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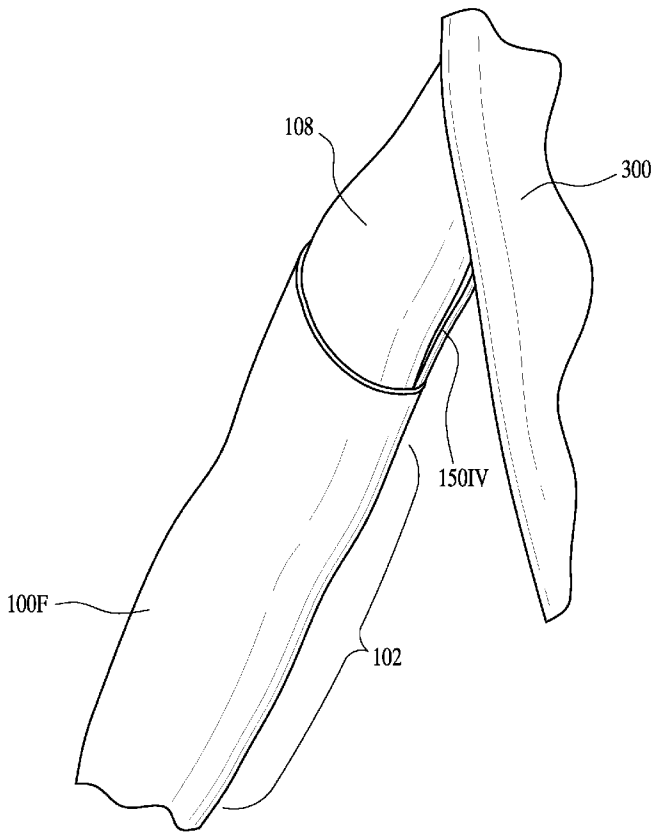
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*[Continued on next page]*

(54) Title: INTRAVENOUS (IV) TRAINING SYSTEM




(57) Abstract: A system (100) for simulating one or more blood vessels (150, 150IV) to provide more dynamic and realistic intravenous (IV) training and testing in order to educate medical personnel and other critical care givers, such as first responders, medics, and emergency medical technicians (EMTs) in properly administering IVs. The system (100) includes a fluid source (99) and at least one conduit (150, 150IV) wherein the system supplies fluid or fake blood to the at least one conduit (150, 150IV) in order to simulate a blood vessel. The system may include a sleeve (100F) or wrap (100G) that covers a portion of a body, such as an arm (108), and has an IV simulation area(s) (102) including simulated blood vessel(s) (150, 150IV). The sleeve (100F) or wrap (100G) may imitate skin. The system may further include a plurality of blood vessels (150, 150IV) that have their respective fluid flows controlled by a fluid flow controller 120.

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# Intravenous (IV) Training System

## I. Field of the Invention

This invention relates to a system that simulates one or more functioning blood vessels and allows for more dynamic and realistic intravenous (IV) training and testing in order to educate medical personnel and other critical care givers, such as first responders, medics, and emergency medical technicians (EMTs), to properly administer IV devices.

## II. Background of the Invention

Intravenous (IV) devices, such as needles, syringes, catheters, and the like, are vital instruments in providing quality healthcare. IVs are used to withdraw or administer substances, e.g., blood, medicinal drugs, nutrient solutions, and other therapeutic substances, that provide benefits critical to proper healthcare. IVs are especially vital to care provided by medics, first-responders, and other emergency care personnel which often require that IV therapy be used immediately on patients in critical or serious condition. However, in order to avail the benefits of these substances to patients, healthcare providers must be trained to properly administer IVs.

Administering IVs, particularly in emergency situations, requires that the care provider be proficient in quickly locating and inserting the IV into a desired blood vessel. Due to a lack of adequate training apparatus, most medical professionals currently rely on a number of alternatives, including faculty instruction and demonstration, volunteer "patients", actual patients, and other objects, to train in administering IVs. Many, if not most, medical professionals are trained to locate blood vessels, as well as proper IV insertion techniques, on volunteers that allow the trainees to practice by inserting IVs into the volunteer's blood vessels. Still, many of these and other personnel train on actual patients, usually under the close supervision of an instructor. Yet still, many of these and other personnel begin IV training by inserting IVs into fruit and other objects.

The risks associated with unnecessary and/or improper IV insertion are significant. Bruising, hematomas, and/or infections can result, at least in part, from improperly administered IVs. One study estimates that intravenous catheter related infections are estimated to total approximately 250,000 annually. The mortality rate associated with these infections is estimated to range between 12-25%, underscoring the risks involved with these procedures.

Simulation training allows trainees to be exposed to elements required to provide care to patients in a controlled, safe environment thereby helping to improve trainee efficiencies.

Of the currently known IV training devices, none provide the ability to vary the simulation conditions, for example, by providing audio feedback to replicate actual emergency situations. Known mannequin devices are not equipped for IV training and the use of live participants involves undesirable risks associated with exposure to needles.

Notwithstanding the usefulness of the above-described methods, a need still exists for an intravenous (IV) training system that provides dynamic and realistic blood vessel simulation in order to train medical personnel and other critical care givers regarding the proper administration of IVs.

## III. Summary of the Invention

In at least one exemplary embodiment, the present invention includes a training system for replicating at least one blood vessel, said system comprising a reservoir capable of storing fluid; at least one conduit in fluid communication with said reservoir, wherein fluid is provided from said reservoir to said at least one conduit to simulate at least one blood vessel; and a sleeve that encloses at least a portion of said at least one simulated blood vessel.

In at least one exemplary embodiment, the present invention includes a training system comprising a mannequin; a reservoir housed in said mannequin; a flow controller in fluid communication with said reservoir and housed in said mannequin; at least one conduit in fluid communication with said flow controller, wherein fluid is delivered from said reservoir to said conduit to simulate a blood vessel; and a sleeve that encloses said at least one conduit.

In at least one exemplary embodiment, the present invention includes a training system comprising a reservoir; a pump in fluid communication with the cavity of said reservoir; a valve connected to said pump; a controller connected to said pump and said valve; a housing containing said reservoir, said pump, and said valve; at least one conduit detachably connected to said valve, wherein said at least one conduit simulates a blood vessel; and a skin-like sleeve attached to said at least one conduit.

The invention in at least one embodiment provides an easy to use system with minimal training required prior to use while maintaining extreme flexibility for a simulation.

The present invention greatly improves the skill, efficiency, and confidence of trainees in administering IVs. The present invention also helps to eliminate unnecessary trauma to "volunteer" patients associated with familiarization and initiation of IV insertion by trainees.

## IV. Brief Description of the Drawings

The present invention is described with reference to the accompanying drawings, wherein:

FIG. 1A illustrates a block diagram of an exemplary embodiment of the IV training and testing system in accordance with the present invention.

FIGs. 2A – 2B illustrate exemplary embodiments of the IV training and testing system in accordance with the present invention.

FIGs. 3A – 3B illustrate exemplary embodiments of the IV training and testing system illustrated in FIGs. 2A – 2B.

FIGs. 4A – 4B illustrate alternative views of the IV training and testing system illustrated in FIGs. 2A – 2B.

FIGs. 5A – 5C illustrate block diagrams of exemplary embodiments of the IV training and testing system in accordance with the present invention.

FIG. 6 illustrates an exemplary portable embodiment of the IV training and testing system in accordance with the present invention.

FIG. 7 illustrates an exemplary portable embodiment of the IV training and testing system in accordance with the present invention.

FIG. 8 illustrates another exemplary portable embodiment of the IV training and testing system in accordance with the present invention.

Given the following enabling description of the drawings, the apparatus should become evident to a person of ordinary skill in the art.

## V. Detailed Description of the Drawings

The present invention includes a training system that provides a simulation of functioning blood vessels. As illustrated in FIG. 1A, the invention includes a fluid source 99, fluid flow conduit(s) 150 in communication with the fluid source 99, and at least one IV simulation area 102 in communication with the fluid flow conduit(s). The fluid flow conduit(s) 150 terminate in the IV simulation area(s) 102. The fluid supplied to fluid flow conduit(s) 150 replicates blood vessels in the IV simulation area(s) 102 for insertion of an IV. The IV simulation area(s) 102 permit the system to be utilized in training individuals, such as medical care providers and first responders, in the treatment of patients. The size, thickness, and materials of the conduit(s) 150 may be varied, as appropriate, to replicate various blood vessels. The system is capable of integration, for example, into a mannequin, a body suit, or a bag/backpack among other types of housings.

Exemplary fluid sources 99 for use with the invention may include flexible membranes, containers, and the like, that are capable of holding fluid for dispensing through the fluid flow conduit(s) to simulate bleeding and that are collapsible as fluid is drawn out of the fluid source 99. Other exemplary fluid sources 99 include an IV bag, a syringe, and similar fluid delivery systems. The conduit itself can be filled with fluid and capped to serve as a fluid source. In at least one embodiment, the fluid source 99 is housed within an elastic bag that constricts as fluid is drawn from the fluid source 99. In other embodiments, the fluid source 99 is an elastic container that resizes to fit the volume of fluid. Depending upon the implementation, the fluid source 99 can range in size from several milliliters to 10 liters and higher depending upon the space that is allotted for the fluid source. Different embodiments as described below include mannequins, body suits, bag enclosures, and backpacks for housing parts or all of the system and as such different levels of space will be available all of which collective are housings. The range of sizes will become more apparent in connection with the discussion of different exemplary embodiments below. Exemplary fluid source 99 can be integrally formed within the structure that houses the system. For example, in the mannequin, utility belt and backpack embodiments the fluid source can be formed as its own compartment within the interior of the mannequin or in the utility belt and the backpack. In contrast, in a retrofit situation, the fluid source is a separate component that is placed in the structure.

In an exemplary embodiment, the present invention simulates blood vessels and provides a system for administering intravenous (IV) training and testing. FIG. 2A illustrates an exemplary embodiment of an intravenous (IV) training and testing simulator in accordance with an embodiment of the present invention. The training and testing simulator may include a mannequin or live participant 300 and includes at least one fluid flow conduit(s) 150IV located just under the surface of an IV simulation sleeve 100F on the mannequin 300 to produce an IV simulation area 102. While this embodiment is discussed with regard to a mannequin 300, it may also be utilized on a live participant, as illustrated in FIG. 2B, and may have multiple fluid flow conduit(s) 150IV. The IV simulation sleeve 100F, in at least one exemplary embodiment, is made of a thin, pliable material that imitates skin on at least the IV simulation area 102, where the IV training and testing is performed. The fluid flow conduit(s) 150IV, in at least one exemplary embodiment, are also made of a thin, pliable material, such as plastic or latex, and imitates blood vessels. The fluid flow conduit(s) 150IV are connected to a fluid reservoir and may be the same or similar fluid flow conduits 150 as utilized to

connect to the fluid reservoir in the embodiment outlined, for example, with respect to FIGs. 2A – 2C.

FIG. 2A illustrates the IV simulation sleeve 100F including an IV simulation area 102 having fluid flow conduit(s) or simulated blood vessel(s) 150IV. The IV simulation sleeve 100F is illustrated in FIG. 2A as being located on an arm 108. However, the IV simulation sleeve 100F, including simulated blood vessel(s) 150IV, may be located on any one part or multiple parts of the mannequin or live participant 300. The IV simulation sleeve 100F may also be incorporated into a bodysuit. In addition to the pump, blood may be provided to the simulated blood vessel(s) by use of a syringe or other fluid delivery mechanism.

FIGs. 3A and 3B, respectively, depict embodiments of the IV simulation sleeve 100F and an alternative IV simulation sleeve wrap 100G. The IV simulation sleeve 100G is designed to fit over a body part, such as an arm 108, as shown in FIG. 2A. The IV simulation sleeve 100F may also be designed as a detachable sleeve or wrap designed to be placed over a body part, such as an arm 108, as shown in FIG. 2B. The detachable sleeve wrap 100G includes open flapped ends 105 such that the sleeve wrap 100G may be quickly placed around a body part. The sleeve wrap 100G may also include a variety of fasteners, such as Velcro® flaps, buttons, ties, etc., that secure the sleeve wrap 100G around the body part. The sleeve 100F and sleeve wrap 100G surround and secure at least one simulated blood vessel(s) 150IV next to the body or body part of the mannequin 300 or live participant. The sleeve 100F and sleeve wrap 100G, in at least one embodiment, are made of a thin, pliable material that resembles skin and conceals the flow conduit 150IV from view such that a trainee must locate the simulated blood vessel(s) in order to administer the IV. The system may include an optional resilient backing material 160 to further support and secure the simulated blood vessel(s) 150IV and serve as a barrier to protect wearers, particularly live participants, from the risks associated with exposure to needles during the administration of IVs and, in the case of mannequins, protect the device from puncture and wear.

FIGs. 4A and 4B, respectively, depict cross-sectional and cutaway views of the IV simulation sleeve 100F used in the IV training and testing system, as outlined in FIGs. 2A. FIGs. 4A and 4B each illustrate simulated blood vessel(s) 150IV surrounded by IV simulation sleeve 100F. Also illustrated is optional resilient backing material 160.

The IV training and testing simulator allows trainers and trainees to locate simulated blood vessel(s) 150IV which is a critical step in administering an IV. When the simulated blood vessel(s) 150IV are located, the trainee inserts a syringe (not shown)

into the simulated blood vessel(s) 150IV. When the syringe is properly inserted into the simulated blood vessel(s) 150IV the syringe is in fluid communication with the interior of the simulated blood vessel(s) 150IV. The trainee is then free to withdraw or administer blood, or administer other fluids such as nutrient solutions, drugs, or various other medicines and substances. Because this simulation is performed using the illustrated system, the risks associated with performing IV training on a live casualty are avoided.

FIGs. 5A – 5C illustrate different exemplary embodiments for the fluid source 99, with FIGs. 5B and 5C illustrating the fluid source 99 being connected to the IV simulations area(s) 102 via fluid flow conduit(s) 150.

FIG. 5A illustrates an exemplary embodiment of the fluid source 99 including a flow controller 120A having a power supply 130 and a controller (or activation mechanism) 126 connected to a pump 122 and a valve 124 such as a solenoid or pin valve. The controller 126 may include a manually activated component such as, for example, a switch, button, or dial. The variable adjustment of the power supplied to the pump 122 allows the fluid volume to be controlled to provide varying amounts of fake blood flow during a particular simulation. The adjustable power supplied to the pump 122 may be provided by a variable adjuster such as a rheostat. The power may also be adjustably supplied to provide a pulsating flow to the IV simulation area(s) that simulates pumped blood.

FIG. 5B illustrates an exemplary embodiment of the fluid source 99 including a flow controller 120B having a power supply 130 and a controller 126 connected to a pump 122 and a valve 124, similar to the embodiment as shown in FIG. 5A. However, the embodiment as illustrated in FIG. 5B includes a manifold 128 connected to the output of the valve 124. The manifold 128 provides an output of fake blood to multiple flow lines such that artificial blood may be provided to various IV simulation area(s) 102. Check valves 125 are provided between the manifold 128 and the IV simulation area 102 in order to prevent fluid backflow when the direction of flow for the fake blood is up from the check valve 125. In at least one embodiment, the check valves 125 are replaced with an adjustable valve such as a solenoid or pin valve. Also illustrated are quick connectors 158 (although other types of connectors can be used that includes a diaphragm or other rubber seal capable of resealing upon disconnection to prevent flow of fluid from the end) located in fluid flow conduit(s) 150 connecting the IV simulation area(s) 102 to the fluid flow controller 120. The quick connectors 158 allow quick and easy line connections to be able to connect different IV simulation area(s) 102 depending upon the desired simulation.

FIG. 5C illustrates an exemplary embodiment of the fluid source 99 of the present invention, including a flow controller 120C, a programmable controller 127 connected to pump 122, valve 124 and manifold 128. The programmable controller 127 allows a user to select which IV simulation area(s) 102 receives fake blood flow. The programmable controller 127 also allows the user to select the flow rate to each site(s) 102.

The system allows for body parts or feeds to be connected to the hub, which acts as the hub for the system. The body part locations, for example, include a right arm, a right leg, a left leg, a left arm, and a head along with outer layers of the torso being able to be interchanged to provide a variety of IV simulation area(s) combinations. Alternatively, a body part could be omitted as a potential host of a site 102 and thus eliminate one of the connectors and corresponding portion of the flow controller. Each site for a body part will include a site 102, a conduit 150, and a connector 158. The conduit 150 connects the site 102 to the connector 158.

FIG. 6 illustrates an exemplary embodiment of the present invention provided in a container 100B. The reservoir 110 and the flow controller 120, similar to embodiments illustrated in FIG. 5A – 5C, are enclosed in the container 100B. Container 100B may, for example, be a backpack, shoulder bag or elastic bag having an opening such as a zipper for placement, for example, in a mannequin. In at least one embodiment, the elastic bag will contract onto the contents as fluid is dispensed from the reservoir 110 allowing the pump to remain in contact with the fluid still present in the reservoir 110 and thus primed for pumping. The portable container allows live participants to attach the system of the present invention to their bodies and locate the simulation sites 102 at a variety of locations on their bodies. This allows for a more realistic simulation of a live casualty by enabling the live participant to provide more meaningful feedback to the trainee. The valves 128 include means that can restrict flow through the fluid pathway including clamps applied to the conduit. FIG. 6 also illustrates an exemplary refill conduit 152 and refill connector 174 for refilling reservoir 110. The conduit 152 in at least one embodiment passes through a cap of the reservoir 110 and in other embodiments passes through its own opening proximate to the pump's location in the reservoir 110.

FIG. 7 illustrates an exemplary embodiment of the present invention utilizing a bag 100C for storing the IV training and testing system. The bag 100C may be a backpack, body bag, shoulder bag, elastic bag, or the like, and is used to enclose and attach the IV training and testing system to a training mannequin or live participant. The bag 100C preferably includes a compartment for storing all components of the IV training and

testing system, including the fluid source 99 and at least parts of the fluid flow conduit(s) 150. The bag 100C may be designed to fit closely to the body of a mannequin or live participant 300 such that it is not disruptive to the training process. The system may include one or more IV simulation area(s) 102 that may be located on various parts of the body. The bag 100C may also include one or more holes for fluid flow conduit(s) 150 to pass through to the IV simulation area(s) 102. The bag 100C may include shoulder straps 202 and/or a belt 204 to help secure the bag. The bag 1800 may also include a detachable harness (not shown) to mount the bag to the system or live participant 1810. In other embodiments, the bag 100C is incorporated into a body suit.

FIG. 8 illustrates an exemplary embodiment with a belt such as a utility belt housing the system. A reservoir 110 shaped like a canteen is on one part of the belt and a storage bin contains the fluid flow controller 120 with the two components being connected via conduit 150. The housing for the reservoir 110 in at least one embodiment where the reservoir 110 is collapsible includes a door that allows the user to prime the pump 122 by compressing the collapsible reservoir 110. In at least one embodiment, an elastic band (or bag) rings the reservoir 110 to facilitate the reservoir in collapsing on itself. In at least one embodiment, the pump 122 is a submersible pump in the reservoir 110. The fluid flow controller 120 is illustrated as having two conduits 150 attached to it for providing fake blood to IV simulation area(s) 102. Based on this disclosure, one of ordinary skill in the art will appreciate that a variety of number of simulation sites could be feed by the fluid flow controller 120. As mentioned above, the conduits 150 connected to IV simulation area(s) 102 could be feed beneath clothing, incorporated into the material of the clothing, or run above the clothing worn by an individual or mannequin.

In addition to the IV simulation area(s), the system can also have one or more wound sites connected to the system to provide different simulations. In some embodiments, one or more wound site(s) are connected to the fluid flow conduit(s). The wound sites include an opening in the fluid flow conduit(s) for dispensing fluid therethrough in order to simulate bleeding wounds. The wound sites and IV simulation area(s) may be combined in a variety of number and locations.

It will be understood that each block of the block diagrams and combinations of those blocks can be implemented by means for performing the illustrated function.

The exemplary and alternative embodiments described above may be combined in a variety of ways with each other. Furthermore, the steps and number of the various steps illustrated in the figures may be adjusted from that shown.

It should be noted that the present invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, the embodiments set forth herein are provided so that the disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The accompanying drawings illustrate exemplary embodiments of the invention.

Although the present invention has been described in terms of particular exemplary and alternative embodiments, it is not limited to those embodiments. Alternative embodiments, examples, and modifications which would still be encompassed by the invention may be made by those skilled in the art, particularly in light of the foregoing teachings.

Those skilled in the art will appreciate that various adaptations and modifications of the exemplary and alternative embodiments described above can be configured without departing from the scope and spirit of the invention. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.

IN THE CLAIMS:

I claim:

1. A training system for replicating at least one blood vessel, said system comprising:

a reservoir capable of storing fluid;

at least one conduit in fluid communication with said reservoir, wherein fluid is provided from said reservoir to said at least one conduit to simulate at least one blood vessel; and

a sleeve that encloses at least a portion of said at least one simulated blood vessel.

2. The training system according to claim 1, wherein said sleeve includes a detachable wrap.

3. The training system according to claim 1, wherein said sleeve fits around a body part of a person or mannequin.

4. The training system according to any one of claims 1-3, further comprising a resilient backing material that secures said at least one simulated blood vessel between said sleeve and said backing material.

5. The training system according to any of claims 1-3, further comprising:

a pump in fluid communication with said reservoir and said at least one conduit, said pump located between said reservoir and said at least one conduit.

6. The training system according to claim 5, further comprising:

at least one valve in fluid communication with said pump; and

a controller connected to said pump and said at least one valve, wherein said controller manages the delivery of fluid from said reservoir to said simulated blood vessels.

7. The training system according to claim 6, wherein said controller includes a programmable controller in communication with at least one of said pump, said valve, and said manifold, wherein said programmable controller manages the delivery of fluid to each of said simulated blood vessels.

8. The training system according to claim 6, further comprising:

a manifold connected to said at least one valve;

a second of said at least one valve connected to said manifold; and

a third of said at least one valve connected to said manifold;

said at least one conduit includes:

a first conduit connected to said second valve, said first conduit replicates a first simulated blood vessel; and

a second conduit connected to said third valve, said second conduit replicates a second simulated blood vessel.

9. The training system according to claim 6, further comprising a container housing said reservoir, said pump, and said at least one valve.

10. The training system according to claim 6, further comprising a resilient backing material that secures said at least one simulated blood vessel between said sleeve and said backing material.

11. A training system comprising:

a mannequin;

a reservoir housed in said mannequin;

a flow controller in fluid communication with said reservoir and housed in said mannequin;

at least one conduit in fluid communication with said flow controller, wherein fluid is delivered from said reservoir to said conduit to simulate a blood vessel; and

a sleeve that encloses said at least one conduit.

12. The training system according to claim 11, wherein said mannequin includes at least one extremity, and said at least one simulated blood vessel is located on said at least one extremity.

13. The training system according to claim 11, wherein said at least one simulated blood vessels are disposed at various locations on said mannequin.

14. The training system according to claim 11, wherein said sleeve comprises a detachable wrap.

15. The training system according to any one of claims 11-14, wherein said sleeve fits around a body part of said mannequin.

16. The training system according to any one of claims 11-14, further comprising a resilient backing material that secures said at least one simulated blood vessel between said sleeve and said backing material.

17. The training system according to claim 11, wherein said flow controller includes:

a pump in fluid communication with said reservoir;

a valve in fluid communication with said pump;

a power supply connected to said pump and said valve; and

a manifold in fluid communication with said valve and said at least one conduit.

18. A training system comprising:

a reservoir;

a pump in fluid communication with the cavity of said reservoir;

a valve connected to said pump;

a controller connected to said pump and said valve;

a housing containing said reservoir, said pump, and said valve;

at least one conduit detachably connected to said valve, wherein said at least one conduit simulates a blood vessel; and

a skin-like sleeve attached to said at least one conduit.

19. The training system according to claim 18, further comprising a resilient backing material that sandwiches said simulated blood vessel between said sleeve.

20. The training system according to claim 18 or 19, further comprising:

a manifold connected to said valve;

a plurality of conduits in fluid communication with said manifold, each conduit having a connector and seal at its free end configured to engage said manifold; and

wherein each of said plurality of conduits simulates a blood vessel.

21. A training system comprising:

a fluid source; and

at least one conduit in communication with said fluid source, wherein said at least one conduit replicates at least one blood vessel.

22. The system according to claim 21, further comprising a sleeve enclosing at least a portion of said at least one conduit.

23. The system according to claim 22, further comprising a resilient backing material attached to said sleeve, wherein said backing material secures said at least one conduit between said sleeve and said backing material.

24. A training system, comprising:

at least one conduit, wherein said at least one conduit replicates at least one blood vessel; and

a sleeve attached to at least a portion of said at least one conduit.

25. The system according to claim 24, further comprising a resilient backing material attached to said sleeve, wherein said backing material secures said at least one conduit between said sleeve and said backing material.

26. The system according to claim 24 or 25, wherein said sleeve includes a wrap capable of covering a body part, wherein said wrap imitates skin.

27. The system according to claim 24 or 25, wherein said sleeve is part of a bodysuit.

28. A method for simulating a blood vessel, comprising:

providing a fluid source;

providing at least one fluid flow conduit in communication with said fluid source, wherein said at least one fluid flow conduit replicates at least one blood vessel; and

supplying a fluid to said at least one fluid flow conduit.

29. The method according to claim 28, further comprising:

covering at least a portion of said at least one fluid flow conduit with a sleeve, wherein said sleeve replicates skin.

30. The method according to claim 28, further comprising:

covering at least a portion of said at least one fluid flow conduit with a wrap, wherein said wrap replicates skin.

31. An IV training system being substantially as herein described with reference to the accompanying figures.

32. A blood vessel simulation system as herein described with reference to the accompanying figures.

33. A training system with IV and wound sites.

34. A system comprising:

a fluid source;

a first conduit fluidly connected to said fluid source;

a sleeve attached to said first conduit;

a second conduit fluidly connected to said fluid source; and

a wound site fluidly attached to said second conduit.

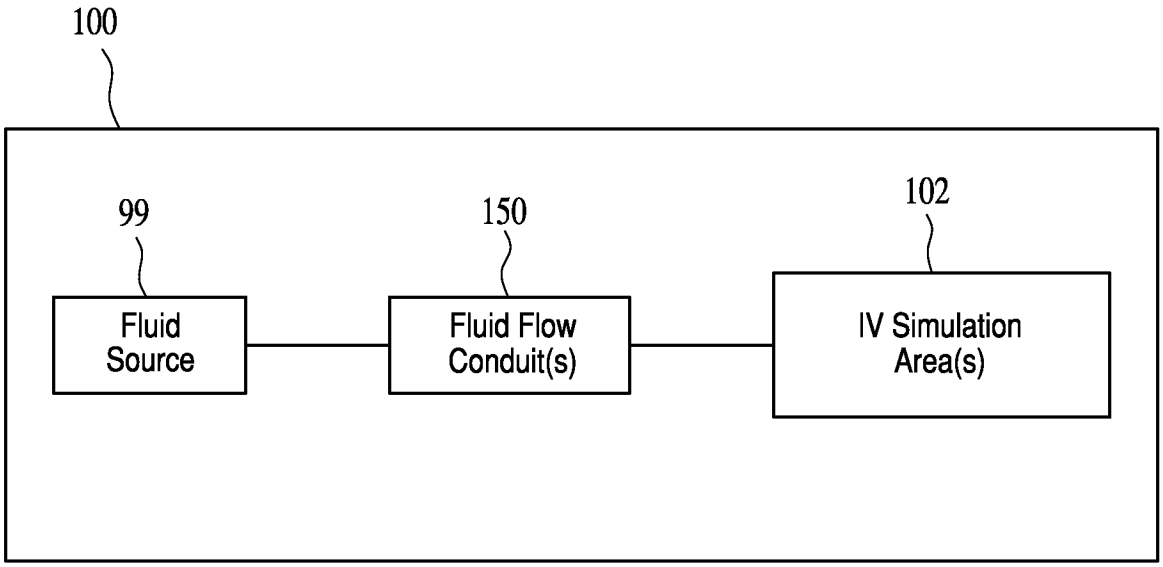

100
99
150
102
Fluid Source
Fluid Flow Conduit(s)
IV Simulation Area(s)

FIG. 1

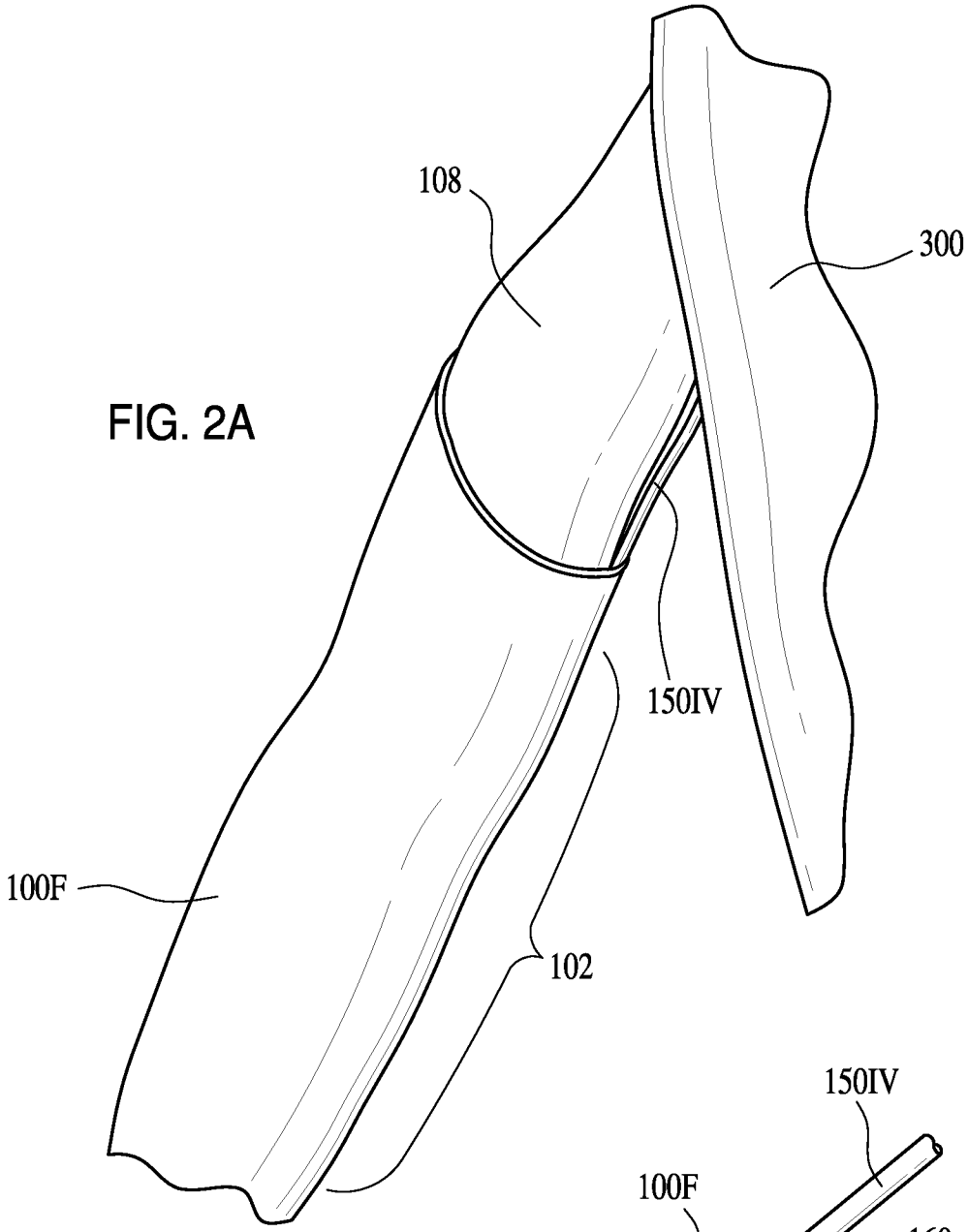



FIG. 2A

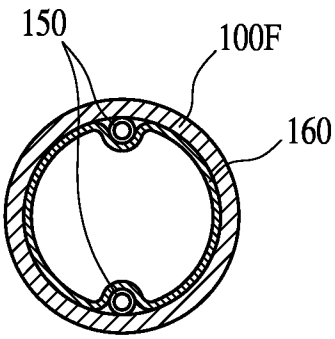



FIG. 4A

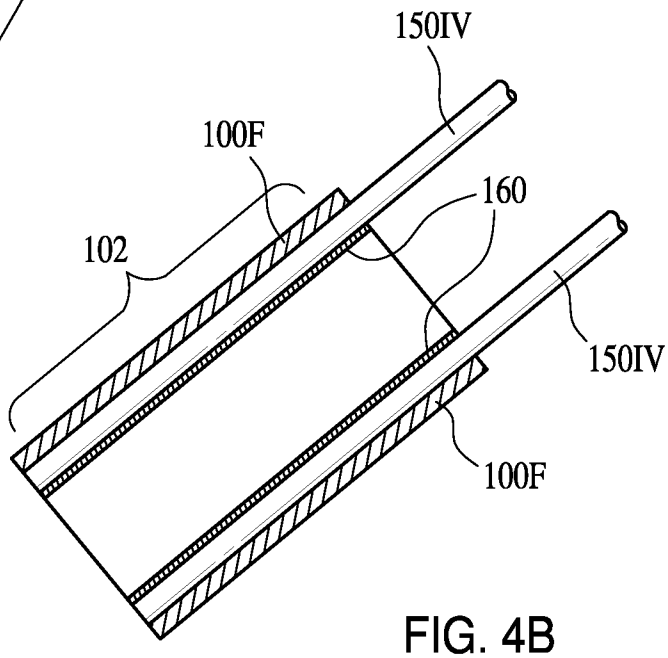



FIG. 4B

FIG. 2B

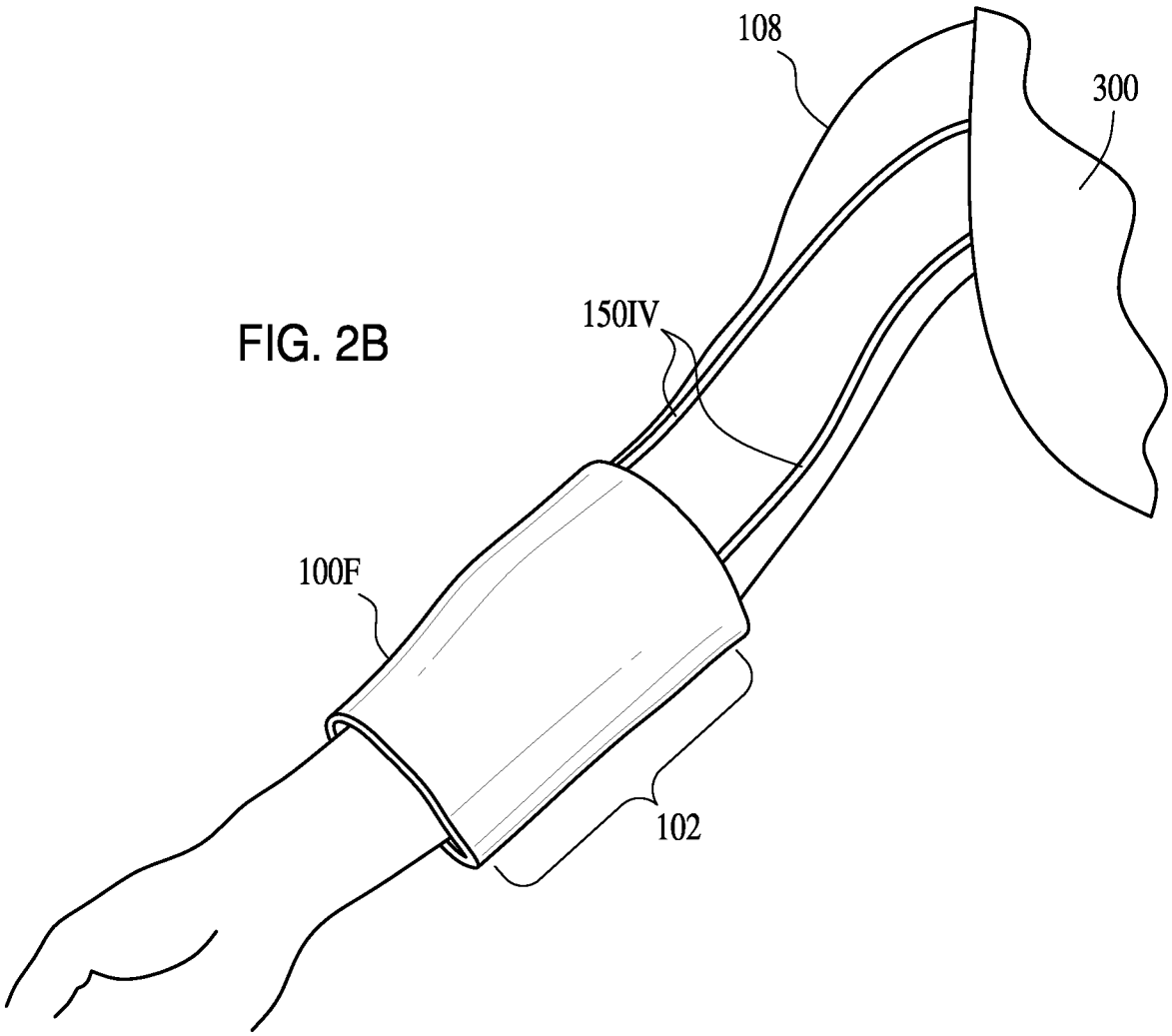
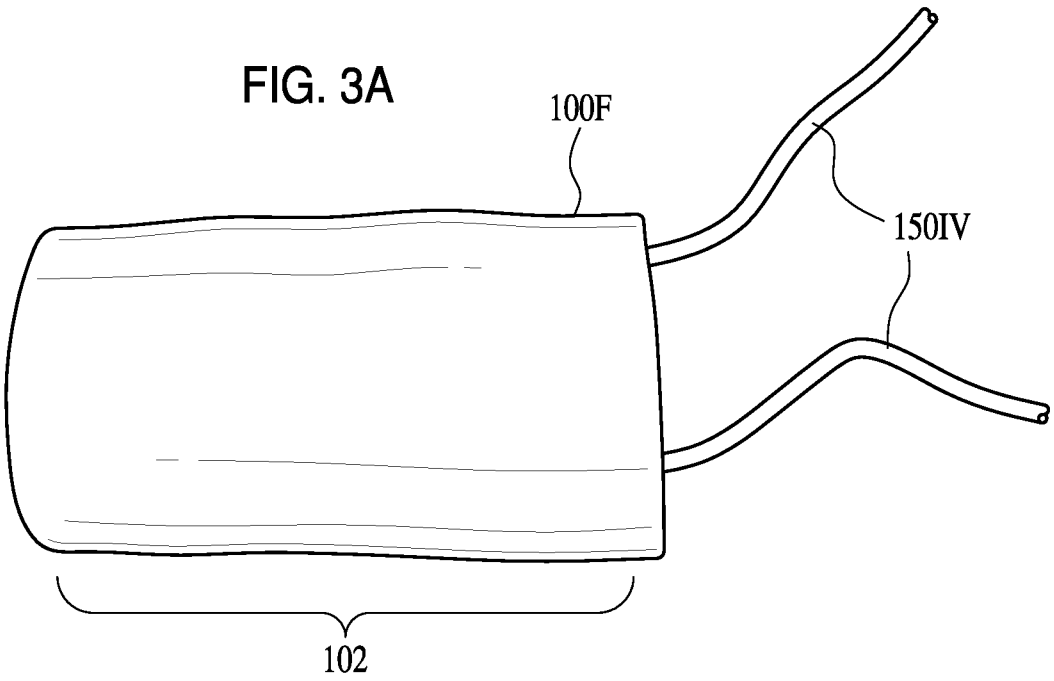



FIG. 3A



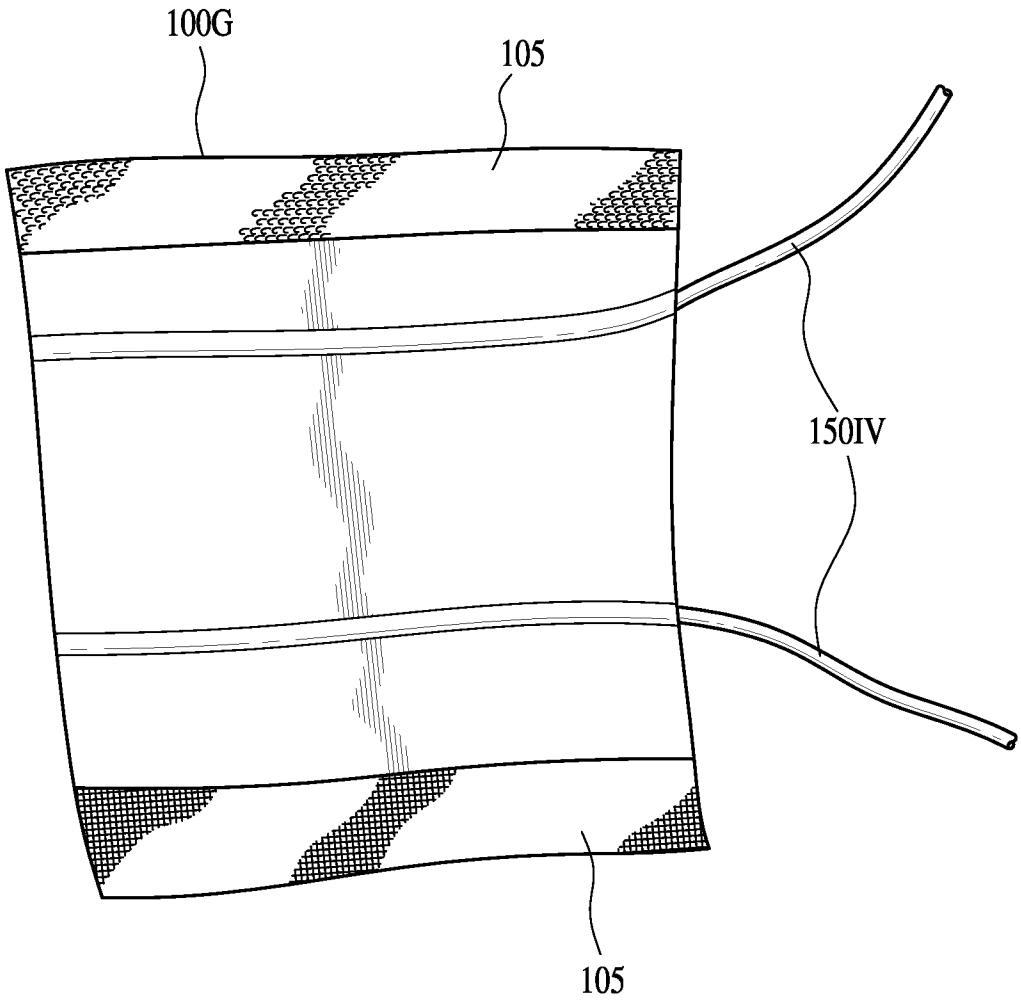



FIG. 3B

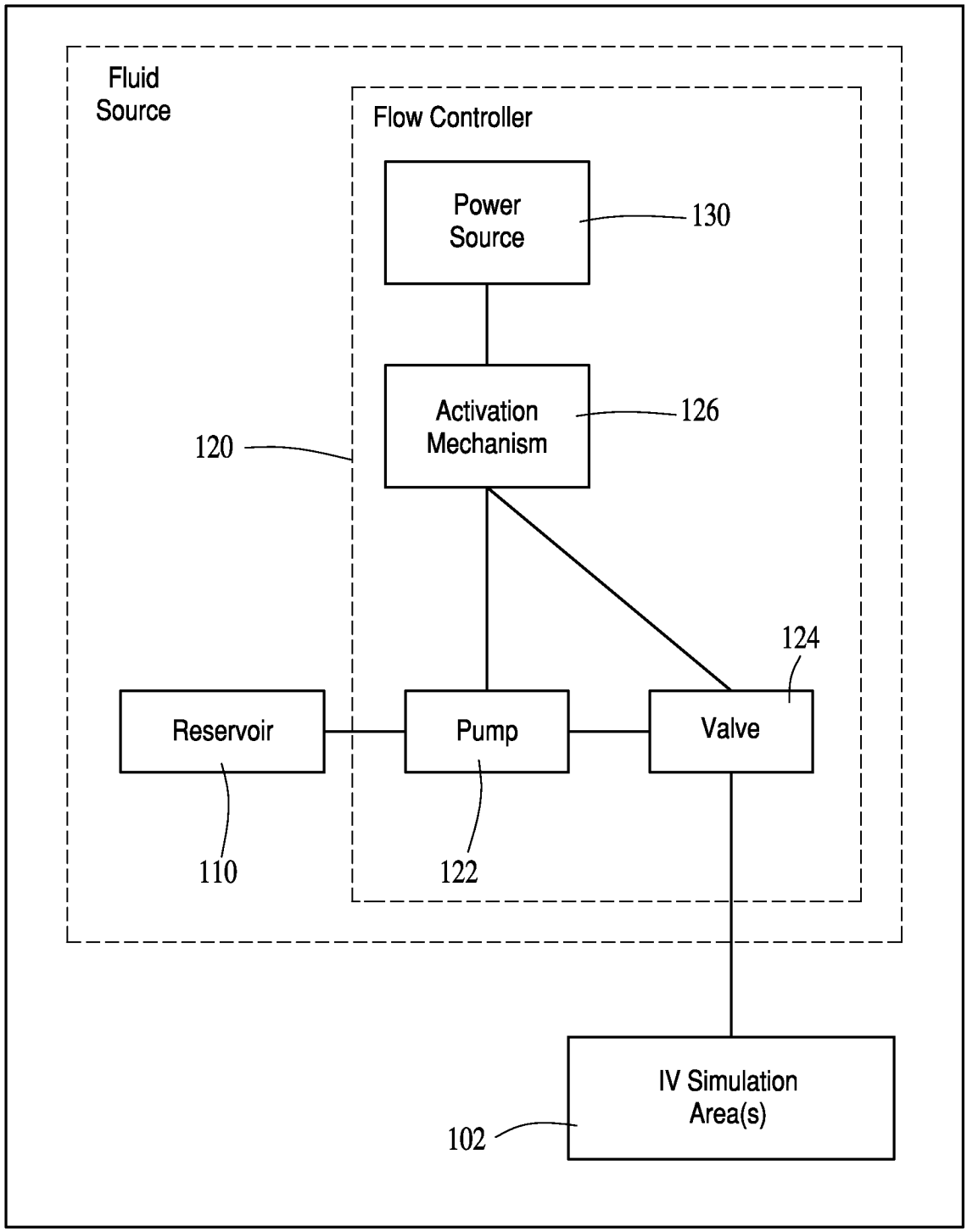

Fluid Source
Flow Controller
Power Source
130
Activation Mechanism
126
120
124
Reservoir
Pump
Valve
110
122
IV Simulation Area(s)
102

FIG. 5A

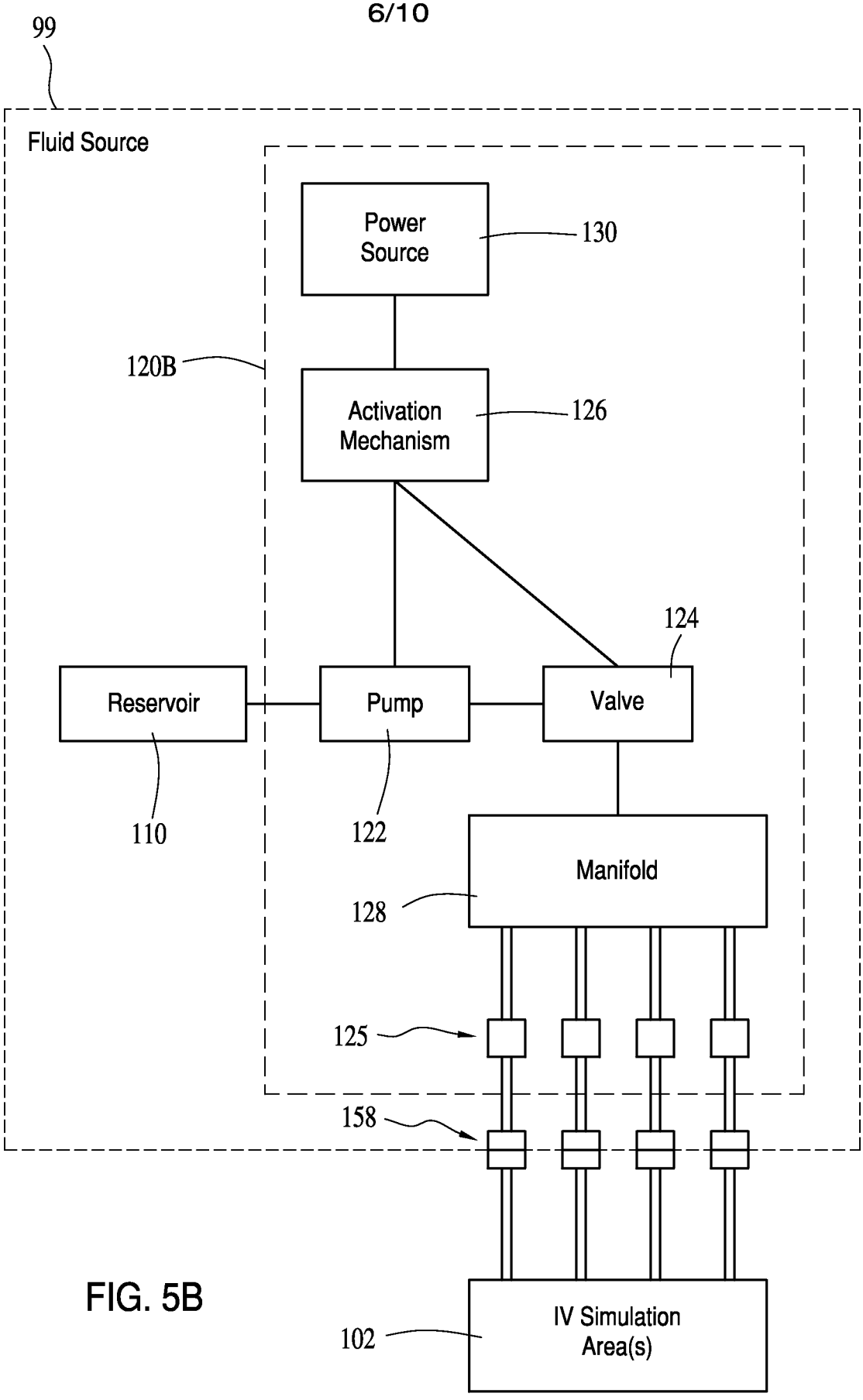

99
Fluid Source
Power Source
130
120B
Activation Mechanism
126
124
Reservoir
Pump
Valve
110
122
Manifold
128
125
158
IV Simulation Area(s)
102

FIG. 5B

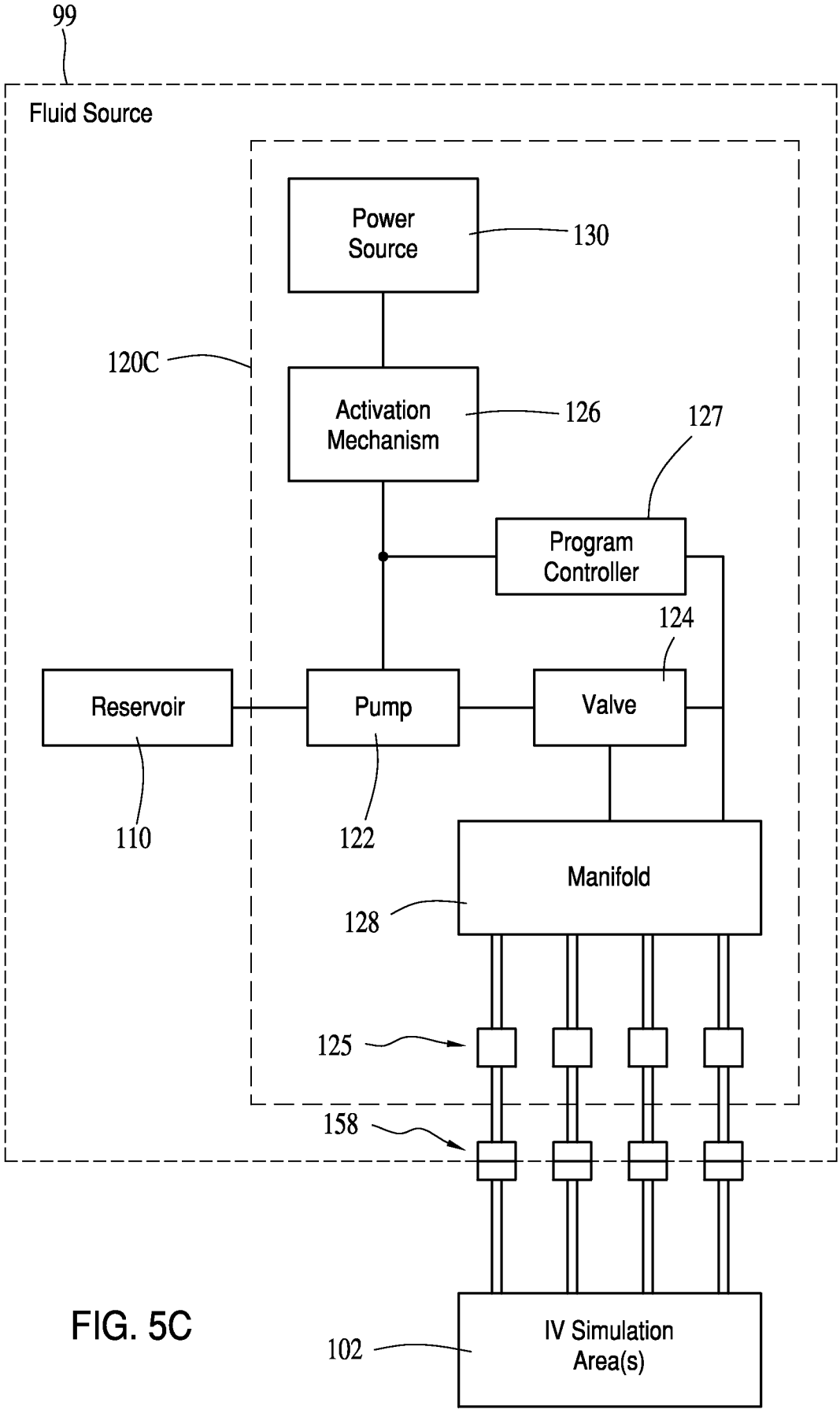

99
Fluid Source
Power Source
130
120C
Activation Mechanism
126
127
Program Controller
124
Reservoir
Pump
Valve
110
122
Manifold
128
125
158
IV Simulation Area(s)
102

FIG. 5C

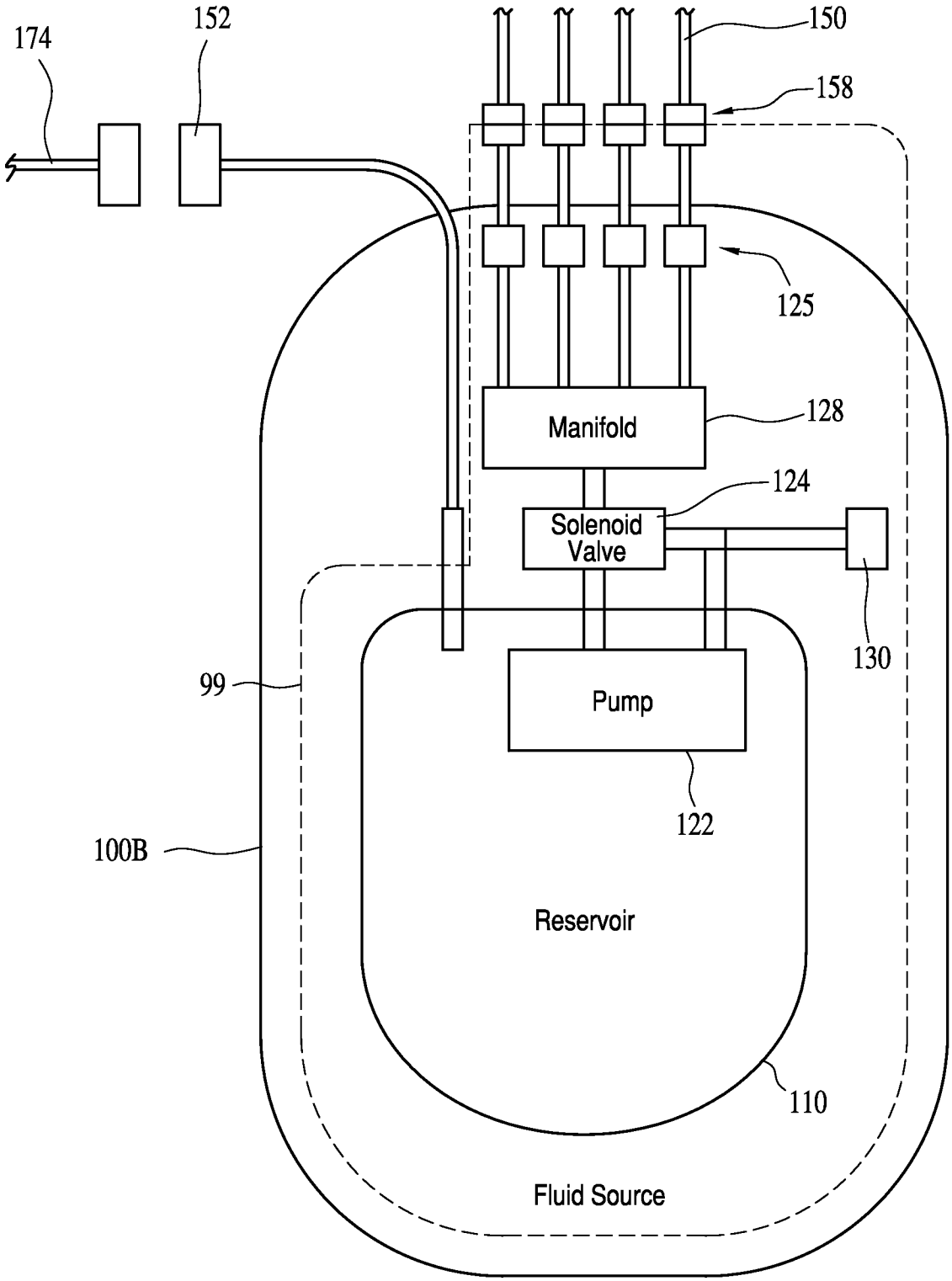

174
152
150
158
125
Manifold
128
124
Solenoid Valve
130
99
Pump
122
100B
Reservoir
110
Fluid Source

FIG. 6

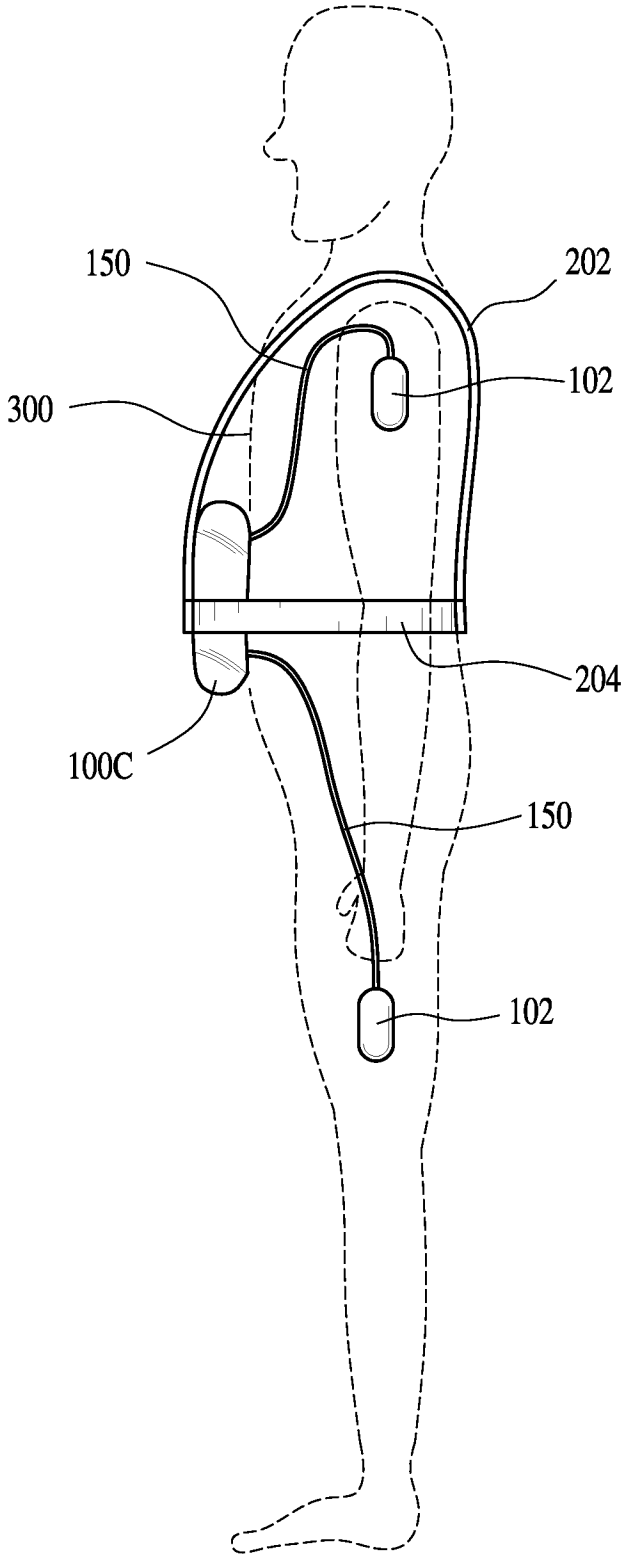



Figure 7

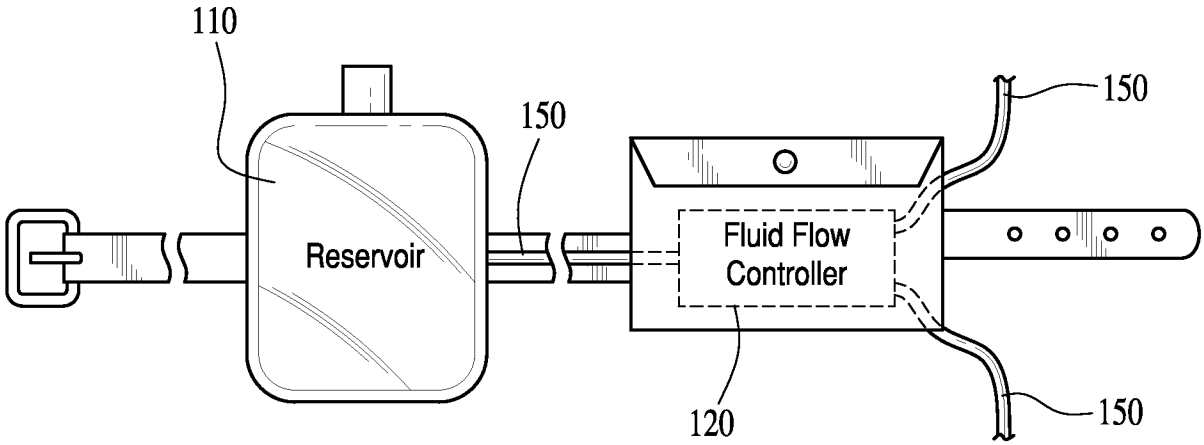



FIG. 8