condition of the first and/or second fluid in the first and second fluid containers 136, 138. For example, the viewing port 133 may provide a visual indication of the fluid level within the first and/or second fluid containers 136, 138. Further, in embodiments where the second fluid is contrast, the viewing port 133 allows a visual verification of crystallinity of the contrast. One or both of the first and second fluid containers 136, 138 may have the viewing port 133. The viewing port 133 may be aligned with a corresponding viewing port on an exterior of cartridge carrier 108.

[0067] With continued reference to FIG. 6B, the cartridge 120 may have a level indicator 137. In some embodiments, the level indicator 137 may be in the form of indicia on the viewing window 133 to provide a visual indication of the volume of the first and/or second fluid inside the first and second fluid containers 136, 138. In other embodiments, the level indicator 137

may be an electronic sensor, such as an optical, ultrasound, or a weight sensor, configured to measure the volume of the first and/or second fluid inside the first and second fluid containers 136, 138. The output from the level indicator 137 may be visually displayed on the user interface 112.

[0068] According to certain embodiments, a power source 156, such as a battery or rechargeable battery, may be provided within the outer shell 132 of the cartridge 120 for powering the pump 134 and/or the valve 140. The power source 156 may also be provided externally, such as by a power cord connection to an external power source.

[0069] Referring to FIG. 7A, a schematic diagram of the cartridge 120 is illustrated in accordance with an embodiment. First and second fluids are delivered from the first and second fluid containers 136, 138 to the valve 140 via first and second fluid lines 142, 144, respectively. Each of the first and second fluid containers 136, 138 may include a connector 146 for connecting the first and second containers 136, 138 to the first and second fluid lines 142, 144, respectively. In some embodiments, the connector 146 may comprise a one-way valve to prevent the flow of fluid from the first and second fluid lines back to the first and second fluid containers 136, 138. In other embodiments, the connector 146 may be an aseptic connector configured to prevent contamination of the first and second fluids flowing from the first and second containers 136, 138 through the first and second fluid lines 142, 144. In yet another embodiment, the connector 146 may be a combination of a one-way valve with aseptic features. Connectors 146 may allow for removal and replacement of the first and/or second containers 136, 138. In a further embodiment, the first and second fluid containers 136, 138 are directly connected to the valve 140.

[0070] With continuing reference to FIG. 7A, the valve 140 may be a multi-position valve that is connected to a third fluid line 148. The valve 140 may be configured to receive first and second fluids from the first and second fluid containers 136, 138 through the first and second fluid lines 142, 144, respectively. In another embodiment, the valve 140 may be configured to receive first and second fluids directly from the first and second fluid containers 136, 138. Depending on the position of the valve 140, the supply of the first and second fluids may be open or closed such that only one of the first or second fluids or both of the first and second fluids can flow through the valve 140. For example, the valve 140 may have three positions/states: (1) the flow of first and second fluids received from the first and second fluid containers 136, 138 is

closed; (2) the flow of the first fluid received from the first fluid container **136** is open, while the flow of the second fluid received from the second fluid container **138** is closed; and (3) the flow of the second fluid received from the second fluid container **138** is open, while the flow of the first fluid received from the first fluid container **136** is closed. Alternatively, the valve **140** may have three positions/states as follows: (1) the flow of first and second fluids received from the first and second fluid containers **136**, **138** is closed; (2) the flow of the second fluid received from the second fluid container **138** is open, while the flow of the first fluid received from the first fluid container **136** is closed; and (3) the flow of the second fluid received from the second fluid container **138** is open, while the flow of the first fluid received from the first fluid container **136** is closed. The valve **140** may optionally include a fourth state where the flow of the first fluid received from the first fluid container **136** and the flow of the second fluid from the second fluid container **138** are open. The valve **140** may be electronically controlled to switch between the three positions/states through the user interface **112** or it may be manually actuated.

[0071] With continued reference to **FIG. 7A**, the first fluid or the second fluid flows from the valve **140** to the pump **134** through the third fluid line **148**. In another embodiment, the valve **140** is connected directly to the pump **134**. In one embodiment, the valve **140** may be formed integrally with the pump **134**. In some embodiments, the pump **134** may be a high pressure peristaltic pump having an input configured for receiving at least one of or both of the first and second fluids and an output for delivering a quantity of the first and/or second fluid under pressure. In another embodiment, the pump **134** is electronically controlled through the user interface **112**. Depending on the performance requirements, alternate pump designs may be used. For example, the pump may be, without limitation, one or more of the following: a piston pump, a syringe-based pump, a diaphragm pump, a rotary pump, a screw pump, a gear pump, and a vane pump. An outlet of the pump **134** may be connected to the multi-patient connector **116** by way of a fluid outlet line **117**.

[0072] With reference to **FIG. 7B**, a schematic diagram of the cartridge **120** is illustrated in accordance with another embodiment. First and second fluids are delivered from the first and second fluid containers **136**, **138** to the valve **140** via first and second fluid lines **142**, **144**, respectively. The valve **140** is a multi-position valve that may be connected to a first outlet line **149** and a second outlet line **151**. In one embodiment, the first fluid flows from the first fluid container **136** through the first fluid line **142**, through the valve **140** and through the first outlet

line 149. The second fluid flows from the second fluid container 138 through the second fluid line 144, through the valve 140 and through the first and/or second outlet line 149, 151. Depending on the position of the valve 140, the supply of the first and second fluids may be open or closed such that only one of or both of the first and second fluids can flow through the valve 140. For example, the valve 140 may have three positions/states: (1) the flow of first and second fluids received from the first and second fluid containers 136, 138 is closed; (2) the flow of the first fluid received from the first fluid container 136 is open to allow the first fluid to flow through the second outlet line 151, while the flow of the second fluid received from the second fluid container 138 is closed; and (3) the flow of the first and second fluids received from the first and second fluid containers 136, 138 is open to allow the first and second fluids to flow through the first and second outlet lines 149, 151. The valve 140 may be electronically controlled to switch between the three positions/states through the user interface 112 or it may be manually actuated.

[0073] With continued reference to FIG. 7B, the first fluid and the second fluid flow from the valve 140 to a first pump 134 and a second pump 135 through the first and second fluid outlet lines 149, 151, respectively. In another embodiment, the valve 140 is connected directly to the first and second pumps 134, 135. Outlets of the first and second pumps 134, 135 are connected to the multi-patient connector 116 by way of a first and second pump outlet lines 119, 121. The first and second pump outlet lines 119, 121 may be joined together to a single fluid outlet line 117 at a connector 123. A one-way check valve 125 is provided on the second pump outlet line 121 to prevent the first fluid from flowing into the second pump 135, or the second fluid container 138 and contaminating the second fluid. In one embodiment, the connector 123 and the check valve 125 may be integrated into a unitary structure.

[0074] With reference to FIG. 7C, a schematic diagram of the cartridge 120 is illustrated in accordance with another embodiment. First and second fluids are delivered from the first and second fluid containers 136, 138 to the valve 140 via first and second fluid lines 142, 144, respectively. The valve 140 is a multi-position valve that is connected to a first outlet line 149 and a second outlet line 151. In one embodiment, the first fluid flows from the first fluid container 136 through the first fluid line 142, through the valve 140 and through the first outlet line 149. The second fluid flows from the second fluid container 138 through the second fluid line 144, through the valve 140 and through the second outlet line 151. Depending on the

position of the valve **140**, the supply of the first and second fluids may be open or closed such that both or neither of the first and second fluids can flow through the valve **140**. For example, the valve **140** may have two positions/states: (1) the flow of first and second fluids received from the first and second fluid containers **136**, **138** is closed; and (2) the flow of the first and second fluids received from the first and second fluid containers **136**, **138** is open to allow the first and second fluids to flow through the first and second outlet lines **149**, **151**, respectively. The valve **140** may be electronically controlled to switch between the two positions/states through the user interface **112** or it may be manually actuated. Two separate valves **140** can be provided for each of the first and second fluid lines **142**, **144**.

[0075] With continued reference to **FIG. 7C**, the first fluid and the second fluid flow from the valve **140** to a first pump **134** and a second pump **135** through the first and second fluid outlet lines **149**, **151**, respectively. In another embodiment, the valve **140** is connected directly to the first and second pumps **134**, **135**. Outlets of the first and second pumps **134**, **135** are connected to the multi-patient connector **116** by way of a first and second pump outlet lines **119**, **121**. The first and second pump outlet lines **119**, **121** may be joined together to a single fluid outlet line **117** at a connector **123**. A one-way check valve **125** is provided on the second pump outlet line **121** to prevent the first fluid from flowing into the second pump **135** or the second fluid container **138** and contaminating the second fluid. In one embodiment, the connector **123** and the check valve **125** may be integrated into a unitary structure.

[0076] With reference to **FIG. 7D**, a schematic diagram of the cartridge **120** is illustrated in accordance with an additional embodiment. First and second fluids are delivered from the first and second fluid containers **136**, **138** to the valve **140** via first and second fluid lines **142**, **144**, respectively. Each of the first and second fluid containers **136**, **138** may include a connector **146** for connecting the first and second containers **136**, **138** to the first and second fluid lines **142**, **144**, respectively. In some embodiments, the connector **146** may be a one-way valve to prevent the flow of fluid from the first and second fluid lines **142**, **144** back to the first and second fluid containers **136**, **138**. In other embodiments, the connector **146** may be an aseptic connector configured to prevent contamination of the first and second fluids flowing from the first and second containers **136**, **138** through the first and second fluid lines **142**, **144**. In yet another embodiment, the connector **146** may be a combination of a one-way valve with aseptic features. The valve **140** is a multi-position valve that is connected to a first outlet line **149** and a second

outlet line 151. In one embodiment, the first fluid flows from the first fluid container 136 through the first fluid line 142, through the valve 140 and through the first or second outlet line 149, 151. The second fluid flows from the second fluid container 138 through the second fluid line 144, through the valve 140 and through the second outlet line 151. Depending on the position of the valve 140, the supply of the first and second fluids may be open or closed such that only one or both of the first and second fluids can flow through the valve 140. For example, the valve 140 may have three positions/states: (1) the flow of first and second fluids received from the first and second fluid containers 136, 138 is closed; (2) the flow of the first fluid received from the first fluid container 136 is open to allow the first fluid to flow through the first outlet line 149, while the flow of the second fluid received from the second fluid container 138 is open to allow the second fluid to flow through the second outlet line 151; and (3) the flow of the first fluids received from the first fluid container 136 is open to allow the first a fluid to flow through the second outlet line 151. The valve 140 may be electronically controlled to switch between the three positions/states through the user interface 112 or it may be manually actuated.

[0077] With continued reference to FIG. 7D, the first fluid and the second fluid flow from the valve 140 to a first pump 134 and a second pump 135 through the first and second fluid outlet lines 149, 151. In another embodiment, the valve 140 is connected directly to the first and second pumps 134, 135. Outlets of the first and second pumps 134, 135 are connected to the multi-patient connector 116 by way of a first and second pump outlet lines 119, 121. The first and second pump outlet lines 119, 121 may be joined together to a single fluid outlet line 117 at a connector 123. A one-way check valve 125 may be provided in the second pump outlet line 121 to prevent the first fluid from flowing into the second pump 135 or the second fluid container 138 and contaminating the second fluid in the pump 135 or in fluid line 151. In one embodiment, the connector 123 and the check valve 125 may be integrated into a unitary structure.

[0078] With reference to FIG. 7E, a schematic diagram of the cartridge 120 is illustrated in accordance with a further embodiment. First and second fluids are delivered from the first and second fluid containers 136, 138 to the valve 140 via first and second fluid lines 142, 144, as further detailed hereinabove. One or both of the first and second fluid containers 136, 138 may include a connector 146 for connecting the first and second fluid containers 136, 138 to the first and second fluid lines 142, 144, respectively. In some embodiments, the connector 146 may be a

one-way valve to prevent the flow of fluid from the first and second fluid lines back to the first and second fluid containers **136**, **138**. In other embodiments, the connector **146** may be an aseptic connector configured to prevent contamination of the first and second fluids flowing from the first and second fluid containers **136**, **138** through the first and second fluid lines **142**, **144**. In yet another embodiment, the connector **146** may be a combination of a one-way valve with aseptic features.

[0079] With further reference to **FIG. 7E**, a third fluid is selectively delivered from a third container **139** to one of or both of the first and second fluid lines **142**, **144** via a third fluid line **143**. The third fluid line **143** may include a connector **147** configured to selectively deliver the third fluid from the third fluid container **139** to one or both of the first and second fluid lines **142**, **144**. In one embodiment, the third fluid line **143** connects directly to the connector **147** on the first and second fluid lines **142**, **144**. In another embodiment, the third fluid line **143** connects directly to the first and second fluid lines **142**, **144**. In a further embodiment, each of the first and second fluid lines **142**, **144** may be in fluid communication with a separate container having a third and fourth fluid (not shown). Connector **147** may also include a valve that may be operated by either manually or via interface **112** to open fluid communication from the third container to one of or both of the first and second fluid lines **142**, **144** via a third fluid line **143**.

[0080] With continued reference to **FIG. 7E**, the third fluid container **139** may contain a third fluid that is a disinfecting or sterilizing fluid. Once the third fluid passes through one or both of the first and second fluid lines **142**, **144**, the third fluid disinfects or sterilizes the fluid line through which it flows. In this manner, the fluid path between the first and/or second fluid containers **136**, **138** and the multi-patient connector **116** can be disinfected and/or sterilized. The cleaning/sterilization of the fluid path between the first and second fluid containers **142**, **144** and the multi-patient connector **116** can be carried out after each injection procedure, or it may be carried out selectively after a number of injection procedures have been completed. While **FIG. 7E** illustrates the combination of the third fluid container **139** with the valve **140** and pump **134** arrangement as shown in **FIG. 7A**, it is to be understood that third fluid container **139** may be incorporated into the valve and pump arrangement of any of the embodiments shown in **FIGS. 6B** and **7B-7H** to provide cleaning and/or sterilization capability to all embodiments of the cartridge **120** described herein.

[0081] With reference to **FIG. 7F**, a schematic diagram of the cartridge **120** is illustrated in accordance with a further embodiment. First and second fluids are delivered from the first and second fluid containers **136, 138** to the valve **140** via first and second fluid lines **142, 144**, as further detailed herein with reference to **FIG. 7A**. The cartridge **120** may further include at least one sterilization device **150** disposed therein, for example in fluid connection with at least one of the fluid paths between the first and second containers **136, 138** and the multi-patient connector **116**. In one embodiment, the sterilization device **150** is disposed between the first and second fluid containers **136, 138** and the valve **140**. For example, the sterilization device **150** may be disposed between the first and second fluid containers **136, 138** and the valve **140** such that it acts on one or both of the first and second fluid lines **142, 144**. The sterilization device **150** may be configured to inject vaporized fluid into one or both of the first and second fluid lines **142, 144**. Once the vaporized fluid, such as water, alcohol, or hydrogen peroxide, passes through one or both of the first and second fluid lines **142, 144**, the vaporized fluid disinfects or sterilizes the fluid line through which it flows. In this manner, at least a portion of the fluid path between the first and second fluid containers **136, 138** and the multi-patient connector **116** can be cleaned and sterilized. The cleaning of the fluid path between the first and second fluid containers **136, 138** and the multi-patient connector **116** can be carried out after each injection procedure, or it may be carried out selectively after a number of injection procedures have been completed. While **FIG. 7F** illustrates the combination of sterilization device **150** with the valve and pump arrangement as shown in **FIG. 7A**, it is to be understood that the sterilization device **150** may be incorporated into the valve **140** and pump **134** arrangement of any of the embodiments shown in **FIGS. 6B** and **7B-7H** to provide cleaning and/or sterilization capability to all embodiments of the cartridge **120** described herein. Further, while **FIG. 7F** illustrates the sterilization device **150** provided between the first and second fluid containers **136, 138** and the valve **140**, the sterilization device **150** may also be provided in a fluid path between the valve **140** and the multi-patient connector **116**. In certain embodiments, one or more sterilization devices **150** may be provided within the cartridge **120**.

[0082] With reference to **FIG. 7G**, a schematic diagram of the cartridge **120** is illustrated in accordance with another embodiment. First and second fluids are delivered from the first and second fluid containers **136, 138** to the valve **140** via first and second fluid lines **142, 144**, as further detailed herein with reference to **FIG. 7A**. The cartridge **120** may further include at least

one sterilization device **150** disposed therein, for example in connection with at least one of the fluid paths between the first and second containers **136**, **138** and the multi-patient connector **116**. In one embodiment, the sterilization device **150** may be disposed between the first and second fluid containers **136**, **138** and the valve **140**. In another embodiment, the sterilization device **150** may be provided between the valve **140** and the multi-patient connector **116**. One or more sterilization devices **150** may be provided within the cartridge **120**.

[0083] With continued reference to **FIG. 7G**, the sterilization device **150** may be configured to irradiate at least a portion of the fluid path between the first and second fluid containers **136**, **138** and the multi-patient connector **116** with electromagnetic radiation. For example, the sterilization device **150** may be configured to direct ultraviolet light or other high energy radiation onto the fluid path. Once the electromagnetic radiation acts on at least a portion of the fluid path between the first and second fluid containers **136**, **138** and the multi-patient connector **116**, the portion of the fluid path that is irradiated with electromagnetic radiation is sterilized to prevent contamination of the fluid flowing therethrough. In this manner, at least a portion of the fluid path between the first and second fluid containers **136**, **138** and the multi-patient connector **116** can be cleaned and/or sterilized. The cleaning/sterilization of the fluid path between the first and second fluid containers **136**, **138** and the multi-patient connector **116** can be carried out after each injection procedure, or it may be carried out selectively after a number of injection procedures have been completed. While **FIG. 7G** illustrates the combination of sterilization device **150** with the valve and pump arrangement as shown in **FIG. 7A**, it is to be understood that the sterilization device **150** may be incorporated into the valve **140** and pump **134** arrangement of any of the embodiments shown in **FIGS. 6B** and **7B-7H** to provide cleaning and/or sterilization capability to all embodiments of the cartridge **120** described herein.

[0084] With reference to **FIG. 7H**, a schematic diagram of the cartridge **120** is illustrated in accordance with another embodiment. In the embodiment shown in **FIG. 7H**, at least one of the first fluid container **136** and the second fluid container **138** may have a sampling chamber **158** associated therewith. The sampling chamber **158** may be configured for withdrawing or containing a volume of the first and/or second fluid from the first and/or second fluid container **136**, **138**, respectively, to test the fluid for quality control prior to use of the container. The sampling chamber **158** may be configured to allow a small sample volume of fluid to be withdrawn and tested from the first and/or second fluid container **136**, **138** without

contaminating the remaining contents of the first and second fluid containers **136**, **138**. In one embodiment, the sampling chamber **158** has a sampling tube **160** that is sealed at a distal end **162**. Fluid from the first fluid container **136** or the second fluid container **138** fills the sampling tube **160**. The proximal end **164** of the sampling tube **160** may then be sealed, such as by heat sealing, and the sampling tube **160** is cut off at the proximal end **164** or otherwise removed while the container and its contents remains sealed. The sampling chamber **158** is then removed and used for testing the fluid contained therein. While **FIG. 7H** illustrates the combination of sampling chamber **158** with the arrangement of cartridge components as shown in **FIG. 7A**, it is to be understood that the sampling chamber **158** may be incorporated into at least one of the fluid containers associated with any of the embodiments shown in **FIGS. 6B** and **7B-7H** to provide fluid sampling capability to all embodiments of the cartridge **120** described herein.

[0085] While each of the embodiments of the cartridge **120** in **FIGS. 6B** and **7A-7H** shows the pump **134**, and in certain embodiments, pump **135** and valve **140** assembly provided within the cartridge **120**, in other embodiments, one or more of the pump(s) and/or valve assembly may be provided outside the interior cavity of the cartridge **120**. In such embodiments, the cartridge **120** may include a connection interface to connect the fluid path from the first and/or second fluid containers **136**, **138** to the valve **140** and/or pump(s) **134** (and/or pump **135**) provided outside the cartridge **120**. One of ordinary skill in the art will appreciate that one or more of a plurality of connection interfaces may be utilized to connect the fluid path from the first and second fluid containers **136**, **138** to the valve **140** and/or pump(s) **134** (and/or pump **135**). In some embodiments, the cartridge **120** may include a self-contained power source **156** (shown in **FIG. 6B**), such as a battery pack, or it may be connected to an external power source, such as an external power outlet to power the pump(s) **134** (and/or pump **135**) and/or the valve **140** and other powered components of cartridge **120** and fluid delivery system **100**.

[0086] In various embodiments, one or more of the fluid connections within cartridge **120**, for example between the first and second fluid containers **136**, **138**, the valve **140**, one or more pumps **134**, **135**, and the multi-patient connector **116** may be made at the time of manufacture to ensure a sterile fluid path between the first and second fluid containers **136**, **138** and the multi-patient connector **116**. In other embodiments, one or more of the fluid connections within cartridge **120**, for example between the first and second fluid containers **136**, **138**, the valve **140**, one or more pumps **134**, **135**, and the multi-patient connector **116** are made after the

manufacture. In such embodiments, it may be desirable to sterilize at least a portion of the fluid path between the first and second fluid containers **136, 138** and the multi-patient connector **116** prior to initial use. Additionally, the fluid delivery system **100** and the various components of cartridge **120**, such as at least a portion of the fluid path between the first and second fluid containers **136, 138**, the valve **140**, one or more pumps **134, 135**, and the multi-patient connector **116** may be configured to be primed prior to each use with a single-patient set. The priming operation purges air that may be trapped in the fluid path between the first and second fluid containers **136, 138** and the multi-patient connector **116**. In some embodiments, the priming operation may be carried out continuously at a low flow rate, for example a low flow rate of saline and/or contrast, to prevent contamination of the fluid path between the first and second fluid containers **136, 138** and the multi-patient connector **116**. Such a continuous purging/priming process may further prevent crystallization of the contrast when the fluid delivery system **100** is idle between patient injections. In certain embodiments, the fluid delivery system **100** may further comprise a waste receptacle (not shown) in fluid connection with at least one fluid path within cartridge **120**, for example, at multi-patient connector **116**, to collect any flow of purging/priming fluid.

[0087] Referring to **FIGS. 8A-8D**, a plurality of multi-patient connectors **116a-116d** and corresponding connectors **118a-118d** on the single-patient connector is illustrated. In each embodiment, the multi-patient and single-patient connectors **116a-116d, 118a-118d**, respectively, are configured for retaining a sterile connection therebetween. Each of the connectors may be configured for use on the connection interface **110** for connecting the fluid delivery system **100** to the single patient fluid path set **114** (shown in **FIG. 3**). For example, a fluid connection may be established using a luer-type connection, such as illustrated in **FIG. 8C**.

[0088] With reference to **FIG. 8D**, the connector assembly includes a multi-patient connector **116d** having a fluid path port configured for fluid connection with the fluid delivery system **100** and a waste fluid port in fluid connection with a waste container (not shown). In some embodiments, the waste container may be provided within the cartridge **120** or the cartridge carrier **108**, or it may be a separate component connectable to the fluid delivery system **100**. The fluid path set **114** (for example, shown in **FIGS. 3** and **6B**) includes: a fluid path port removably engageable with the fluid path port of the multi-patient connector **116d** to establish a fluid connection therewith; a waste fluid port removably engageable with the waste fluid port of the

multi-patient connector **116d** to establish a fluid connection therewith; and a patient fluid line connected, at one end, to the fluid path port of the single-patient connector **118d** and removably connected, at the other end, to the waste fluid port of the single-patient connector **118d**. Fluid flow through the patient fluid line **114** is unidirectional, from the end of the patient line connected to the fluid path port to the end of the patient fluid line connected to the waste fluid port. The patient fluid line is capable of being disconnected from the waste fluid port and connected to a patient catheter to establish a fluid connection from the fluid delivery system **100** (shown in **FIGS. 3** and **6B**) to the patient through the fluid path ports and patient fluid line. Various embodiments of the connector assembly shown in **FIG. 8D** are disclosed in U.S. Provisional Patent Application No. 61/925,940, filed January 10, 2014, entitled "Single-Use Disposable Set Connector", and assigned to the application of the present disclosure.

[0089] Referring to **FIGS. 9-20F**, a medical connector assembly **10** (hereinafter "connector assembly **10**") is illustrated in accordance with various embodiments of the present disclosure. The connector assembly **10** is configured for use as the connection interface **110** between the fluid delivery system **100** and the fluid path set **114** (shown in **FIG. 3**).

[0090] With initial reference to **FIGS. 9-12**, the assembled connector assembly **10**, generally includes a multi-patient connector **116** and a single-patient connector **118** releasably connected to the multi-patient connector **116**. In one embodiment, the multi-patient connector **116** is provided on the fluid delivery system **100** (shown in **FIG. 3**), such as on the cartridge **120**. The single-patient connector **118** is configured for removably connecting to the multi-patient connector **116** to deliver the first fluid, the second fluid, or a mixture thereof from the fluid delivery system **100** to the patient.

[0091] The multi-patient connector **116** is desirably a hollow, tubular structure made from a material suitable for medical applications, such as medical-grade plastic. In some embodiments, the multi-patient connector **116** is constructed from a clear medical-grade plastic in order to facilitate visual verification that a fluid connection has been established with the single-patient connector **118**. The multi-patient connector **116** may be formed on at least a portion of the cartridge **120**. At least one multi-patient connector **116** is provided on the cartridge **120**. Additionally, or in the alternative, one or more fluid path elements (not shown), such as medical tubing, a catheter, or other fluid path element, may be connected to the multi-patient connector **116** to enable fluid communication to the multi-patient connector **116**. For example, in one

embodiment, the multi-patient connector **116** is in fluid communication with the fluid outlet line **114** (shown in **FIG. 7A**). The multi-patient connector **116** desirably has one or more fluid passageways **18** configured for interfacing with the single-patient connector **118**. The one or more fluid passageways **18** are configured for allowing the passage of fluid through the multi-patient connector **116** for delivery of the first fluid, the second fluid, or a mixture thereof from the fluid delivery system **100** to the patient.

[0092] As described in detail herein, the multi-patient connector **116** is configured for connecting to a single-patient connector **118** which is configured to be disposed after a single use. Each single-patient connector **118** is desirably a hollow, tubular structure made from a material suitable for medical applications, such as medical-grade plastic. With specific reference to **FIG. 9**, the connector assembly **10** is shown with one single-patient connector **118** that is connected to the multi-patient connector **116** and one single-patient connector **118** that is ready for disposal after use. Both single-patient connectors **118** are shown in **FIG. 9** in a state after removal from packaging (not shown). Each single-patient connector **118** is desirably packaged in a pre-sterilized, sealed package that protects the single-patient connector **118** from contamination with air or surface-borne contaminants.

[0093] With reference to **FIG. 9**, each single-patient connector **118** includes a housing **20** having a hollow tubular form. The housing **20** has a proximal end **22** and a distal end **24** with a central fluid passage **26** extending through a longitudinal length of the housing **20** between the proximal and distal ends **22, 24**. The central fluid passage **26** is desirably recessed relative to the proximal end **22** to prevent undesired contact with the central fluid passage **26**. The distal end **24** of the housing **20** includes a substantially quadrilateral flange **28** that extends from the housing **20**. A seal **30** is provided around a perimeter of the flange **28**. The housing **20** further includes one or more recesses **32** configured for engaging a male connector of a fluid path, as will be described hereafter. Referring to **FIG. 16**, a cap **34** is provided on the distal end **24** of the housing **20**. The cap **34** has a generally quadrilateral shape that is adapted to envelop the flange **28** of the housing **20**. A finger tab **36** is provided on one or more sides of the cap **34** to facilitate removal of the cap **34** from the housing **20**. The cap **34** engages the seal **30** (shown in **FIG. 18**) to maintain a sterile interface at the flange **28**. The cap **34** is slidably mounted on the flange **28** such that it can slide substantially perpendicularly relative to the longitudinal axis of the housing **20**. The finger tab **36** may have a plurality of ribs **38** on the external sidewall thereof to provide

a convenient gripping surface for the user to remove the cap 34 after the single-patient connector 118 is connected to the multi-patient connector 116.

[0094] The single-patient connector 118 may be, for example, removably attached to or, alternatively, part of a syringe, fluid pump device, and like fluid delivery devices. As shown in FIG. 9, the single-patient connector 118 includes a fluid path 40 having a male connector 42 and a fluid line 44. The male connector 42 has one or more resilient tabs 46 that are configured to engage the one or more recesses 32 on the housing 20 of the single-patient connector 118. Engagement between the tabs 46 of the male connector 42 and the recesses 32 of the housing 20 creates a positive locking connection. Once inserted into the central fluid passage 26 of the housing 20, the tip of the male connector 42 extends through a second seal 58 (shown in FIGS. 15 and 19). The second seal 58 may be formed as a septum that is pierced by the tip of the male connector 42. Alternatively, the second seal 58 may have one or more deflectable elements that are deflected by the tip of the male connector 42 as it is advanced through the housing 20.

[0095] As the male connector 42 is inserted into the housing 20, the tip of the male connector 42 interfaces with the fluid passageways 18 of the multi-patient connector 116. As shown in FIG. 15, a seal 48 is provided at the interface of the multi-patient connector 116 and the male connector 42. The seal 48 forms a fluid-tight connection between the mating elements and prevents fluid from a fluid source container, a fluid delivery device, medical tubing, etc., from dripping through the interface between the mating elements of the multi-patient connector 116 or the male connector 42. In one exemplary embodiment, the seal 48 may be an o-ring seal which is formed between a surface on the multi-patient connector 116 and a surface on the single-patient connector 118. Alternately, the seal 48 may be in the form of a face seal or an o-ring provided on the mating surface of a mating element. The mechanical connection between the multi-patient connector 116 and the male connector 42 of the fluid path 40 may be established in a number of other ways. For example, the multi-patient connector 116 may have a threaded female luer connection and the male connector 42 may have a correspondingly threaded male luer connection, or vice versa. Another alternative for making a fluid-tight connection between the multi-patient connector 116 and the male connector 42 is a bayonet connection where a male end on one of the multi-patient connector 116 or the male connector 42 has one or more pins which engage a matching slot provided on the female end of the other of the multi-patient connector 116 or the male connector 42. Other possible embodiments of mechanical connection

between the multi-patient connector **116** and the male connector **42** include a face-sliding attachment, barbed fittings, collet fittings, compression fittings, clamp fittings, and bonding or breakable attachments. In another embodiment, the stem of the male connector **42** could be a needle which engages a receptacle on the housing **20** which is protected by a pierceable septum. One of ordinary skill in the art will recognize that this listing of connection alternatives for making fluid-tight connections between the mating components of the multi-patient connector **116** and the male connector **42** is not exhaustive and that other equivalent mechanical connecting arrangements may be used. Additionally, various combinations and permutations of the foregoing-described mechanical connecting arrangements may be employed in accordance with this disclosure.

[0096] Referring back to **FIG. 9**, the connector assembly **10** further includes a frame **50** that is adapted to slidably receive one or more single-patient connectors **118** and to support the multi-patient connector **116**. In one embodiment, the frame **50** has a width that is at least an integer multiple of the width of the single-patient connector **118**. The height of the frame **50** is substantially equal to the height of the cap **34** of the single-patient connector **118**. In one embodiment, a plurality of single-patient connectors **118** may be disposed in a cartridge **120** for sequential loading into the frame **50**. The frame **50** may be integrally formed with the cartridge **120** or it may be removably or non-removably attached thereto.

[0097] With reference to **FIGS. 20A-20F**, a method of using the medical connector assembly **10** will now be described. Initially, with reference to **FIG. 20A**, the housing **20** of the single-patient connector **118** is positioned into a groove **52** on the frame **50** such that the housing **20** is aligned with the fluid passageway **18** of the multi-patient connector **116**. Such arrangement of the housing **20** protects the fluid passageway **18** of the multi-patient connector **116** from contamination. The frame **50** further includes a shroud **54** that extends opposite of the multi-patient connector **116**, as shown in **FIG. 20B**. The shroud **54** is configured to envelop the housing **20** of the single-patient connector **118**. Referring to **FIGS. 20B-C**, the single-patient connector **118** is inserted into the groove **52** on the frame **50** by aligning the cap **34** of the single-patient connector **118** with the groove **52** and positioning the single-patient connector **118** within the groove **52**. A pair of projections **56** (shown in **FIG. 9**) on the shroud **54** is adapted to fixedly retain the cap **34** of the single-patient connector **118** as the single-patient connector **118** is slid within the groove **52** of the frame **50**.

[0098] With reference to **FIG. 20D**, the inserted single-patient connector **118** is moved laterally toward the housing **20** that covers the fluid passageway **18** of the multi-patient connector **116**. As the single-patient connector **118** slides within the shroud **54**, the cap **34** is removed without exposing the distal end **24** of the housing **20** of the single-patient connector **118**. Sliding of the single-patient connector **118** within the groove **52** of the frame **50** causes the seal **30** at the distal end **24** of the housing **20** to slidably engage the frame **50** to prevent contamination of the single-patient and multi-patient connectors **118**, **116**. In an alternative embodiment, the shroud **54** is slidable relative to the frame **50**. In this embodiment, the single-patient connector **118** is loaded at one end of the shroud **54** while the shroud **54** is oriented in a first position. The shroud **54** is then moved relative to the frame **50** to bring the single-patient connector **118** in alignment with the multi-patient connector **116**. After use, the single-patient connector **118** can be discarded by sliding the shroud **54** in a second position. Once the single-patient connector **118** is aligned with the multi-patient connector **116**, the cap **34** and the displaced housing **20** may be removed from the frame **50** by grasping the finger tab **36** of the cap **34** and by removing the housing **20** from the frame **50**, respectively (see **FIG. 20D**). In another embodiment, the cap **34** and the housing **20** may be automatically disposed into a receptacle (not shown). The male connector **42** is pushed into the housing **20**, thereby disengaging the locking tabs **60** (see **FIG. 17**). Further movement of the male connector **42** into the housing **20** engages the second seal **58** and locks the resilient tabs **46** on the male connector **42** with the recesses **32** in the housing **20**. In another embodiment, male connector **42** may be locked in position with threads. Once a secure, fluid-tight connection between the multi-patient connector **116** and the single-patient connector **118** is made, fluid from a fluid source or a fluid delivery device may be delivered to the fluid path **40**, and either immediately or ultimately delivered to a patient as desired.

[0099] After completion of a fluid delivery procedure, the male connector **42** may be removed, leaving the housing **20** to cover the fluid passageway **18** of the multi-patient connector **116** (see **FIG. 20F**). When it is desired to remove the single-patient connector **118** from connection with the multi-patient connector **116**, a second single-patient connector **118** is inserted into the groove **52** of the frame **50** and is moved into alignment with the multi-patient connector **116**. Movement of the second single-patient connector **118** causes the first single-patient connector **118** to be displaced from connection to the multi-patient connector **116**. After positioning the second

second-patient connector **118** into alignment with the multi-patient connector **116**, the displaced first single-patient connector **118** may be removed from the frame **50** and discarded.

[00100] With reference to **FIG. 21A**, the single-patient connector **118** is shown in accordance with another embodiment. The single-patient connector **118** has a hollow, tubular structure made from a material suitable for medical applications, such as medical-grade plastic. The single-patient connector **118** is configured for being connected to the multi-patient connector **116** shown in **FIG. 21B**. The single-patient connector **118** is shown in **FIG. 21A** in a state after removal from packaging (not shown). Prior to initial use, the single-patient connector **118** is packaged in a pre-sterilized, sealed package that protects the single-patient connector **118** from contamination with air or surface-borne contaminants.

[00101] With continued reference to **FIG. 21A**, each single-patient connector **118** includes a housing **20** having a hollow tubular form. The housing **20** has a proximal end **22** and a distal end **24** with a central fluid passage **26** extending through a longitudinal length of the housing **20** between the proximal and distal ends **22**, **24**. The central fluid passage **26** is desirably recessed relative to the proximal end **22** to prevent undesired contact with the central fluid passage **26**. The housing **20** is configured for telescopically receiving a male connector **42**.

[00102] The male connector **42** includes a central channel **37** surrounded by an annular skirt **39**. The central channel **37** is in fluid communication with the fluid line **44**. The housing **20** includes a substantially quadrilateral flange **28** and an annular skirt **29** extending proximally from the flange **28**. A central opening **31** is provided at the distal end **24** of the housing **20**. A first seal **30** is provided around a perimeter of the flange **28**. A second seal **58** is provided within the annular skirt **29** to seal the fluid path extending through the housing **20**. In one embodiment, the second seal **58** may be formed as a septum that is pierced by the central channel **37** of the male connector **42**. Alternatively, the second seal **58** may have one or more deflectable elements that are deflected by the tip of the male connector **42** as it is advanced through the annular skirt **29** of the housing **20**. In another embodiment, the second seal **58** may be in a form of a dual one-way check valve arrangement.

[00103] A cap **34** is provided on the distal end **24** of the housing **20**. The cap **34** has a generally quadrilateral shape that is adapted to envelop the flange **28**. A finger tab **36** is provided on one or more sides of the cap **34** to facilitate removal of the cap **34** from the housing **20**. The cap **34** engages the seal **30** to maintain a sterile interface at the flange **28**. The cap **34** is

slidably mounted on the flange 28 such that it can slide substantially perpendicularly relative to the longitudinal axis of the housing 20.

[00104] In one embodiment, the male connector 42 and the housing 20 may have a locking mechanism 21 to lock the male connector 42 and the housing 20 from moving relative to each other. For example, the male connector 42 may have a groove 23 that is received within a projection 25 provided on the housing 20. Alternatively, the groove 23 may be provided on the housing 20 while the projection 25 may be provided on the male connector 42. A pair of locking mechanisms can be provided to lock the male connector 42 relative to the housing 20 in a first position and a second position. In the first position, the male connector 42 may be positioned further apart from the housing 20 than in the second position.

[00105] A method of using the single-patient connector 118 shown in FIG. 21A is substantially similar to the method of using the single-patient connector 118 shown in FIGS. 20A-20F. Referring initially to FIG. 22A, the single-patient connector 118 is placed in position on the multi-patient connector 116 as described hereinabove with reference to FIG. 20A-20D. The male connector 42 is pushed into the housing 20 toward the distal end 24. Further movement of the male connector 42 into the housing 20 engages the second seal 58 and locks the locking mechanism 21, as shown in FIG. 22B. In another embodiment, male connector 42 may be locked in position with threads. Once a secure, fluid-tight connection between the multi-patient connector 116 and the single-patient connector 118 is made, fluid from a fluid source or a fluid delivery device may be delivered to the fluid line 44, and either immediately or ultimately to a patient as desired.

[00106] After completion of a fluid delivery procedure, the male connector 42 may be removed, leaving the housing 20 to cover the fluid passageway 18 of the multi-patient connector 116 (see FIG. 22C). When it is desired to remove the single-patient connector 118 from connection with the multi-patient connector 116, a second single-patient connector 118 is inserted into the groove 52 of the frame 50 and is moved into alignment with the multi-patient connector 116. Movement of the second single-patient connector 118 causes the first single-patient connector 118 to be displaced from connection to the multi-patient connector 116. After positioning the second single-patient connector 118 into alignment with the multi-patient connector 116, the displaced first single-patient connector 118 may be removed from the frame 50 and discarded.

[00107] With reference to FIG. 23A, a fluid outlet line 117 of the multi-patient connector 116 is shown in accordance with one embodiment. The fluid outlet line 117 has a generally tubular body 170 with a proximal end 172 configured for connection with the pump 134 (shown in FIGS. 7A-7H) or the valve 140 (shown in FIGS. 7A-7H) or a fluid path extending distally from pump 134. A distal end 174 is provided opposite the proximal end 172. In one embodiment, the fluid outlet line 117 may be spooled on a reel (not shown) such that the distal end 174 can be drawn out from the reel. The tubular body 170 has a plurality of tubular segments 176 connected together by connection members 178. The plurality of tubular segments 176 may be arranged serially such that a proximal end of one tubular segment 176 is connected to a distal end of an adjacent tubular segment 176 or to the fluid path set 114. The connection members 178 may have a one-way valve member that prevents the flow of fluid from the distal end 174 of the fluid outlet line 117 toward the proximal end 172 and thereby prevent contamination of the next proximal segment when the most distal segment is removed. In another embodiment, the connection members 178 have a releasable connection structure that allows the adjacent tubular segments 176 to be separated such that the distal segment may be removed and discarded, for example after a single patient use. Upon removal of the most distal segment, the next adjacent segment becomes the distal segment and may be placed in fluid connection with a patient fluid path, such as a single use patient fluid path.

[00108] In use, the connection member 178 of the distal most tubular segment 176 is configured for connection with the fluid path set 114 for delivering fluid to the patient. After priming the fluid outlet line 117 and completing an injection procedure, the fluid path set 114 is disconnected from the distal most tubular segment 176 and the distal most tubular segment 176 is disconnected from the adjacent tubular segment 176. Alternatively, the fluid path set 114 and the distal most tubular segment 176 may remain connected, while the distal most tubular segment 176 is disconnected from the adjacent tubular segment 176. In this manner, the distal most tubular segment 176 can be connected to a second fluid path set 114 for a second injector procedure. The multi-patient connector 116 can be replaced when all or substantially all of the tubular segments 176 have been used. In another embodiment, the tubular segment 176 may be cut at a proximal end of the distal-most connection member 178. The exposed end of the tubular segment 176 may then be sealed, such as by adding a fitting. The fitting can then be connected with a second fluid path set 114 for the next injection procedure.

[00109] With reference to **FIG. 23B**, a fluid outlet line **117** of the multi-patient connector **116** is shown in accordance with one embodiment. The fluid outlet line **117** has a generally tubular body **170** with a proximal end **172** configured for connection with the pump **134** (shown in **FIGS. 7A-7H**) or the valve **140** (shown in **FIGS. 7A-7H**) or a fluid path extending distally from pump **134**. A distal end **174** is provided opposite the proximal end **172**. In one embodiment, the fluid outlet line **117** may be spooled on a reel (not shown) such that the distal end **174** can be drawn out from the reel. Prior to use, the user can draw out a desired length of the fluid outlet line **117**.

[00110] With continued reference to **FIG. 23B**, the distal end **174** of the fluid outlet line **117** is sealed with a proximal seal **180** and a distal seal **182** that prevent fluid flow through the tubular body **170** of the fluid outlet line **117**. Prior to use, a cut is made between the proximal seal **180** and the distal seal **182** such that the distal portion of the tubular body **170** is cut off from the rest of the fluid outlet line **117** and the proximal portion of the tubular body **170** is sealed by the proximal seal **180**. The exposed end of the tubular body **170** is then connected to a connection member **178** (shown in **FIG. 24**) to facilitate connection with the fluid path set **114**. In another embodiment, the exposed end of the tubular body **170** may be inserted over or into the proximal end of the fluid path set **114** and the connection therebetween can be established by heat or adhesive sealing the interface between the tubular body **170** and the fluid path set **114**. Once connected with the fluid path set **114**, an injector needle **184** pierces the sidewall of the tubular body **170** between the proximal seal **180** and the connection member **178** to deliver fluid to the patient. Tubular body **170** comprises a plurality of proximal seals **180** and distal seals **182** spaced along the length of the tubular body **170** each at a predetermined distance from the next proximally adjacent pair of seals. After the completion of the injection procedure, the tubular body **170** is sealed with a second seal at a location proximate of the proximal seal **180**. The tubular body **170** can then be cut between the second seal and the proximal seal **180** to connect a second connection member **178** to the exposed end of the tubular body **170**.

[00111] With reference to **FIG. 24**, a fluid outlet line **117** of the multi-patient connector **116** is shown in accordance with another embodiment. The fluid outlet line **117** has a generally tubular body **170** with a proximal end **172** configured for connection with the pump **134** (shown in **FIGS. 7A-7H**) or the valve **140** (shown in **FIGS. 7A-7H**). A distal end **174** is provided opposite the proximal end **172**. In one embodiment, the fluid outlet line **117** may be spooled on a reel

(not shown) such that the distal end 174 can be drawn out from the reel. The distal end 174 of the fluid outlet line 117 is configured for being connected to a connection member 178. In one embodiment, the connection member 178 is part of the fluid path set 114 and may be bonded, adhered, sealed, threadably coupled, or otherwise connected with the fluid path set 114. The distal end 174 of the tubular body 170 may be inserted over or into the connection member 178. A seal 190, such as an O-ring, may be provided at the interface between the tubular body 170 and the connection member 178.

[00112] In use, the distal end 174 of the tubular body 170 of the fluid outlet line 117 is inserted into the connection member 178. In this manner, the fluid outlet line 117 is in fluid communication with the fluid path set 114 via the connection member 178. In some embodiments, the connection interface between the fluid outlet line 117 and the connection member 178 may be sealed, such as by heat sealing. After priming the fluid outlet line 117 and completing an injection procedure, the fluid outlet line 117 is disconnected from the fluid path set 114 by cutting of the distal end 174 of the fluid outlet line 117. In some embodiments, the distal end 174 may be removed from the connection member 178 before being cut. For the next injection procedure, the fluid outlet line 117 can be connected to the connection member 178 of a new fluid path set 114.

[00113] While various embodiments of the fluid delivery system 100 and the connector assembly therefor were provided in the foregoing description, those skilled in the art may make modifications and alterations to these embodiments without departing from the scope and spirit of the disclosure. For example, it is to be understood that this disclosure contemplates that, to the extent possible, one or more features of any embodiment can be combined with one or more features of any other embodiment. Accordingly, the foregoing description is intended to be illustrative rather than restrictive.

THE INVENTION CLAIMED IS:

1. A cartridge for a fluid delivery system, the cartridge comprising:
 - a first fluid container configured for storing a first fluid therein;
 - a second fluid container configured for storing a second fluid therein, the second fluid being different from the first fluid;
 - at least one pump configured for delivering under pressure one or both of the first fluid and the second fluid; and
 - at least one valve configured for selectively delivering one or both of the first fluid and the second fluid to the pump,wherein the first and second containers, the at least one pump, and the at least one valve are received within an outer shell of the cartridge, and
wherein the cartridge is removably engagable with the fluid delivery system.
2. The cartridge according to claim 1, wherein the at least one pump further comprises a first pump in fluid communication with the first fluid container for delivering under pressure the first fluid and a second pump in fluid communication with the second fluid container for delivering under pressure the second fluid.
3. The cartridge according to claim 1, wherein the at least one valve has a plurality of states for selectively allowing a flow of the first fluid, the second fluid, or both the first fluid and the second fluid through the at least one valve.
4. The cartridge according to claim 3, wherein the at least one valve comprises:
 - a first state where the flow of the first fluid and the second fluid through the at least one valve is closed;
 - a second state where the flow of one of the first fluid and the second fluid through the valve is open and the flow of the other of the first fluid and the second fluid through the valve is closed; and
 - a third state where the flow of the first fluid and the second fluid through the valve is open.

5. The cartridge according to claim 1, further comprising a first fluid line in fluid communication with the first fluid container and a second fluid line in fluid communication with the second fluid container.

6. The cartridge according to claim 5, further comprising a third fluid container configured for storing a third fluid therein, wherein the third fluid container is in fluid communication with at least one of the first fluid line and the second fluid line.

7. The cartridge according to claim 6, wherein the third fluid is a disinfectant configured for disinfecting at least one of the first fluid line and the second fluid line.

8. The cartridge according to claim 5, further comprising at least one sterilization device in operational communication with at least one of the first fluid line and the second fluid line.

9. The cartridge according to claim 8, wherein the sterilization device is in fluid communication configured to inject vaporized fluid into at least one of the first fluid line and the second fluid line.

10. The cartridge according to claim 8, wherein the sterilization device is configured to irradiate at least a portion of at least one of the first fluid line and the second fluid line with electromagnetic radiation.

11. The cartridge according to claim 10, wherein the electromagnetic radiation is ultraviolet radiation.

12. The cartridge according to claim 1, further comprising at least one fluid level indicator configured for indicating a volume of at least one of the first fluid inside the first fluid container and the second fluid inside the second fluid container.

13. The cartridge according to claim 1, further comprising at least one viewing window on at least one of the first fluid container or the second fluid container, the at least one viewing window configured for providing visual access to an interior of the at least one of the first fluid container and the second fluid container.

14. The cartridge according to claim 1, further comprising at least one refilling port in fluid communication with at least one of the first fluid container and the second fluid container for refilling the at least one of the first fluid container with the first fluid and the second fluid container with the second fluid.

15. The cartridge according to claim 1, wherein at least a portion of the second fluid container is received within an interior of the first fluid container.

16. The cartridge according to claim 1, further comprising at least one sampling chamber in fluid communication with at least one of the first fluid container and the second fluid container, the at least one sampling chamber configured to draw a sample of at least the first fluid from the first fluid container and the second fluid from the second fluid container.

17. The cartridge according to claim 1, further comprising a power source received within the cartridge for providing power to at least one of the at least one pump and the at least one valve.

18. The cartridge according to claim 1, wherein the first fluid is saline and wherein the second fluid is contrast.

19. A fluid delivery system comprising:
a cartridge carrier; and
a cartridge configured for being removably engagable with the cartridge carrier,
the cartridge further comprising:
a first fluid container configured for storing a first fluid therein;

a second fluid container configured for storing a second fluid therein, the second fluid being different from the first fluid;

at least one pump configured for delivering under pressure one or both of the first fluid and the second fluid;

at least one valve configured for selectively delivering one or both of the first fluid and the second fluid to the pump, and

at least one multi-patient connector configured for fluidly connecting the cartridge to a single-patient connector,

wherein the first and second containers, the at least one pump, the at least one valve are received within an outer shell of the cartridge.

20. A medical connector assembly, comprising:

a multi-patient connector;

one or more single-patient connectors removably engagable with the multi-patient connector to establish a fluid path therethrough, each single-patient connector comprising a housing having a proximal end opposite a distal end with a central fluid path extending therebetween, a flange extending around the distal end, and a cap removably engaged to the flange; and

a sterility-maintaining arrangement configured for slidably removing the cap from the one or more single-patient connectors without exposing the distal end of the one or more single-patient connectors to contamination.

1/37

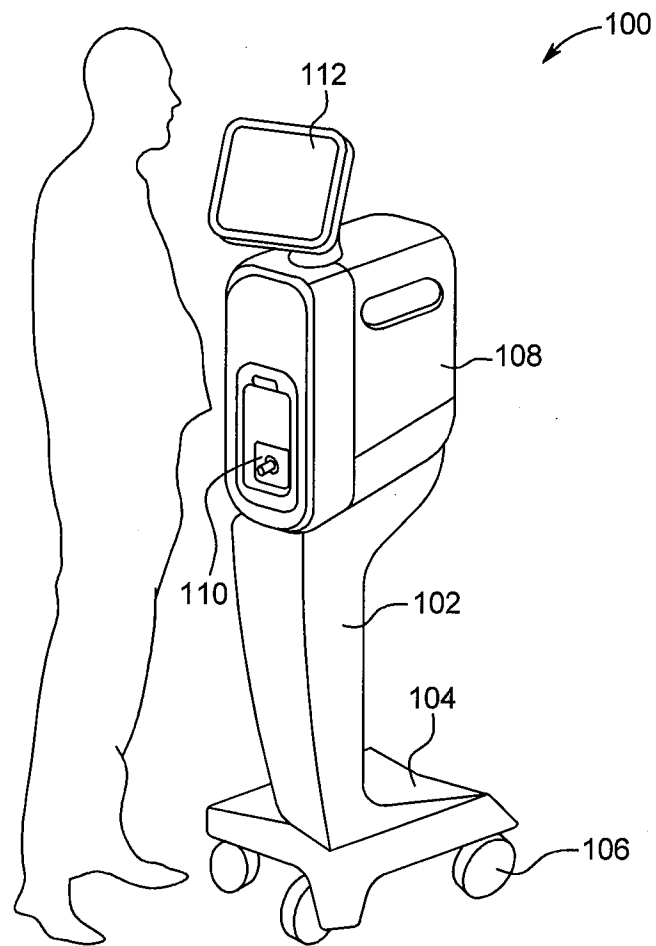


FIG. 1

2/37

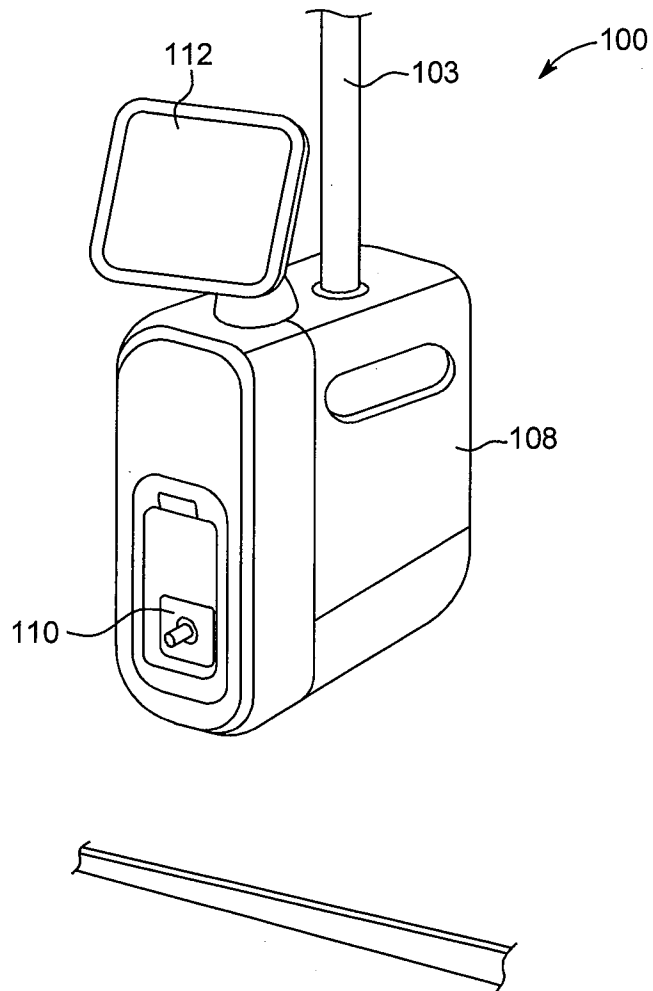


FIG. 2

3/37

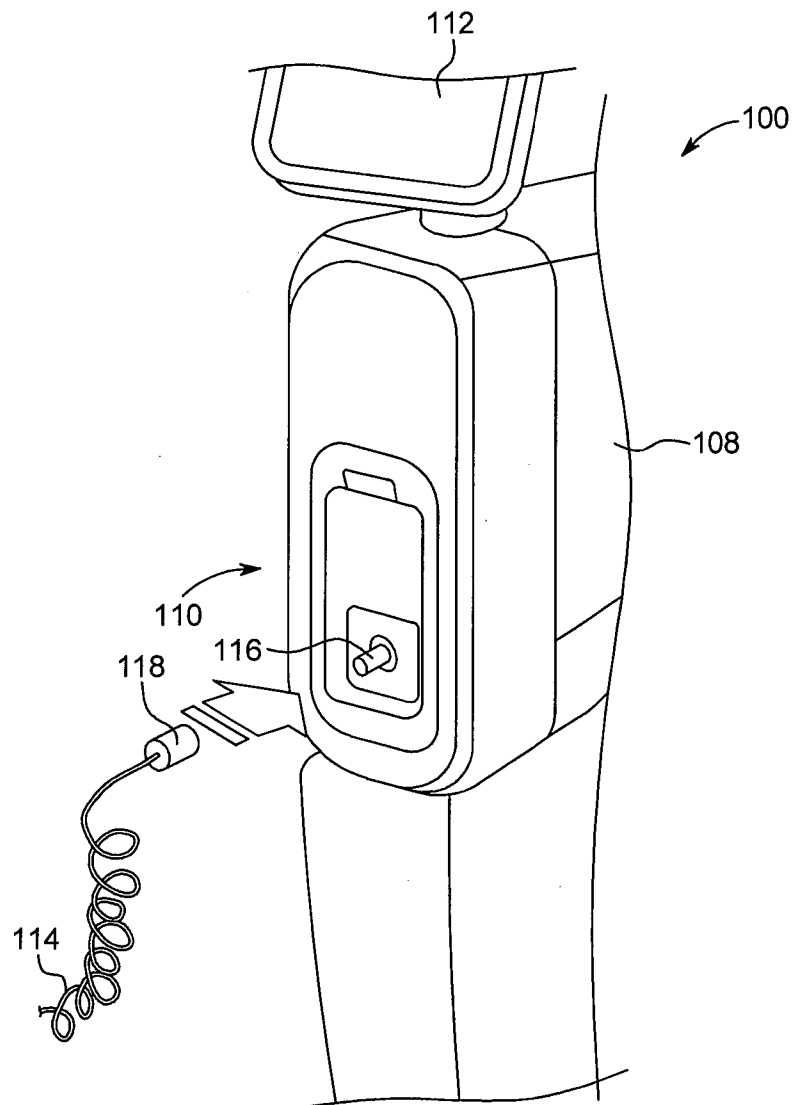


FIG. 3

4/37

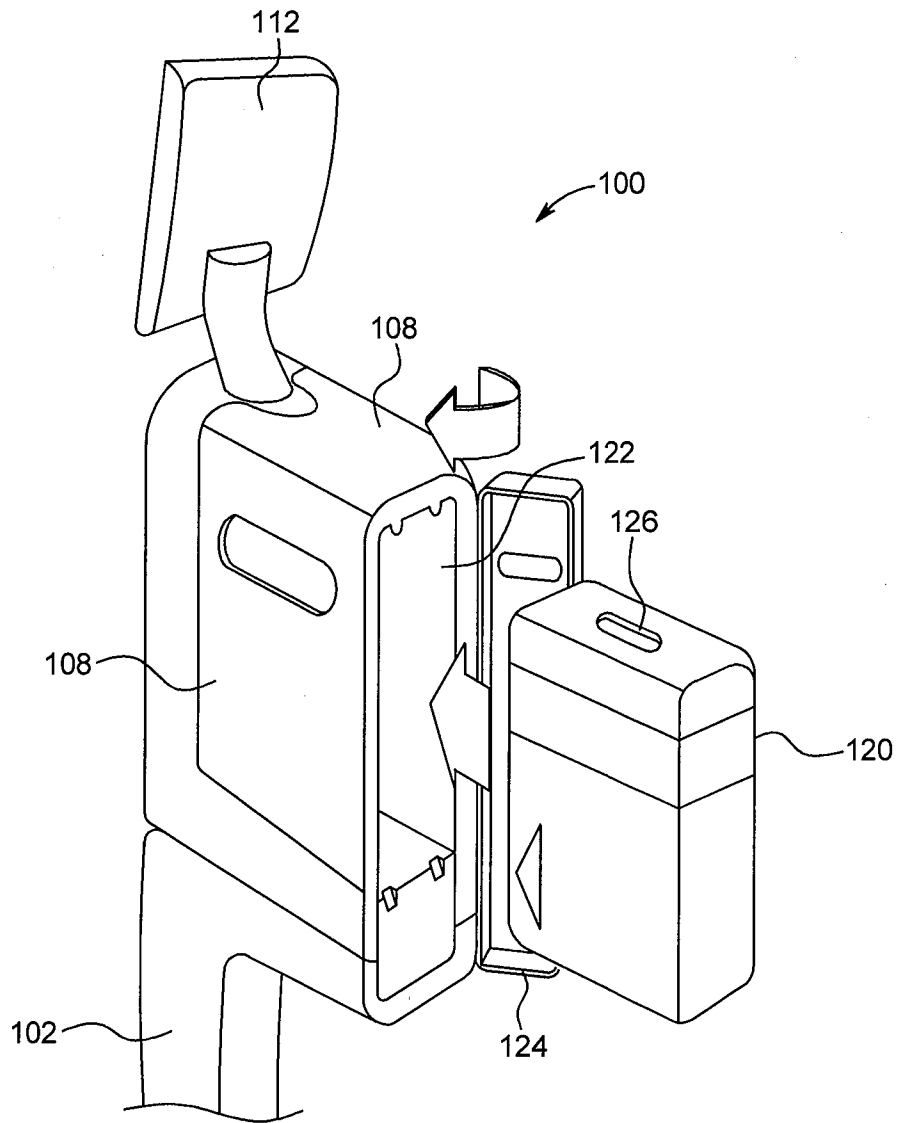


FIG. 4

5/37

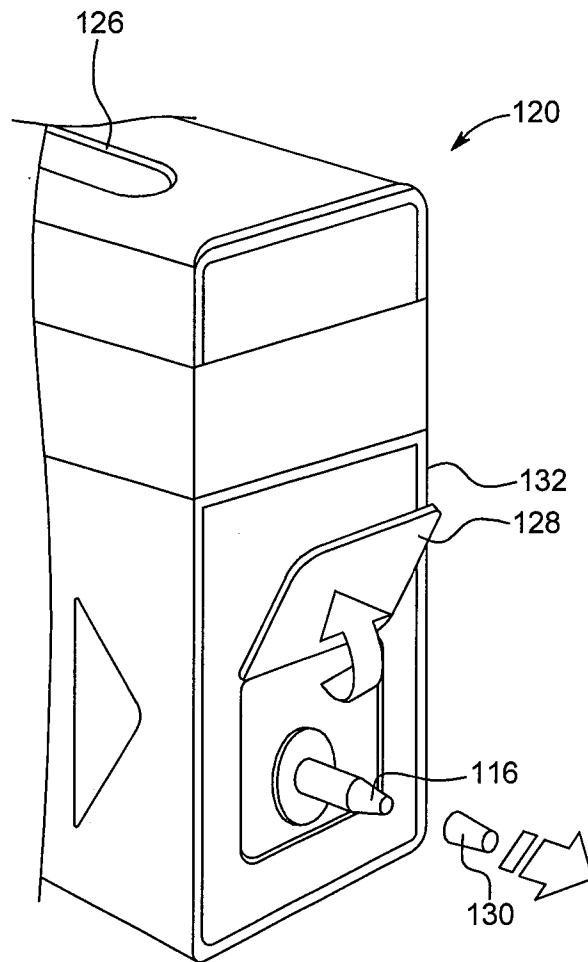


FIG. 5

6/37

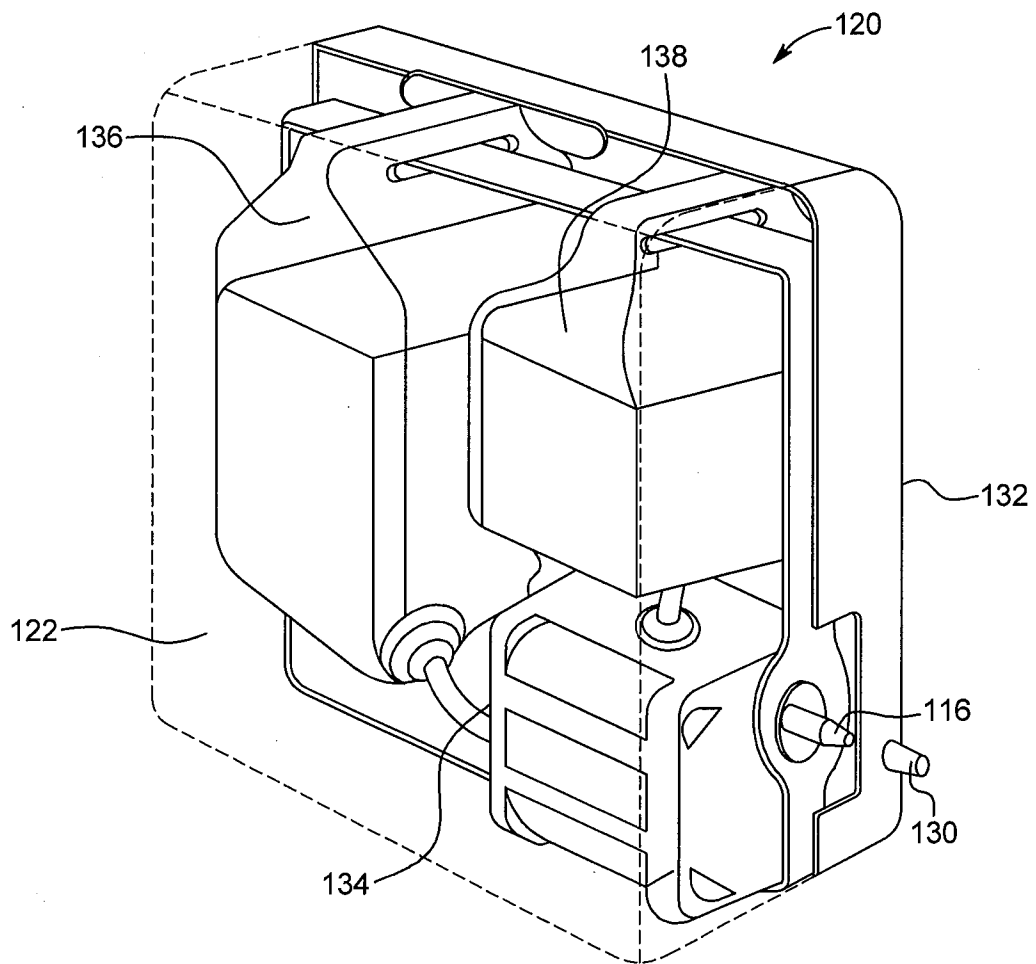


FIG. 6A

7/37

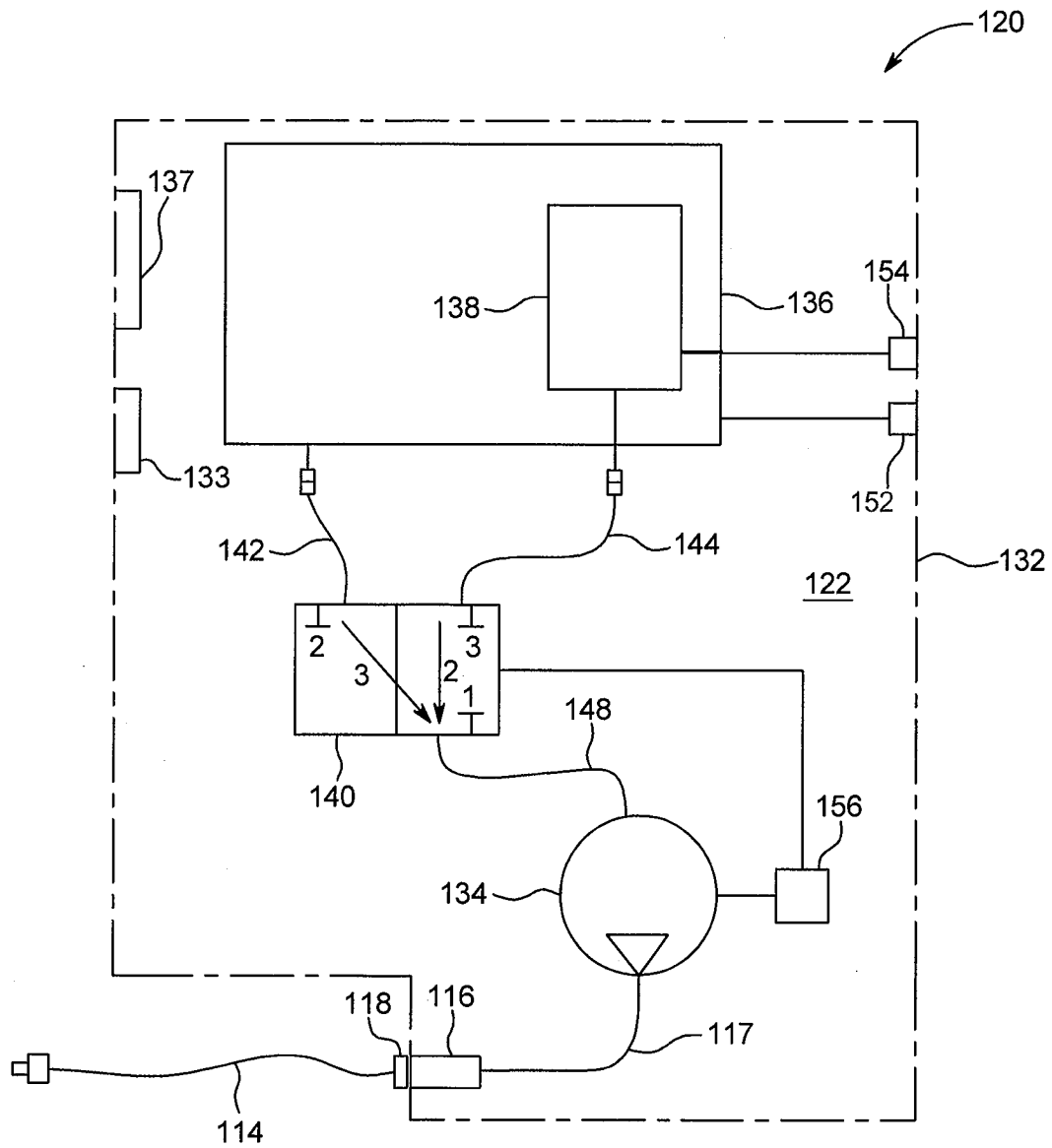


FIG. 6B

8/37

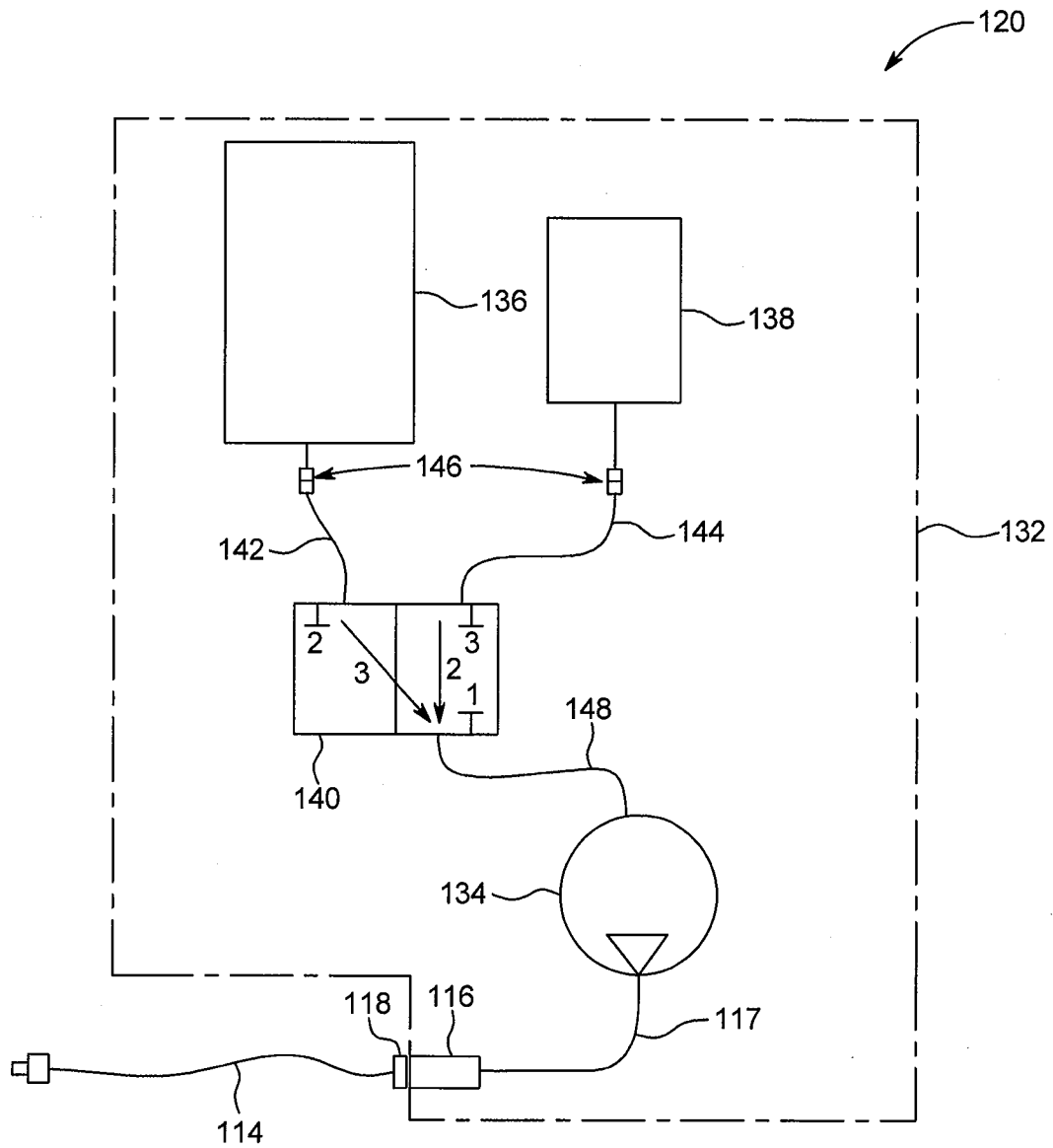


FIG. 7A

9/37

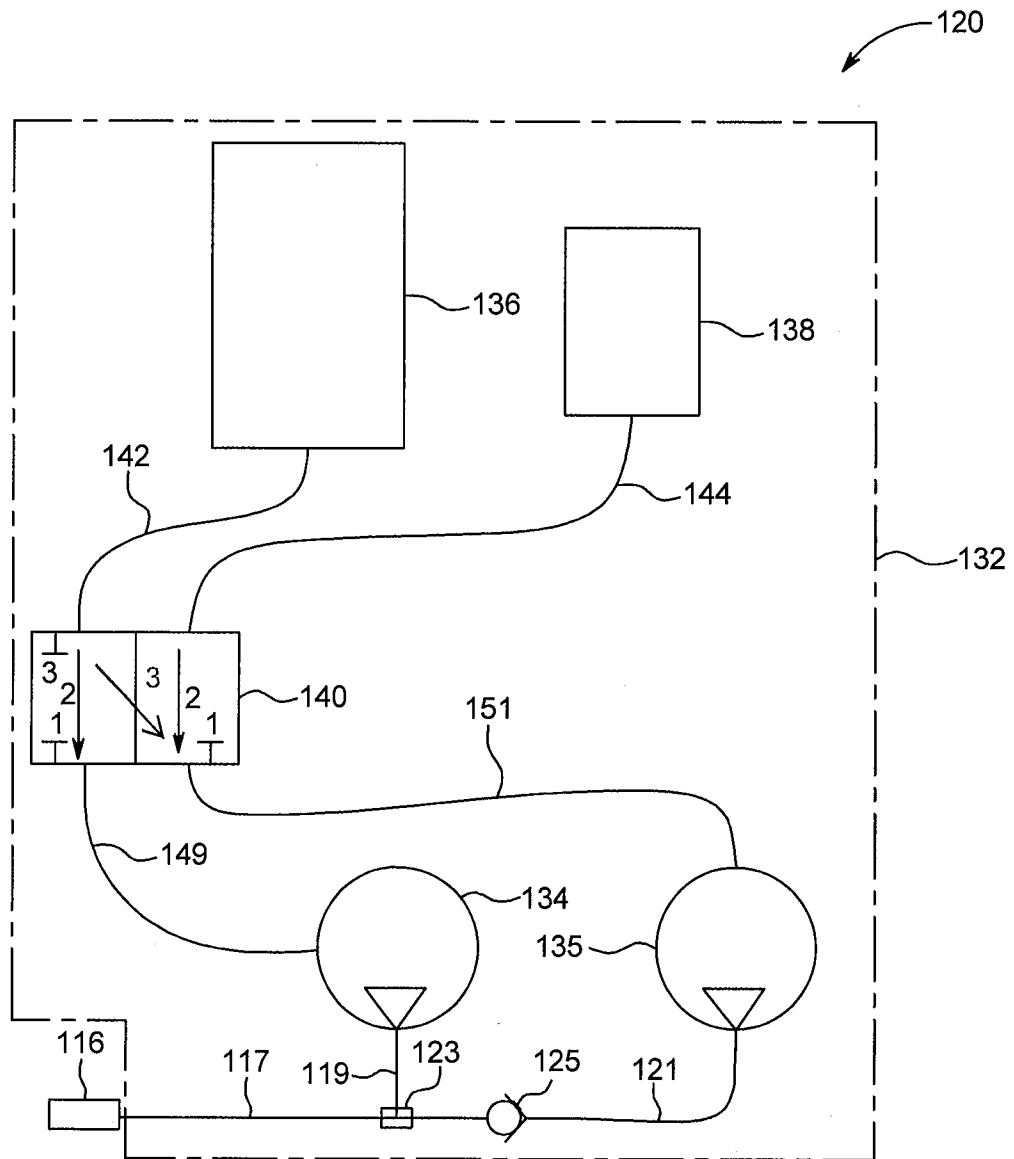


FIG. 7B

10/37

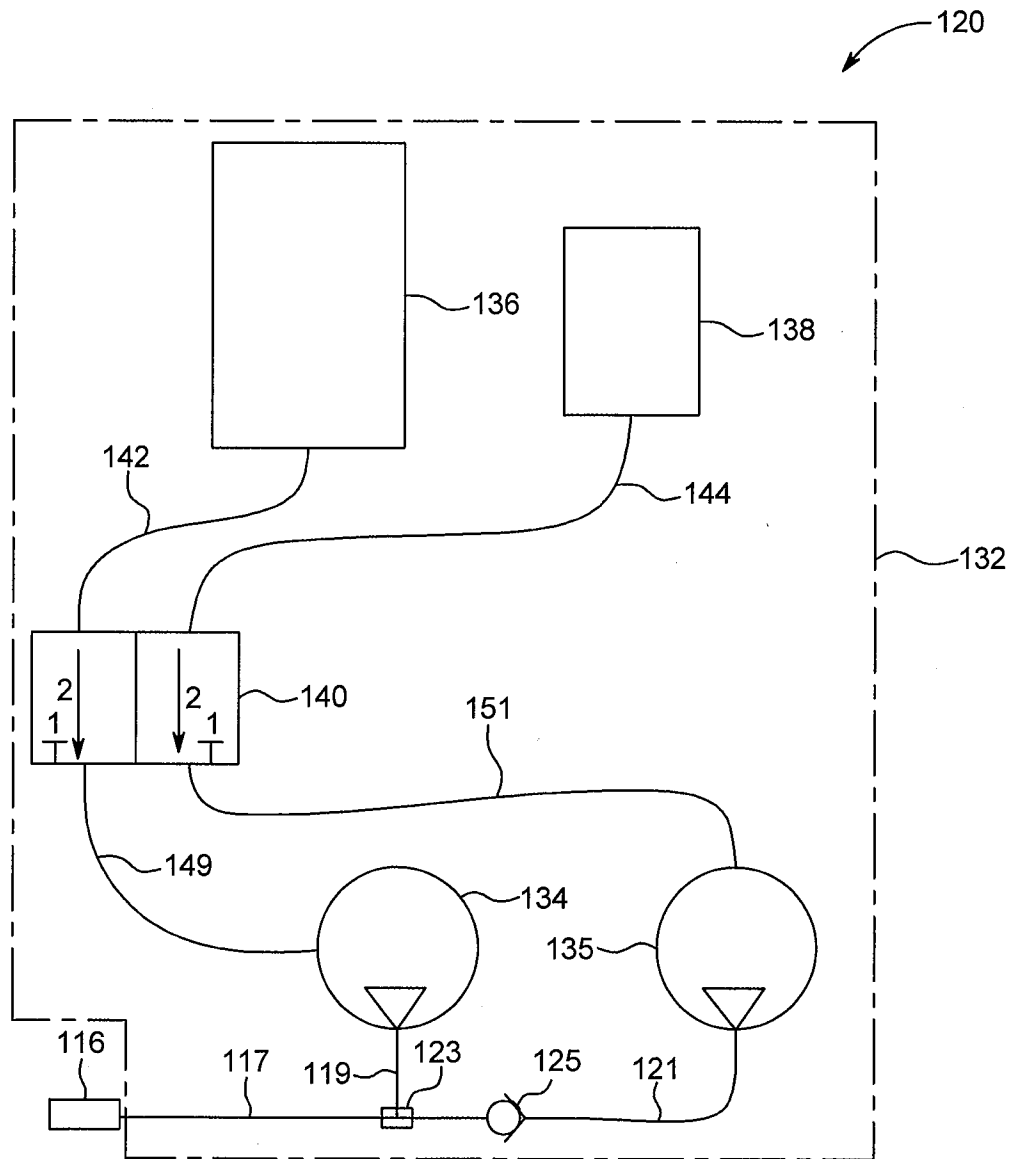


FIG. 7C

11/37

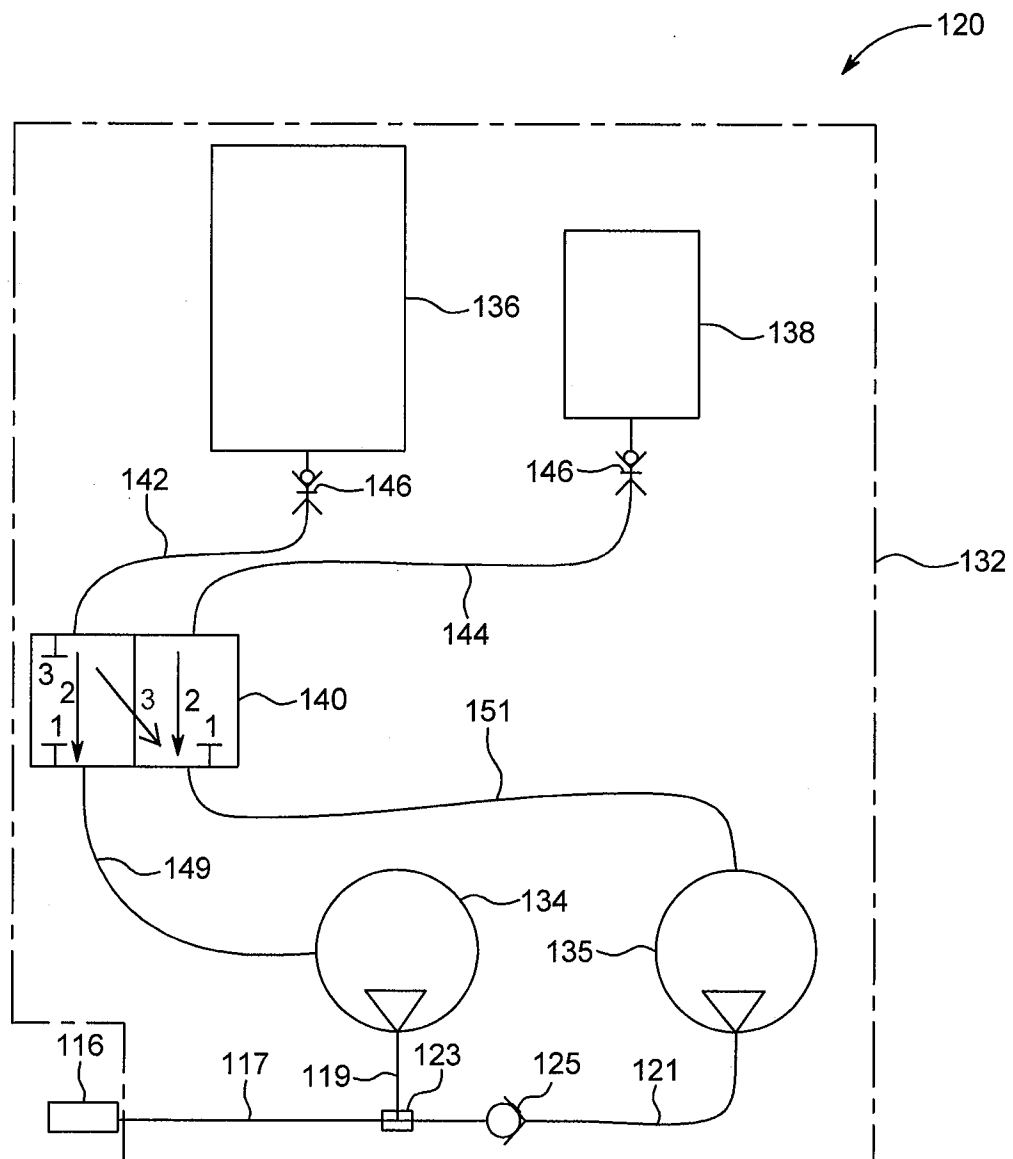


FIG. 7D

12/37

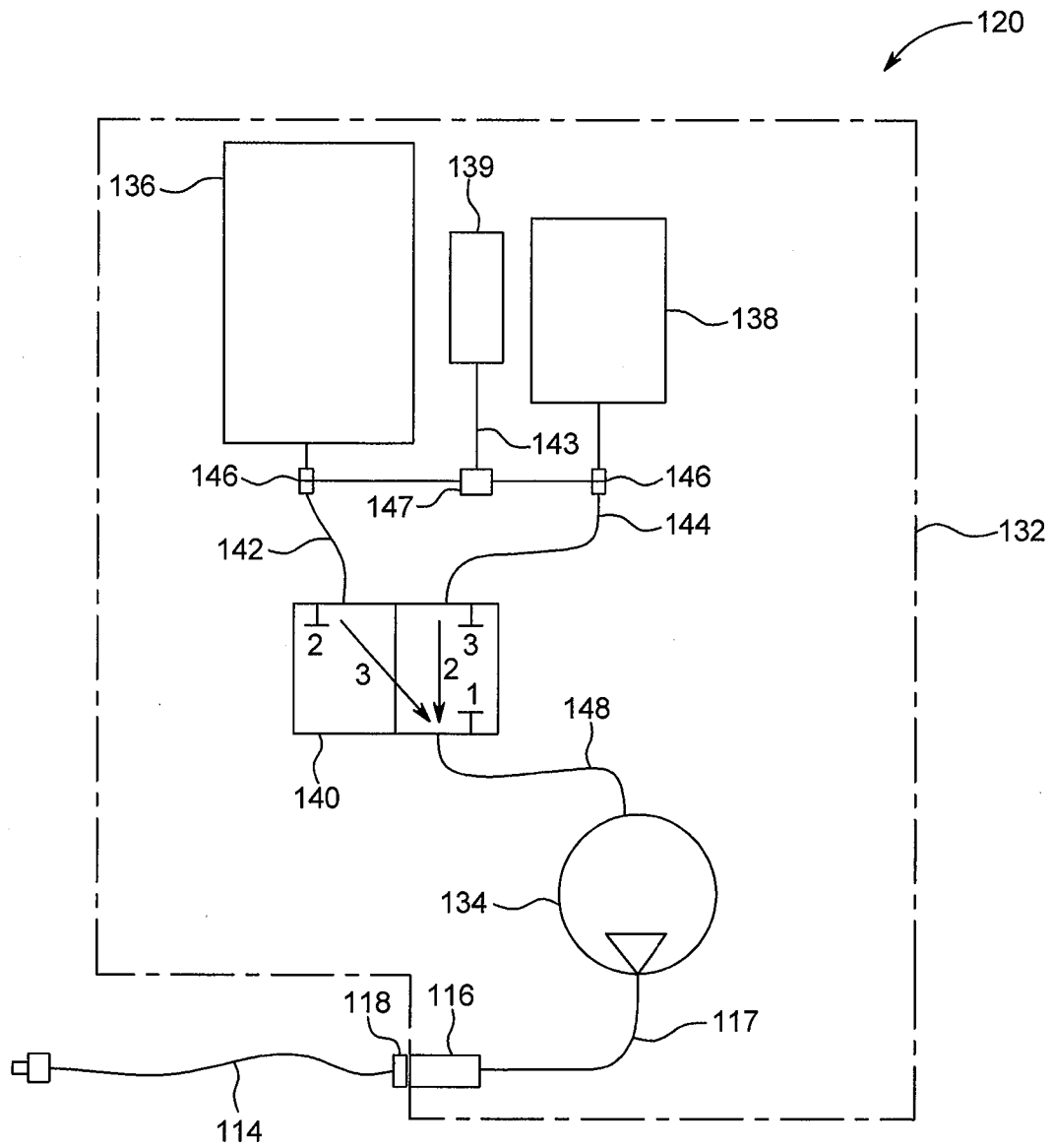


FIG. 7E

13/37

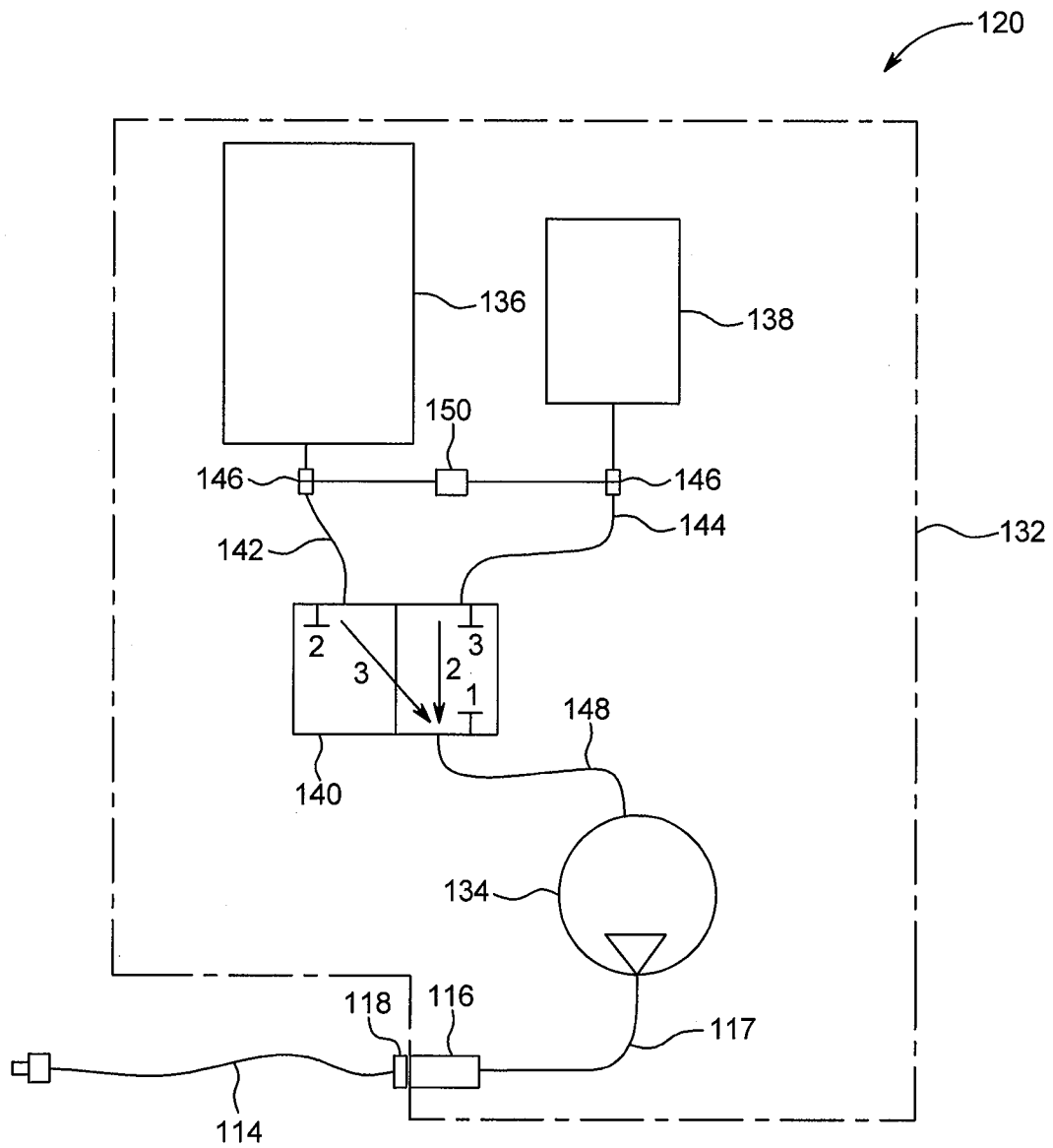


FIG. 7F

14/37

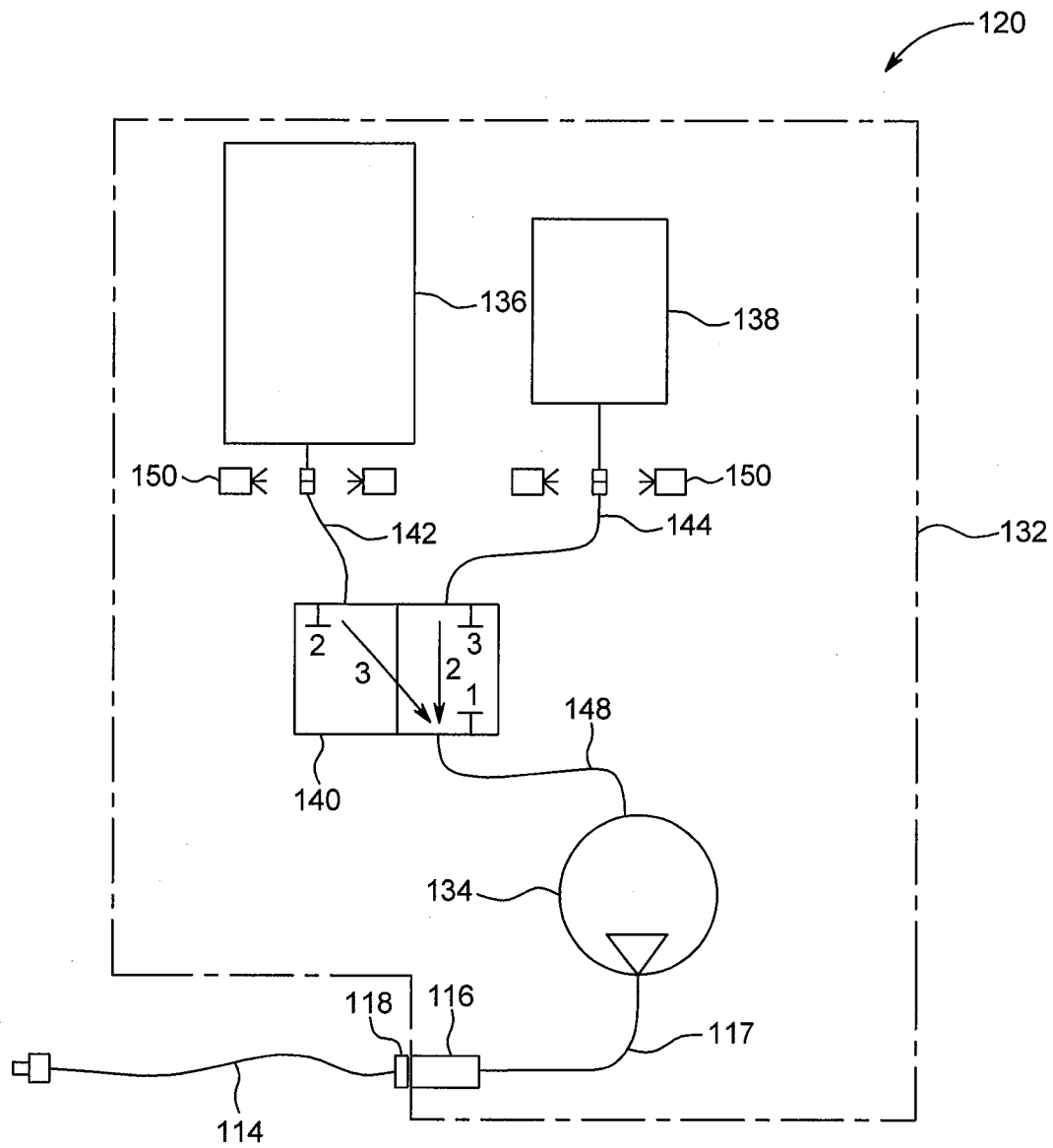


FIG. 7G

15/37

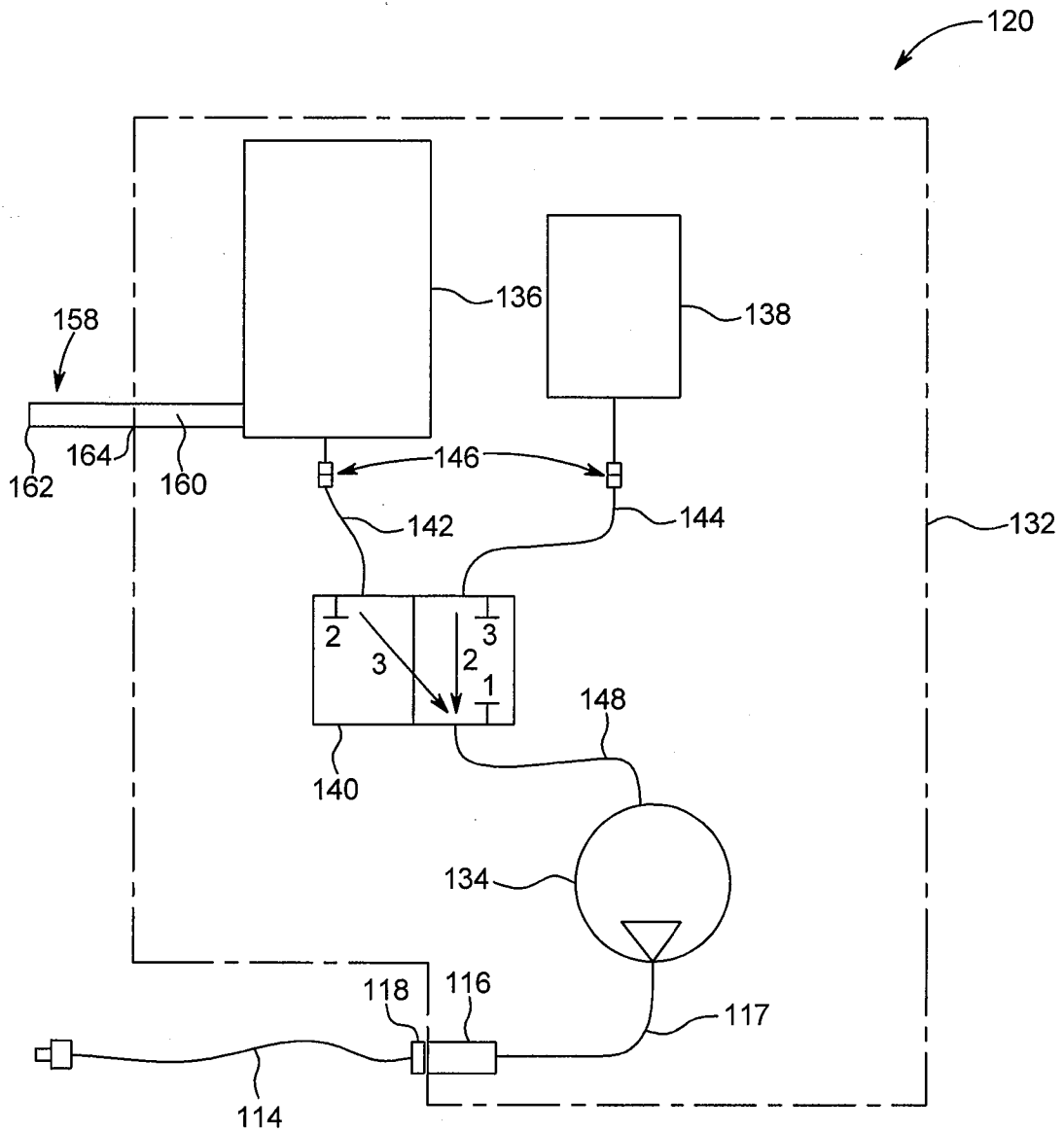


FIG. 7H

16/37

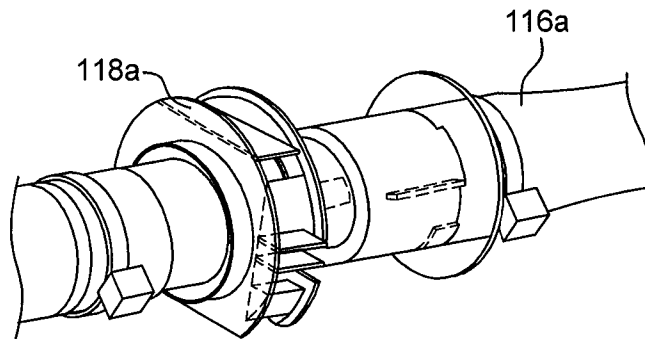


FIG. 8A

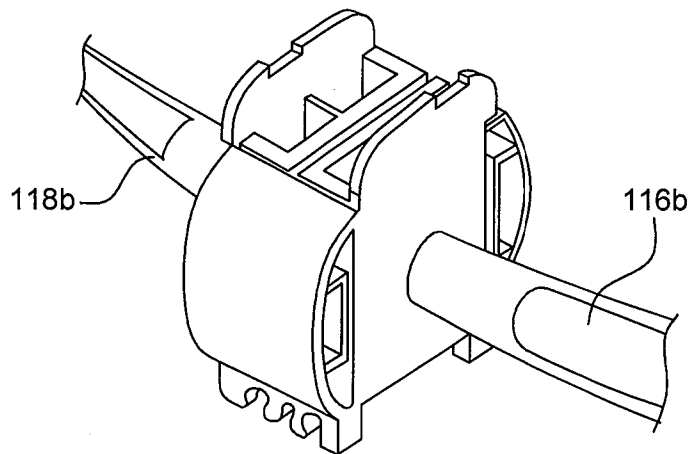


FIG. 8B

17/37

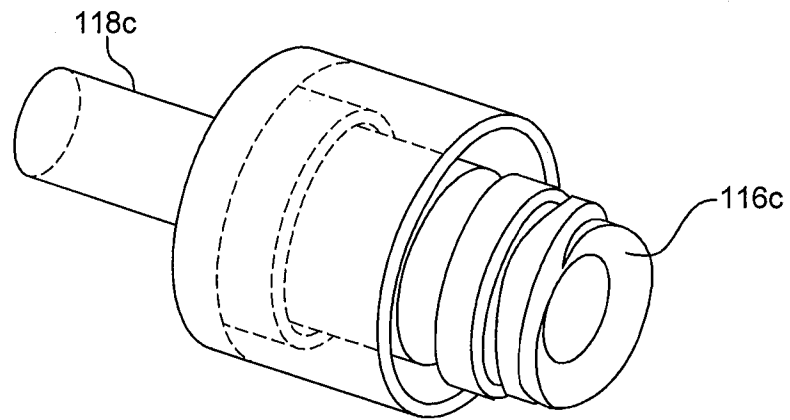


FIG. 8C

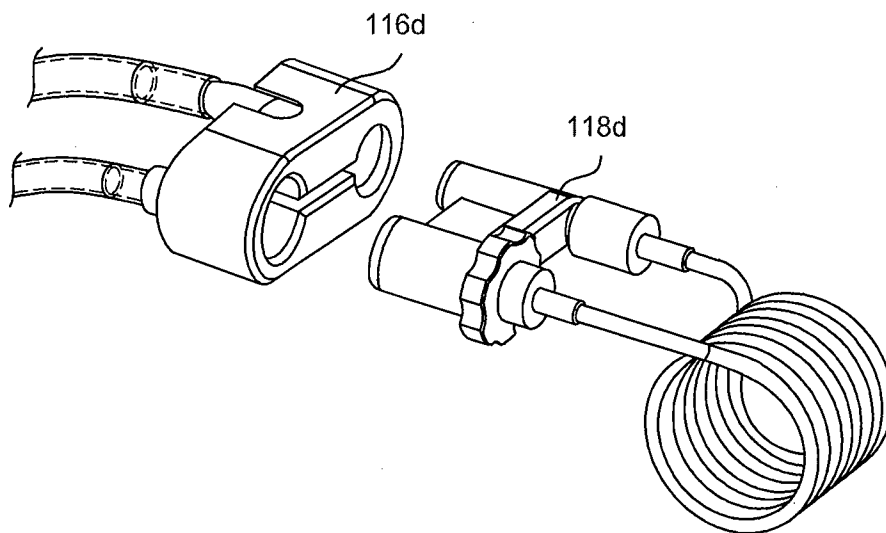


FIG. 8D

18/37

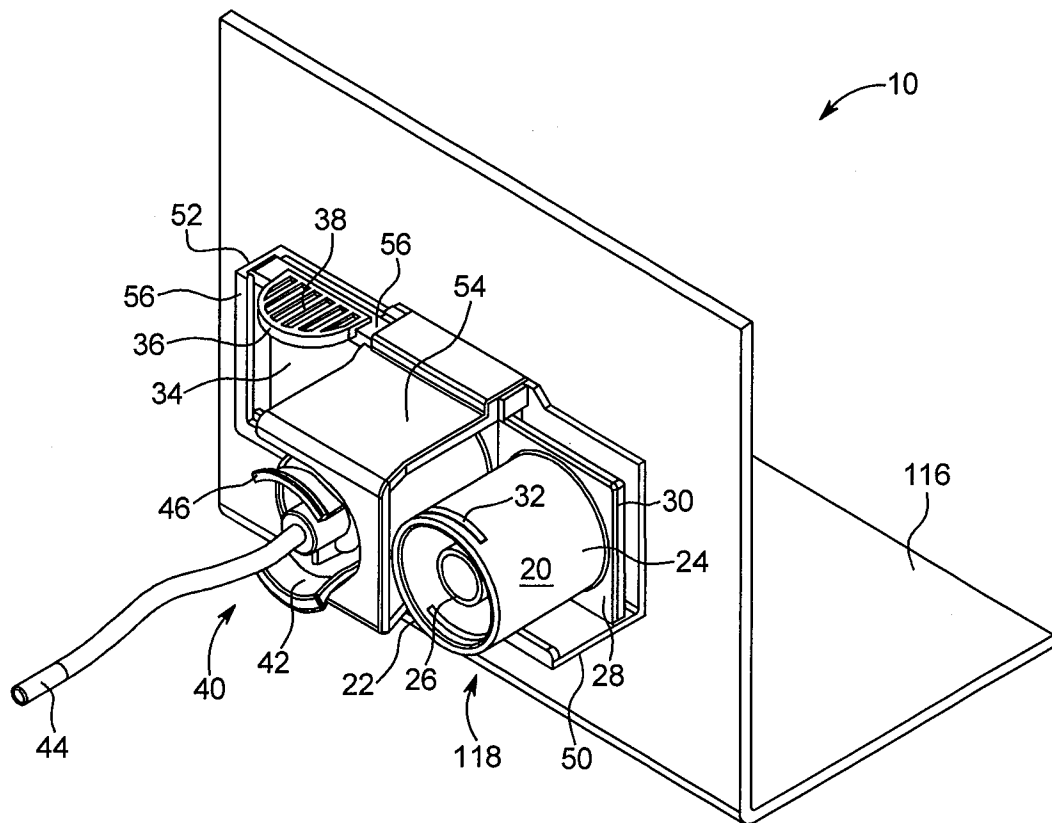


FIG. 9

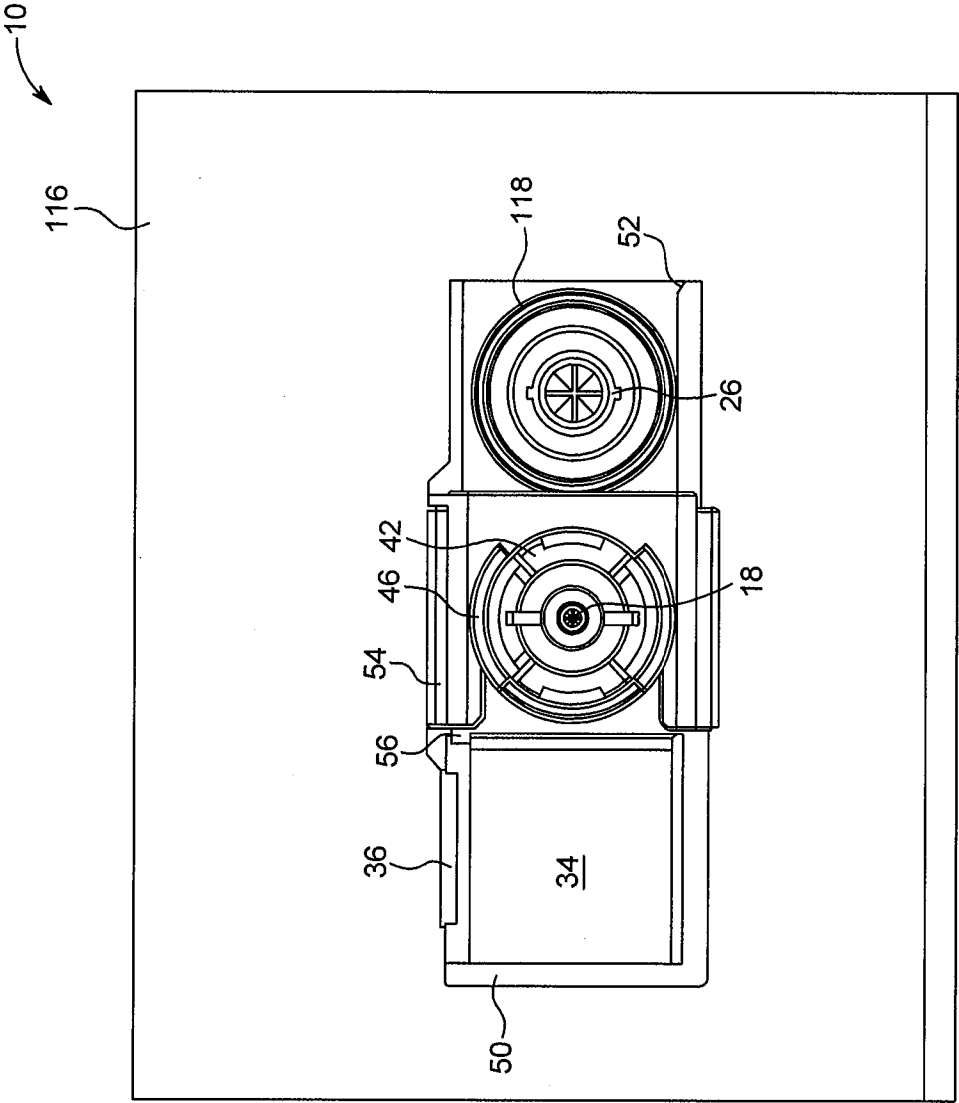


FIG. 10

20/37

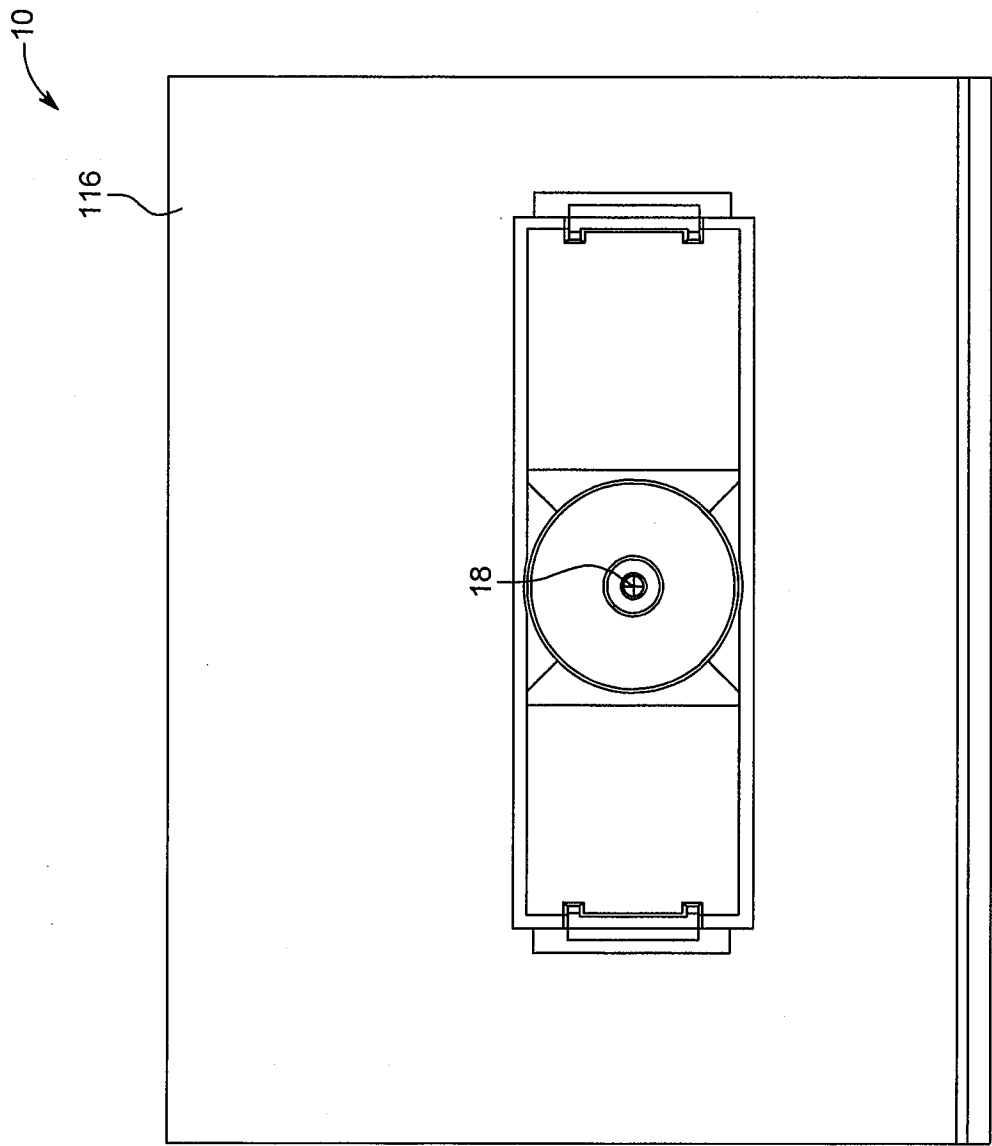


FIG. 11

21/37

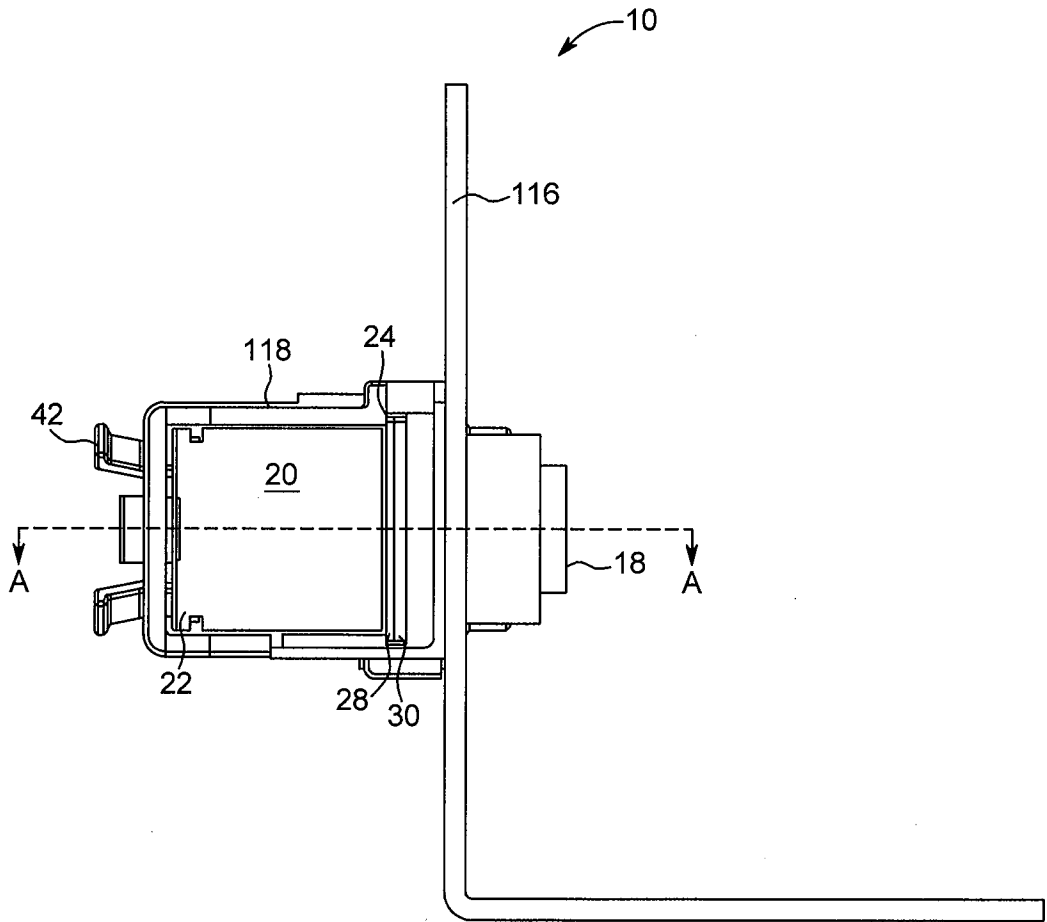


FIG. 12

22/37

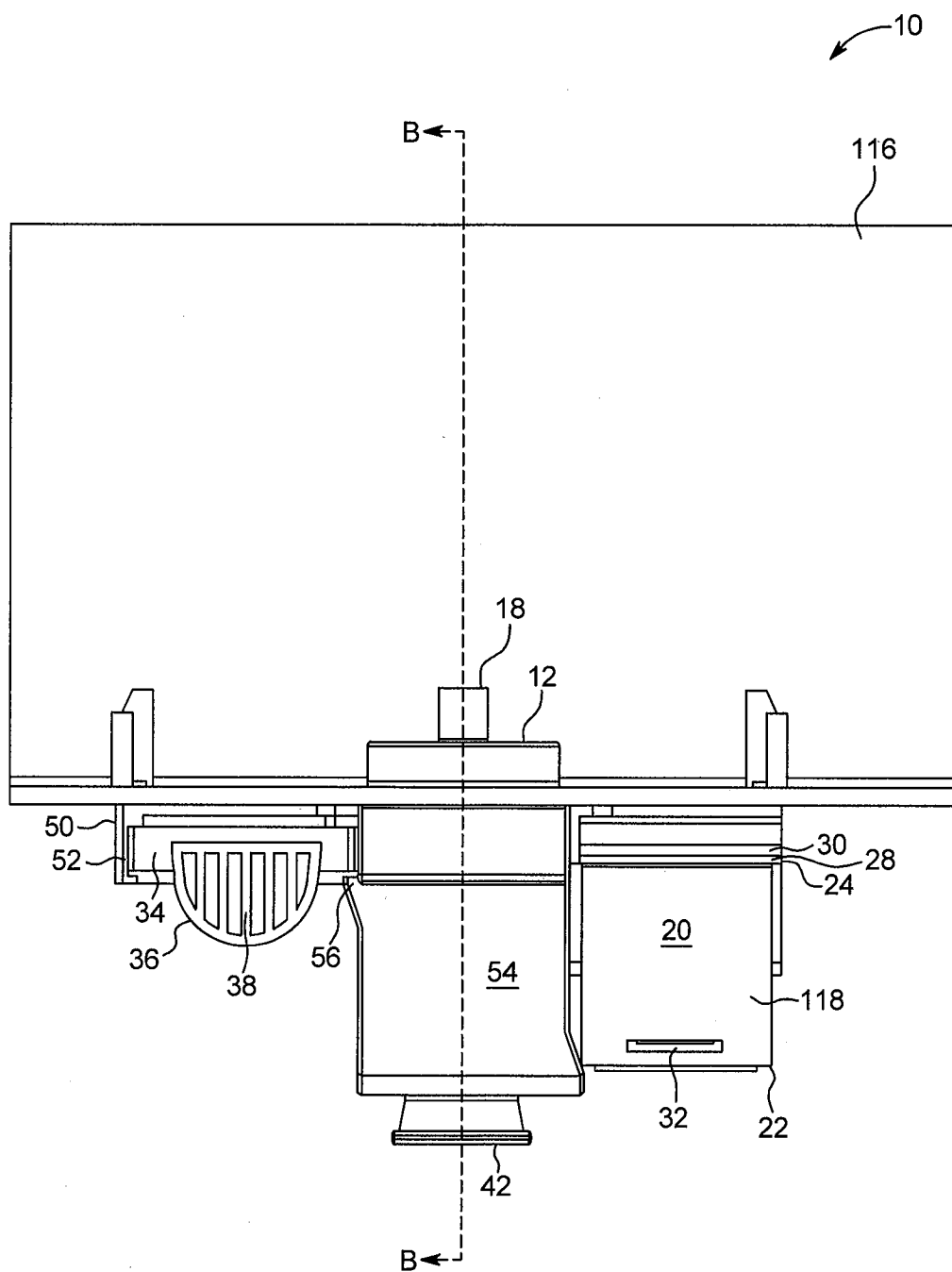


FIG. 13

23/37

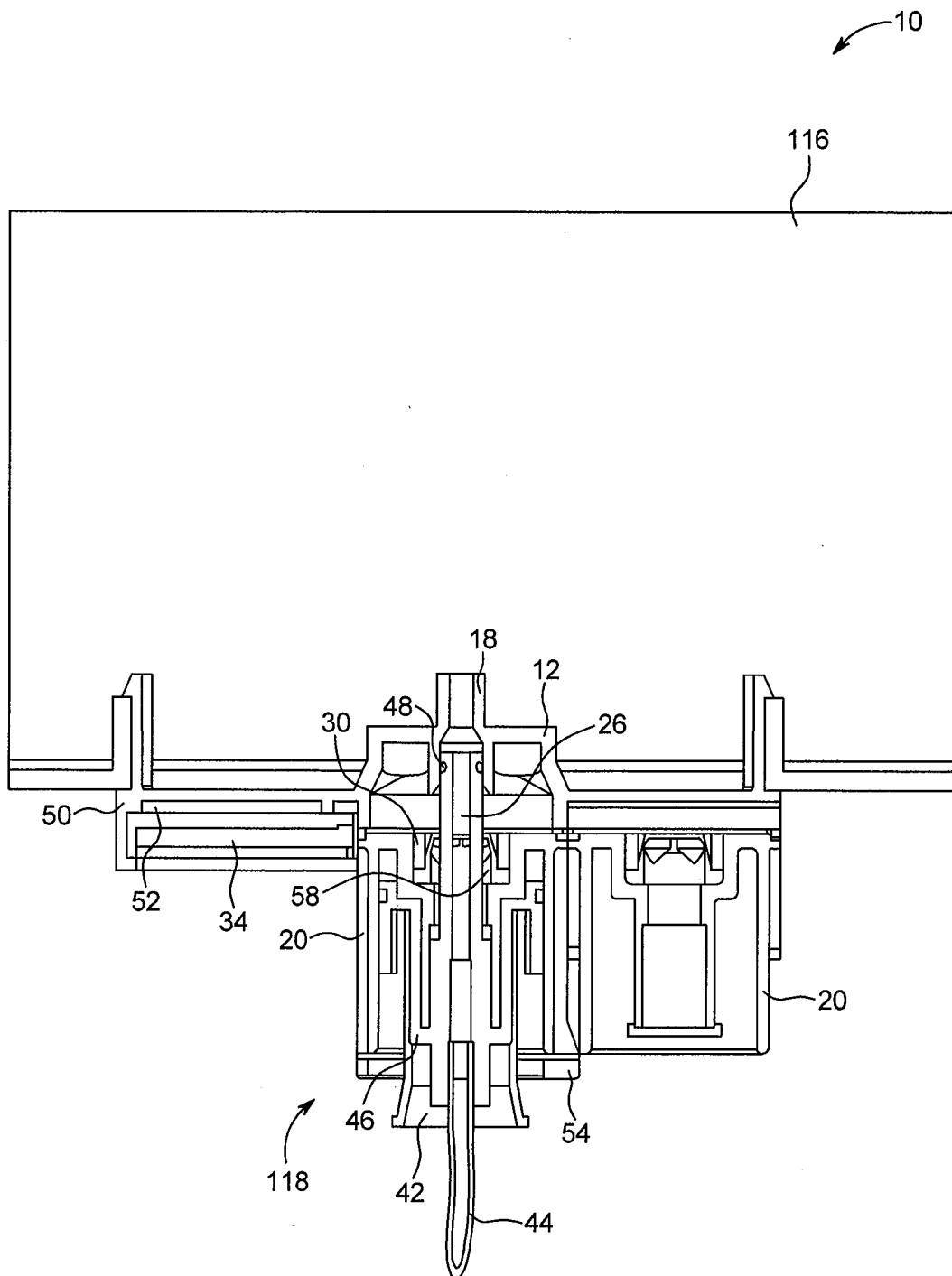


FIG. 14

24/37

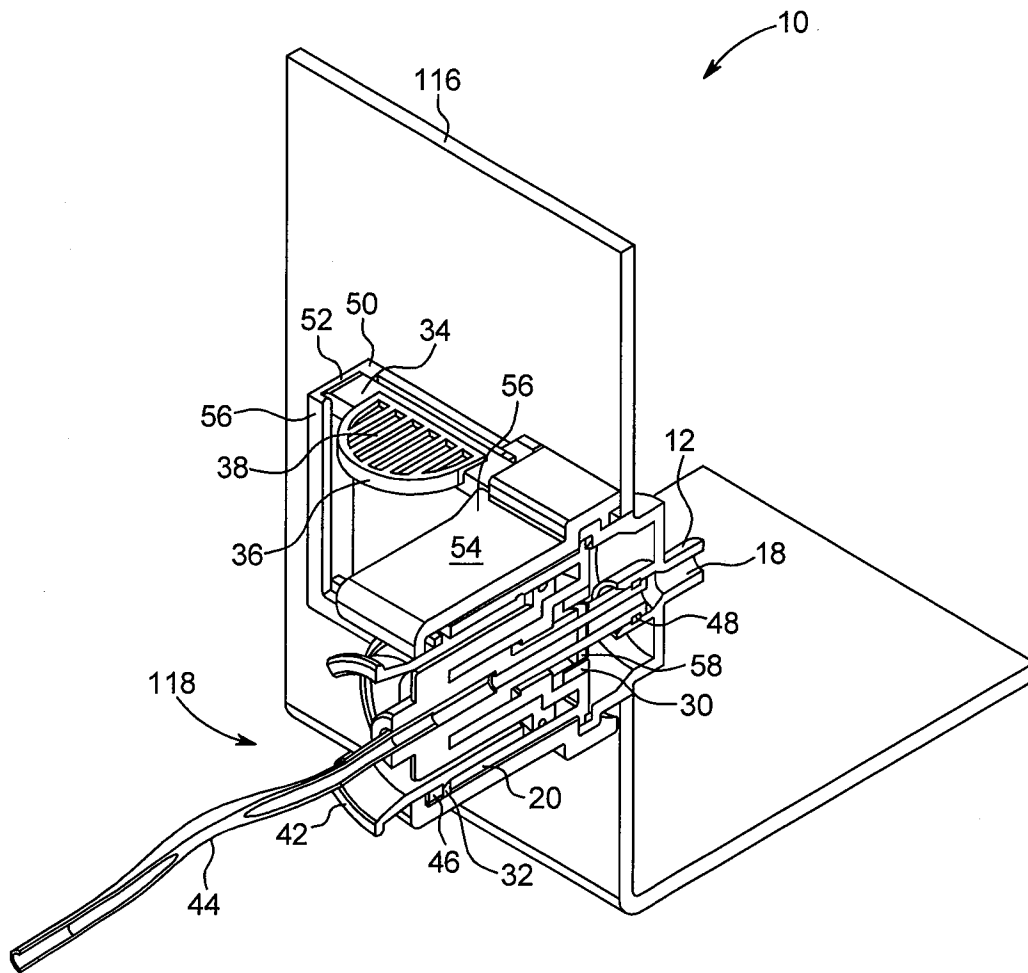


FIG. 15

25/37

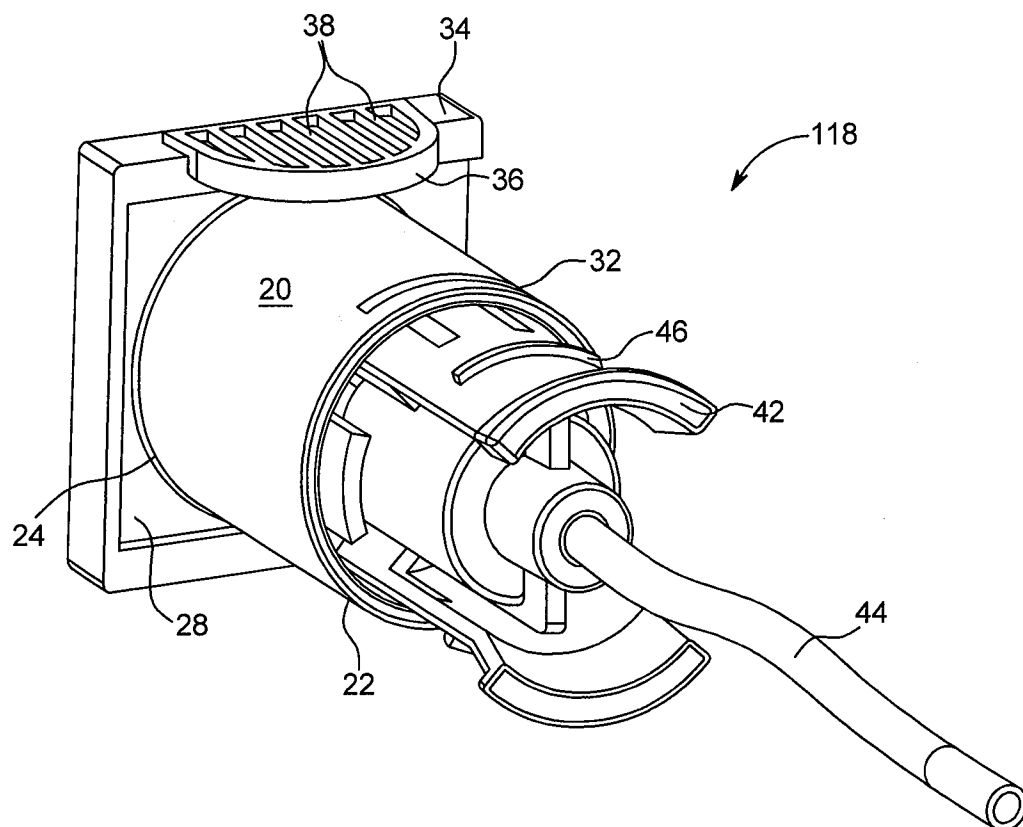


FIG. 16

26/37

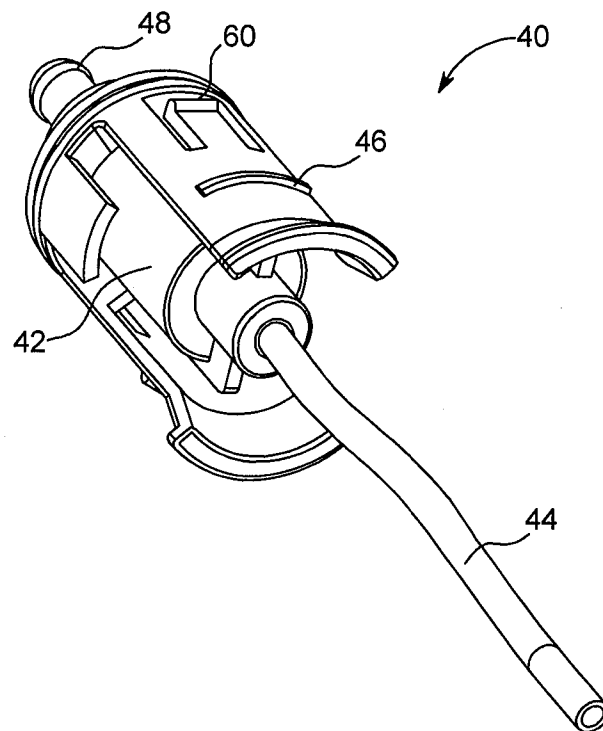


FIG. 17

27/37

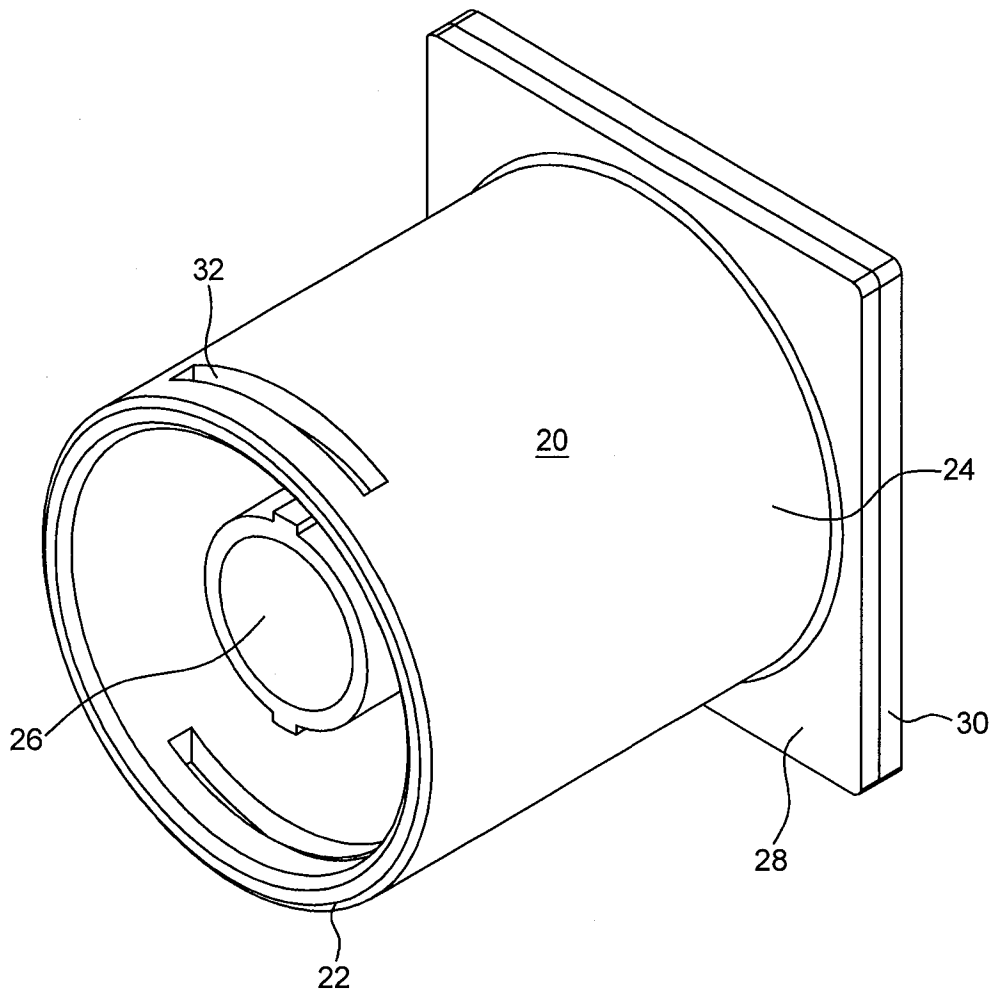


FIG. 18

28/37

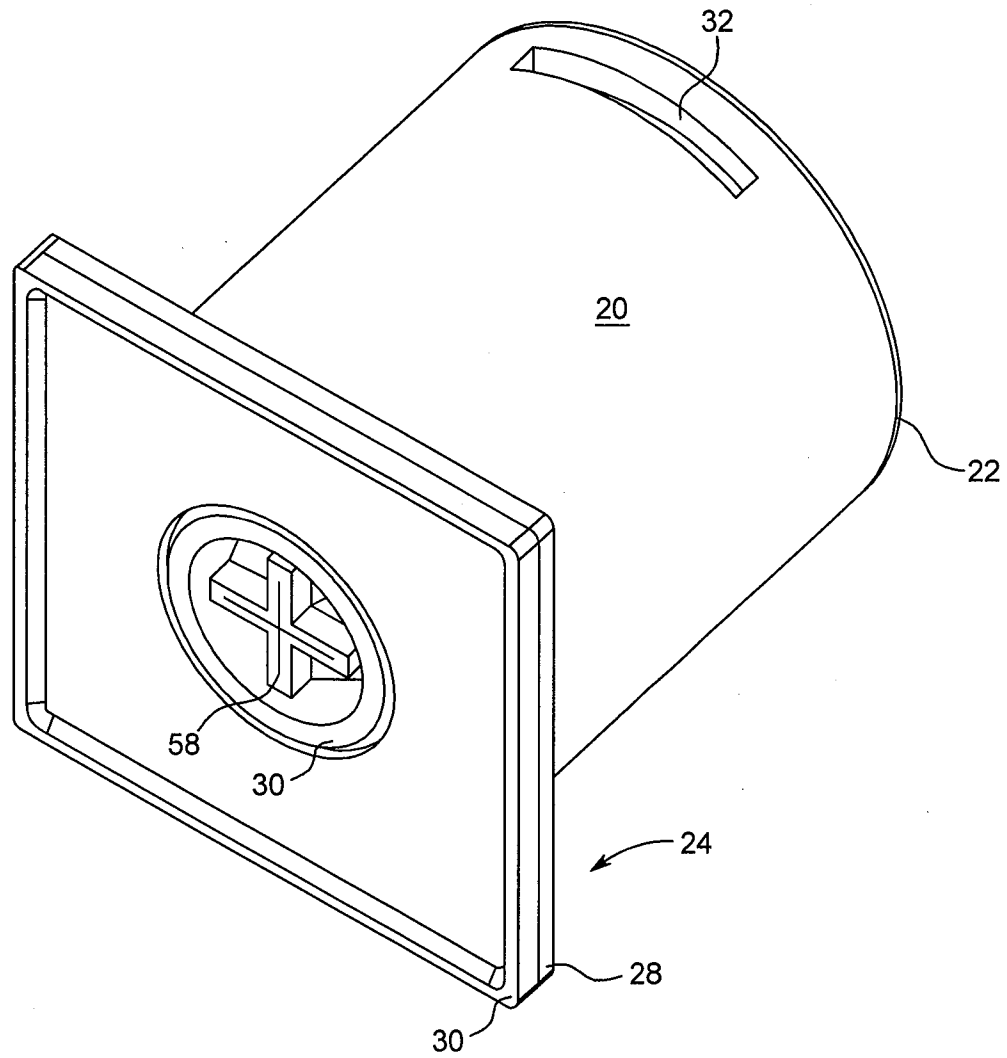


FIG. 19

29/37

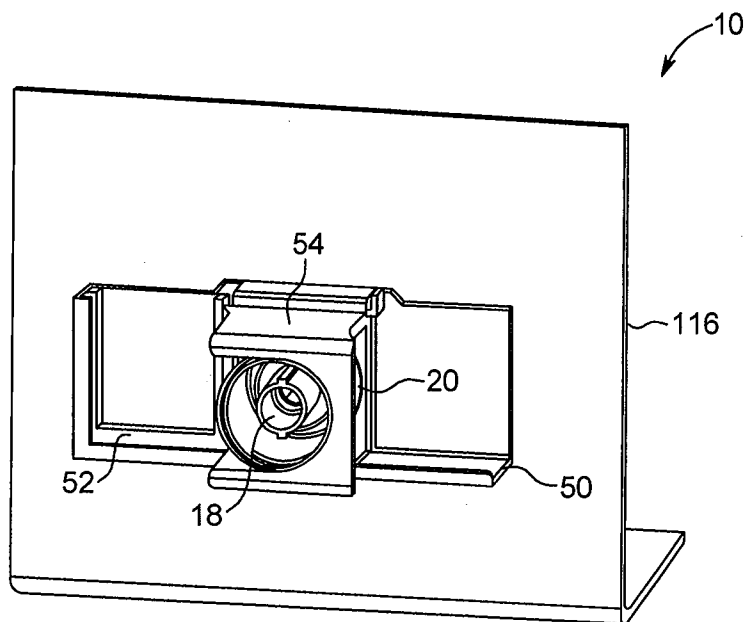


FIG. 20A

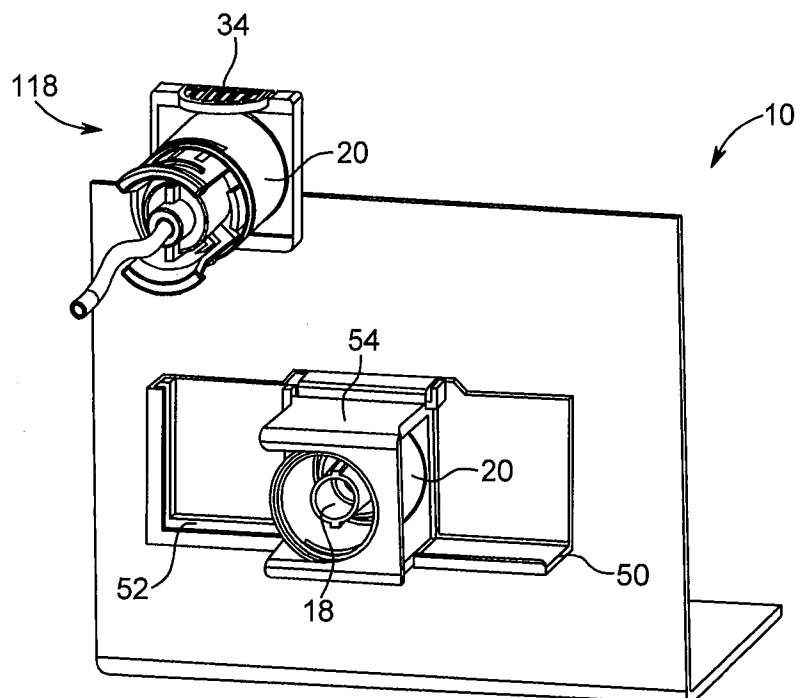


FIG. 20B

30/37

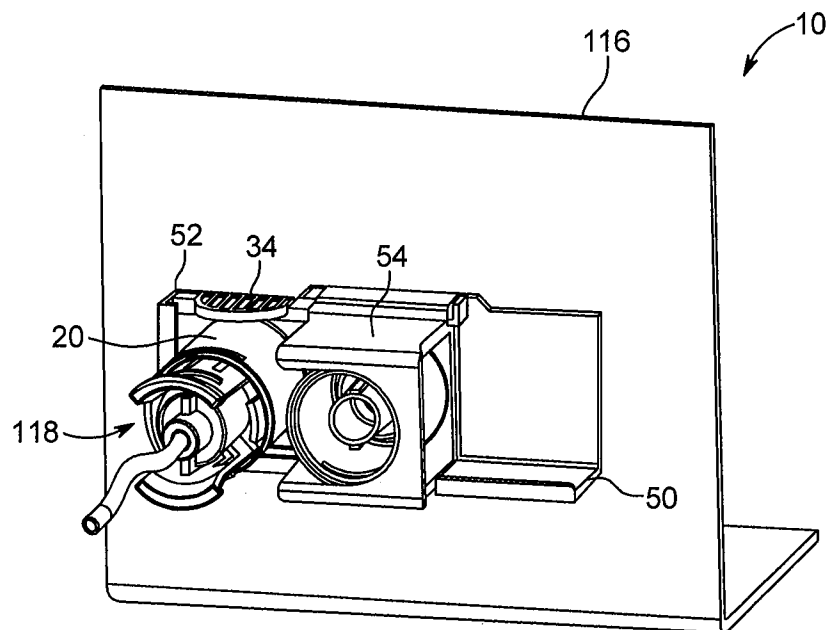


FIG. 20C

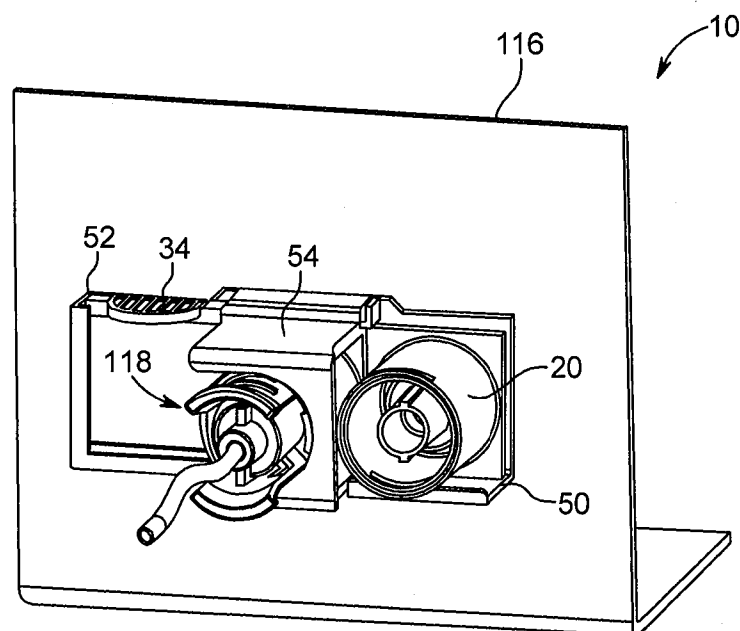


FIG. 20D

31/37

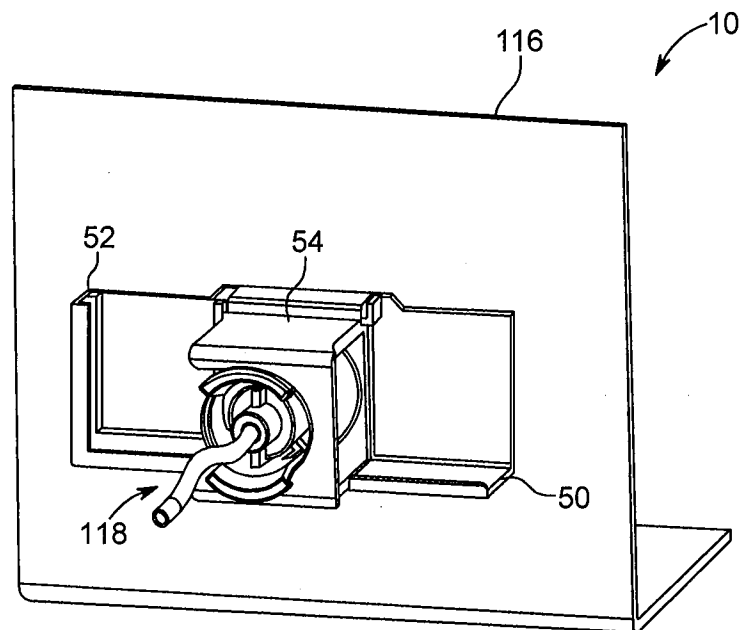


FIG. 20E

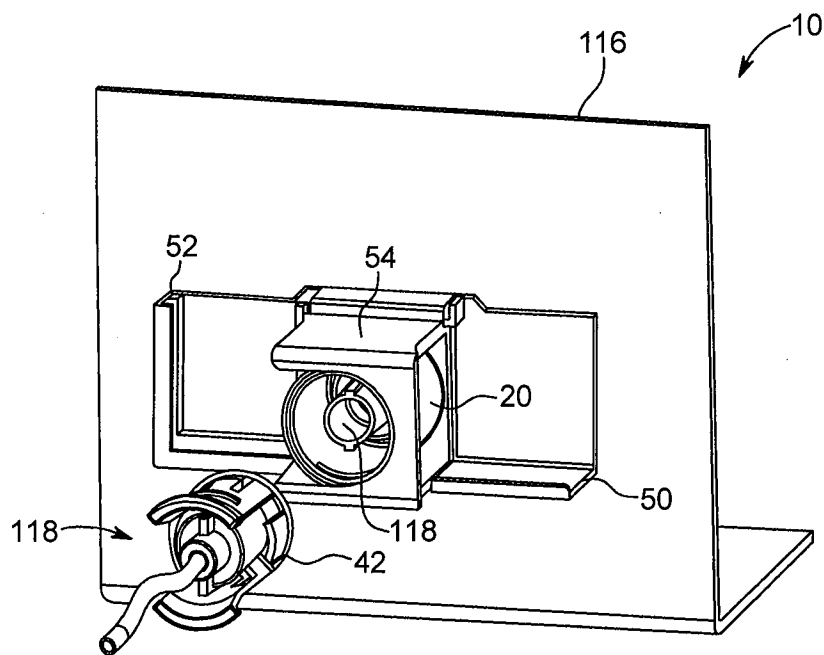


FIG. 20F

32/37

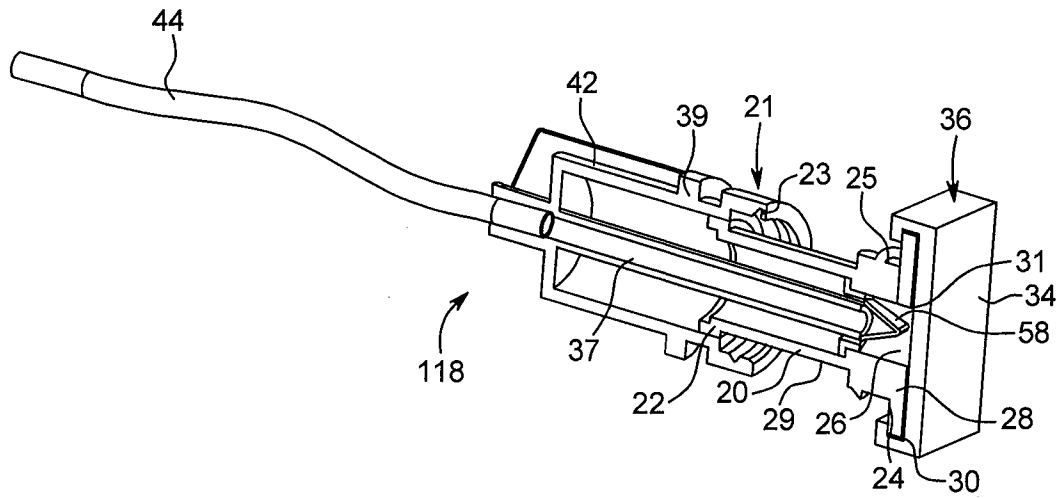


FIG. 21A

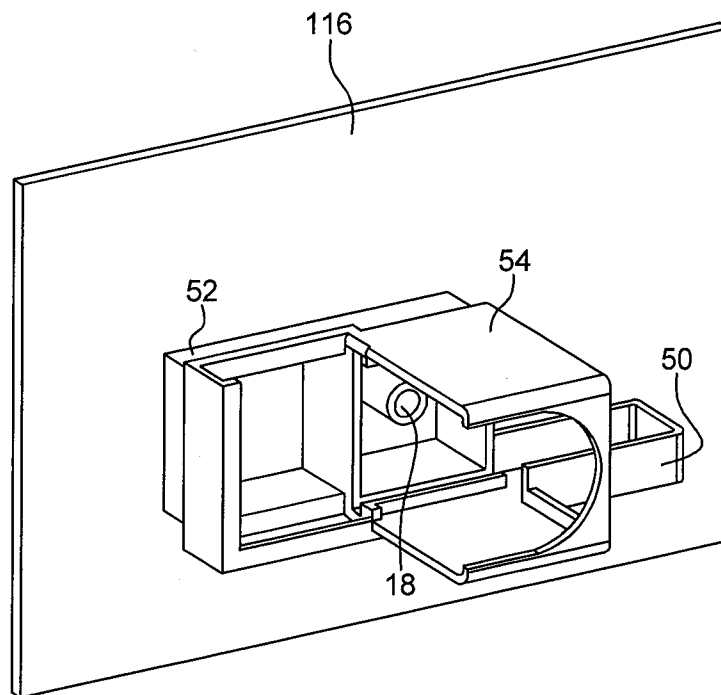


FIG. 21B

33/37

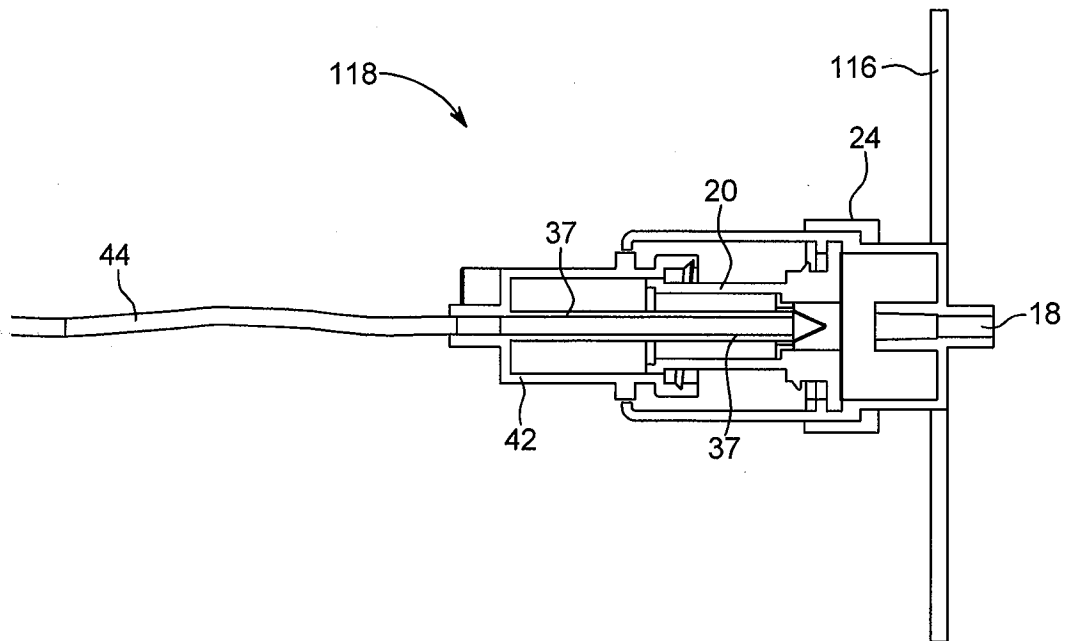


FIG. 22A

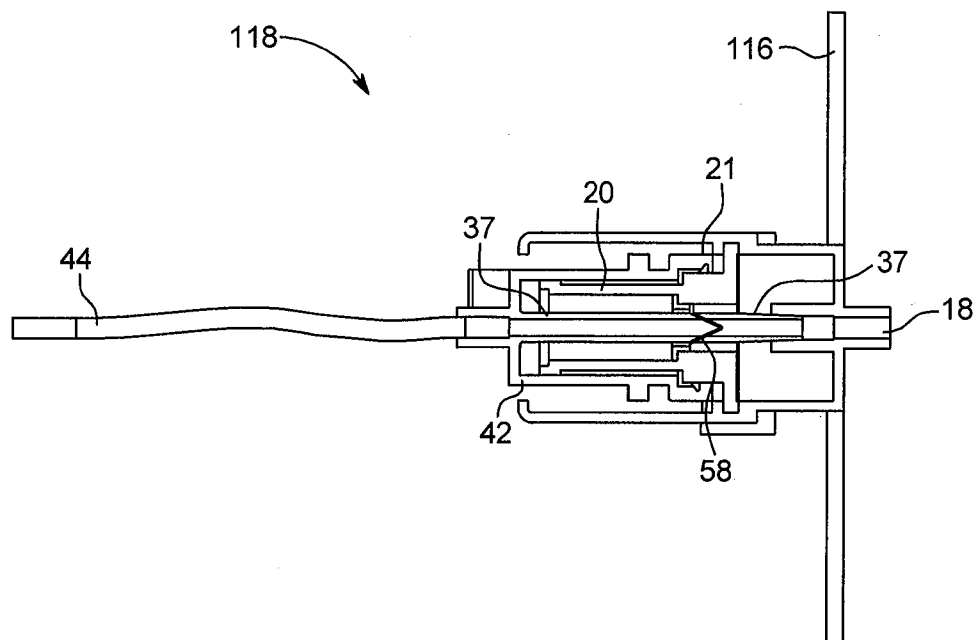


FIG. 22B

34/37

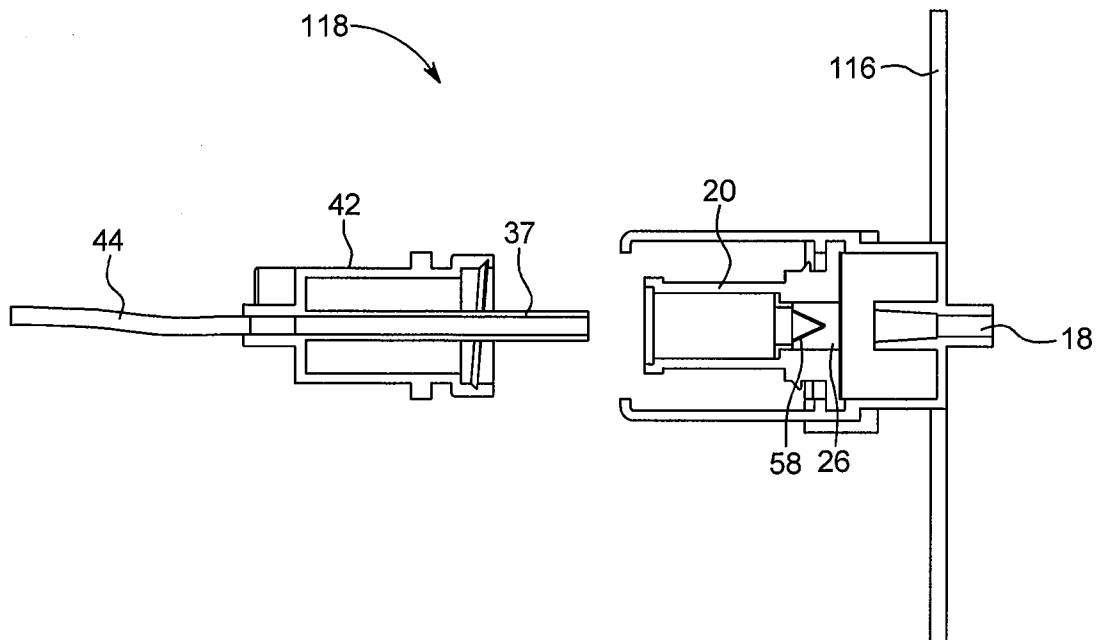


FIG. 22C

35/37

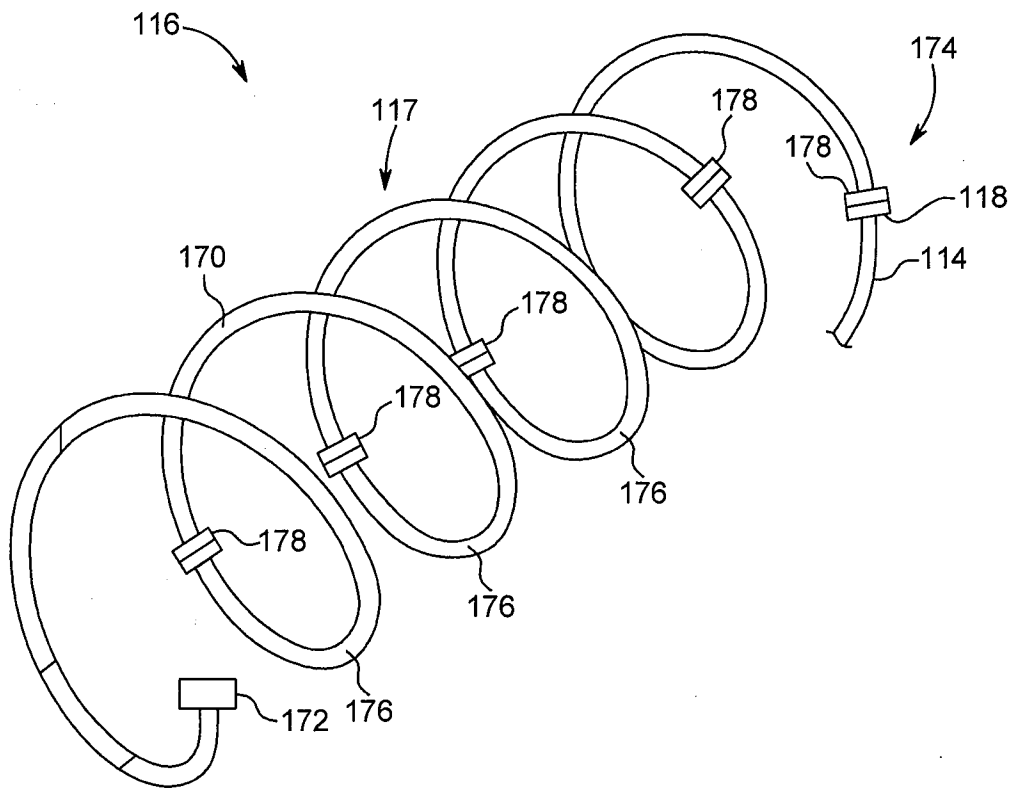


FIG. 23A

36/37

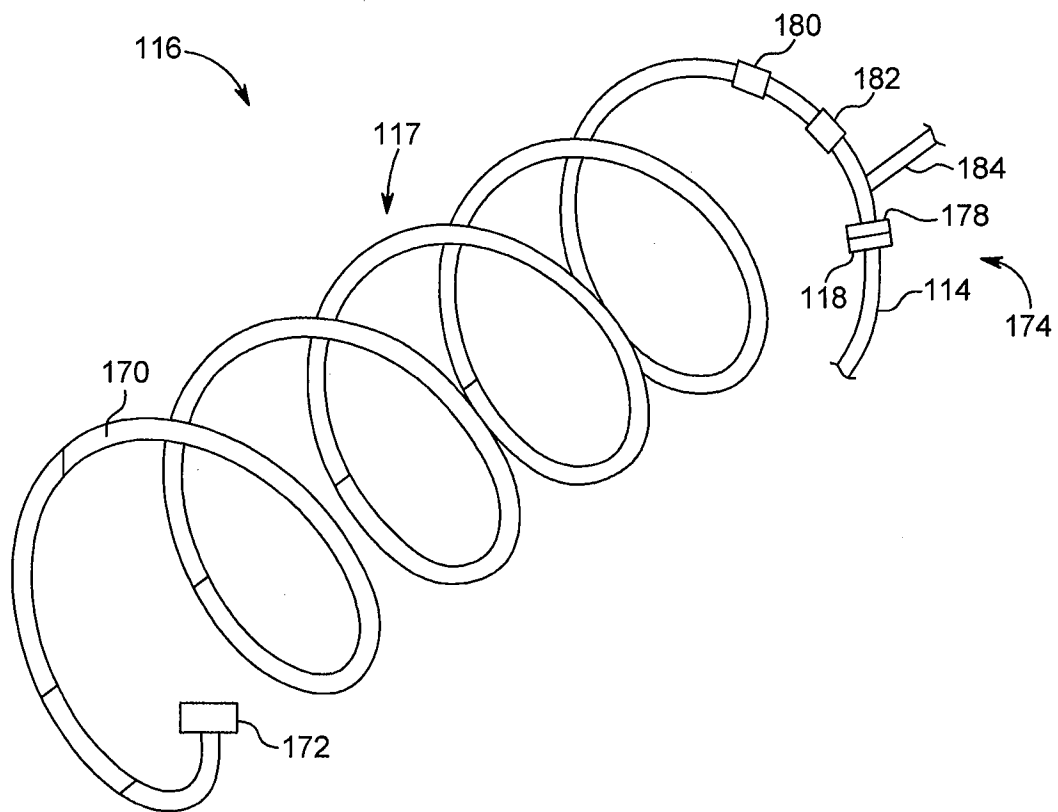


FIG. 23B

37/37

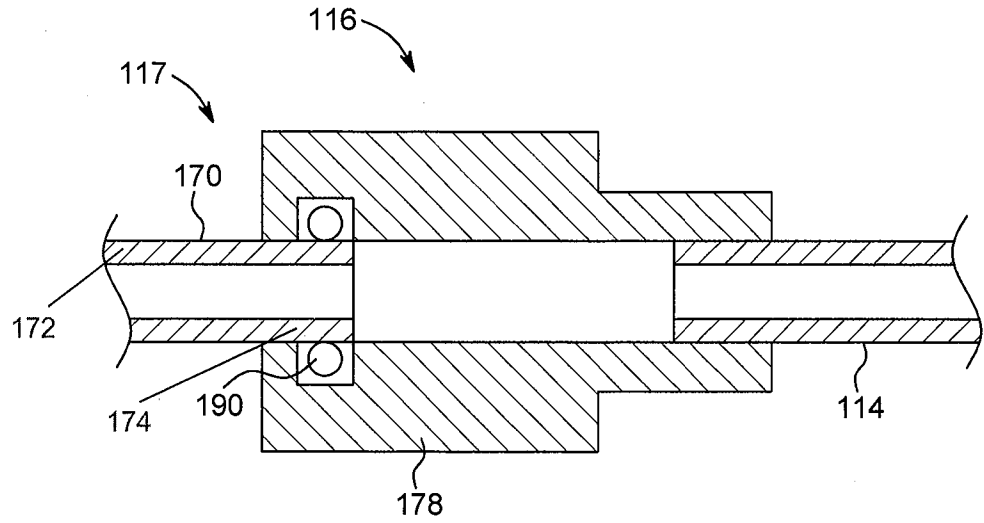


FIG. 24