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(72) Inventors: GYLLAND, Jeffrey, James; 951 Calle Amanecer, San Clemente, CA 92673 (US). BRANN, Gerald, William; 951 Calle Amanecer, San Clemente, CA 92673 (US). JACOBSON, James, Duane; 951 Calle Amanecer, San Clemente, CA 92673 (US). WEBB, Arthur, E.; 951 Calle Amanecer, San Clemente, CA 92673 (US). CUDNEY, 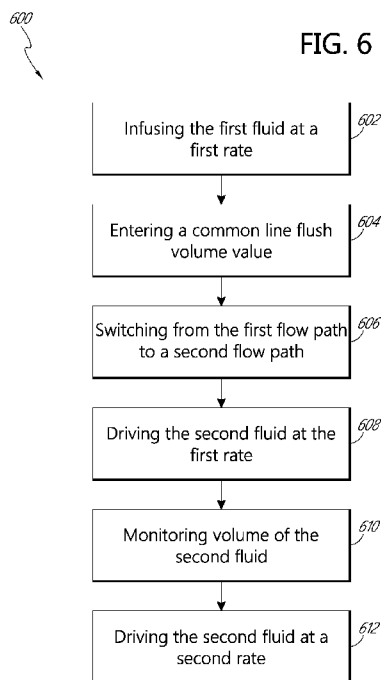James; 951 Calle Amanecer, San Clemente, CA 92673 (US). ASIKHAN-BERLINGUETTE, Nursel; 951 Calle Amanecer, San Clemente, CA 92673 (US).

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600

FIG. 6

Infusing the first fluid at a first rate — 602

Entering a common line flush volume value — 604

Switching from the first flow path to a second flow path — 606

Driving the second fluid at the first rate — 608

Monitoring volume of the second fluid — 610

Driving the second fluid at a second rate — 612

(57) Abstract: An infusion pump system and method with common line auto flush, wherein the infusion pump system has a first reservoir, a second reservoir, a junction, a common line having one end in fluid connection with the junction and having a terminal fluid delivery end, and an infusion pump. The method includes infusing the first fluid at a first rate along a first flow path; entering a common line flush volume value for the common line; switching from the first flow path to a second flow path; driving the second fluid at the first rate along the second flow path; monitoring volume of the second fluid driven at the first rate; and driving the second fluid at a second rate along the second flow path when the monitored volume is equal to or greater than the common line flush volume value.

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INFUSION PUMP SYSTEM AND METHOD WITH COMMON LINE AUTO FLUSH

BACKGROUND OF THE INVENTION

<u>Field of the Invention</u>

[0001] The present invention relates to medical devices. More specifically, the invention relates to infusion pump systems.

[0002] Infusion pumps are medical devices that deliver fluids, including nutrients and medications such as antibiotics, chemotherapy drugs, and pain relievers, in controlled amounts. Many types of pumps, including large volume, patient-controlled analgesia (PCA), elastomeric, syringe, enteral, and insulin pumps, are used worldwide in healthcare facilities, such as hospitals, and in the home. Clinicians and patients rely on pumps for safe and accurate administration of fluids and medications.

[0003] It is desirable to provide more than one therapeutic fluid from the infusion pump for some treatment regimens. Presently, two fluid reservoirs with different therapeutic fluids are connected to the infusion pump and then delivered through a common line having a terminal fluid delivery end. The first therapeutic fluid and second therapeutic fluid are administered alternately by switching the fluid flow path between the first reservoir and the second reservoir.

[0004] Unfortunately, the therapeutic fluid remaining in the common line creates problems when switching between the two therapeutic fluids. First, the remaining therapeutic fluid must be cleared from the common line before the next therapeutic fluid begins administration, delaying the next therapeutic fluid from reaching the patient. Second, when the therapeutic fluids are administered at different rates, the therapeutic fluid remaining in the common line will be administered at the rate of the new fluid being administered, e.g., the remaining first therapeutic fluid will be administered at the rate specified for the second therapeutic fluid. This can result in the patient from receiving more or less than the optimum therapy with respect to the first therapeutic fluid. Third, the remaining therapeutic fluid may not be correctly accounted for, potentially creating errors in the values indicated at the infusion pump. While the pump data will be correct in terms of infusion rates over given times, the actual fluid delivery to the terminal fluid delivery end at the patient is not correctly captured in pump and system data.

[0005] It would be desirable to have infusion pump systems and methods with common line auto flush that would overcome the above disadvantages.

SUMMARY OF THE DISCLOSURE

[0006] One aspect of the present invention provides a method to infuse fluids with an infusion pump system, the infusion pump system having a first reservoir containing a first fluid, a second reservoir containing a second fluid, a junction in fluid communication with the first reservoir and the second reservoir, a common line in fluid communication with the junction at one end and having a terminal fluid delivery end, and an infusion pump operable to drive fluid through the common line. The method includes infusing the first fluid at a first rate along a first flow path including the first reservoir, the junction, and the common line; entering a common line flush volume value for the common line; switching from the first flow path to a second flow path including the second reservoir, the junction, and the common line; driving the second fluid at the first rate along the second flow path; monitoring volume of the second fluid driven at the first rate; and driving the second fluid at a second rate along the second flow path when the monitored volume is equal to or greater than the common line flush volume value.

[0007] Another aspect of the present invention provides an infusion pump system including a first reservoir containing a first fluid; a second reservoir containing a second fluid; a junction in fluid communication with the first reservoir and the second reservoir; a common line in fluid communication with the junction at one end and a terminal fluid delivery end; and an infusion pump operable to drive fluid through the common line. The infusion pump is operable to infuse the first fluid at a first rate along a first flow path including the first reservoir, the junction, and the common line; receive a common line flush volume value for the common line; switch from the first flow path to a second flow path including the second reservoir, the junction, and the common line; drive the second fluid at the first rate along the second flow path; monitor volume of the second fluid driven at the first rate; and drive the second fluid at a second rate along the second flow path when the monitored volume is equal to or greater than the common line flush volume value.

[0008] Yet another aspect of the present invention provides an infusion pump, the infusion pump being operably connected to a common line in fluid communication with a

junction at one end and having a terminal fluid delivery end, the junction being in fluid communication with a first reservoir containing a first fluid and a second reservoir containing a second fluid. The infusion pump includes a memory operable to store programming code; a flow controller operably connected to the memory; and a fluid driver operably connected to receive a control signal from the flow controller, the fluid driver being operable to drive fluid through the common line. The flow controller is operable to execute the programming code and provide the control signal to the fluid driver in response to the programming code. The fluid driver is responsive to the control signal to infuse the first fluid at a first rate along a first flow path including the first reservoir, the junction, and the common line; receive a common line flush volume value for the common line; switch from the first flow path to a second flow path including the second reservoir, the junction, and the common line; drive the second fluid at the first rate along the second flow path; monitor volume of the second fluid driven at the first rate; and drive the second fluid at a second rate along the second flow path when the monitored volume is equal to or greater than the common line flush volume value.

[0009] The foregoing and other features and advantages of the invention will become further apparent from the following detailed description of the presently preferred embodiments, read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the invention rather than limiting. The scope of the invention is defined by the appended claims and equivalents thereof.

[00010] In certain embodiments, a control system can control operation of an infusion pump system. The infusion pump system can include a first reservoir that can hold a first fluid, a second reservoir configured to hold a second fluid, a junction in fluid communication with the first reservoir and the second reservoir, a common line in fluid communication with the junction and having a terminal fluid delivery end, and an infusion pump operable to drive fluid through the common line toward the terminal fluid delivery end. The control system can include one or more hardware processors for executing instructions. The control system can receive instructions for delivery of a first fluid at a first rate followed by a second fluid at a second rate. The control system can further infuse a first fluid at a first rate along a first flow path. The control system can also determine a first volume to clear the first fluid from a common line. The control system can infuse a second fluid at the first rate along a second flow path. The control system can monitor a second volume of the second fluid infused at the first rate. The

control system can determine when the monitored volume of the second fluid meets or exceeds the first volume. The control system can change infusion of the second fluid to a second rate along the second flow path based on the determination when the monitored volume of the second fluid meets or exceeds the first volume.

[00011]   The control system of the preceding paragraph can have any sub-combination of the following features: wherein the first volume is received from a user input; wherein the first volume is stored in a memory; wherein the first volume is retrieved over a network; wherein the first volume is predetermined; wherein the first volume is based on the first fluid; wherein the first rate is different than the second rate; wherein the instructions for the delivery are received from an input via a user interface; wherein the one or more hardware processors can automatically generate a user interface configured to receive an input for the first volume based on a determination of sequential delivery of two different fluids; wherein the one or more hardware processors can control a valve, wherein the valve is configured to switch the infusion of the first fluid along the first flow path to the infusion of the second fluid along the second path; wherein the one or more hardware processors are configured to transmit a control signal to begin the infusion; wherein the one or more hardware processors are configured to transmit a control signal to stop the infusion.

[00012]   A method for controlling operation of an infusion pump system, the infusion pump system comprising a first reservoir configured to hold a first fluid, a second reservoir configured to hold a second fluid, a junction in fluid communication with the first reservoir and the second reservoir, a common line in fluid communication with the junction and having a terminal fluid delivery end, and an infusion pump operable to drive fluid through the common line toward the terminal fluid delivery end. The method can include receiving instructions for delivery of a first fluid at a first rate followed by a second fluid at a second rate. The method can also include infusing a first fluid at a first rate along a first flow path. The method can further include determining a first volume to clear the first fluid from a common line. In some embodiments, the method includes infusing a second fluid at the first rate along a second flow path. The method can include monitoring a second volume of the second fluid infused at the first rate. The method can also include determining when the monitored volume of the second fluid meets or exceeds the first volume. The method also includes changing infusion of

the second fluid to a second rate along the second flow path based on the determination when the monitored volume of the second fluid meets or exceeds the first volume.

[00013]   The method of preceding paragraph can have any sub-combination of the following features: wherein the first volume is received from a user input; wherein the first volume is stored in a memory; wherein the first volume is retrieved over a network; wherein the first volume is predetermined; wherein the first volume is based on the first fluid; wherein the first rate is different than the second rate; wherein the instructions for the delivery are received from an input via a user interface; further comprising automatically generating a user interface configured to receive an input for the first volume based on a determination of sequential delivery of two different fluids; further comprising controlling a valve, wherein the valve is configured to switch the infusion of the first fluid along the first flow path to the infusion of the second fluid along the second path; further comprising transmitting a control signal to begin the infusion; further comprising transmitting a control signal to stop the infusion.

BRIEF DESCRIPTION OF THE DRAWINGS

[00014]   **Figs. 1A & 1B** are block diagrams of infusion pump systems with common line auto flush in accordance with the present invention.

[00015]   **Fig. 2** is a block diagram of an infusion pump with common line auto flush in accordance with the present invention.

[00016]   **Fig. 3** is a schematic diagram of an infusion pump with common line auto flush in accordance with the present invention.

[00017]   **Figs. 4A-4O** are schematic diagrams of a screen for an infusion pump system with common line auto flush in accordance with the present invention.

[00018]   **Figs. 5A & 5B** are graphs of fluid volume delivered at the terminal fluid delivery end of the common line versus time for a method of use for an infusion pump with common line auto flush in accordance with the present invention.

[00019]   **Fig. 6** is a flowchart of a method of use for an infusion pump system with common line auto flush in accordance with the present invention.

[00020]   **Figs. 7A-7E** are schematic diagrams of use for an infusion pump system with common line auto flush in accordance with the present invention.

[00021]   Like elements share like reference numbers throughout the various figures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[00022]   Systems and methods that improve an infusion pump system with common line are described herein. The infusion pump can deliver a first fluid from a first reservoir, then switch to delivering a second fluid from a second reservoir as per patient requirements. As discussed above, switching may result in some of the first fluid remaining in a common line. Furthermore, delivering fluids at rates other than the desired rates may result in air in the line or inaccurate therapy, which can be fatal to the patients. The systems and methods described here can improve delivery and accurately account for the first fluid remaining in the internal volume of the common line. Fluid as used herein can be any fluid suitable to be administered to a patient by infusion, including saline fluid, fluid including a drug or other therapeutic agent, or the like.

[00023]   **Figs. 1A & 1B** are block diagrams for embodiments of infusion pump systems with common line. The infusion pump system illustrated in **Fig. 1A** includes a junction in fluid communication with the first reservoir and the second reservoir internal to the infusion pump, while the embodiment of the infusion pump system illustrated in **Fig. 1B** has a junction in fluid communication with the first reservoir and the second reservoir external to the infusion pump. The location of the junction, in part, determines the length and internal volume of the common line between the junction and the terminal fluid delivery end. The internal shape, which is usually substantially circular, and the diameter of the common line are factors along with the length that determine the internal volume, although other shapes can be used without detracting from the scope of the disclosure.

[00024]   The infusion pump system **100** of **Fig. 1A** includes a junction **180** internal to the infusion pump **130**. The infusion pump system **100** includes a first reservoir **110** that can contain a first fluid **112**; a second reservoir **120** that contain a second fluid **122**; a junction **180** in fluid communication with the first reservoir **110** and the second reservoir **120**; a common line **140** in fluid communication with the junction **180** at one end **140A** and having a terminal fluid delivery end **140B** for connection to the patient **102**, and an infusion pump **130** operable to drive fluid through the common line

140. The infusion pump **130** is operable to: infuse the first fluid **112** at a first rate along a first flow path **150** including the first reservoir **110**, the junction **180**, and the common line **140**; receive a common line flush volume value for the common line **140**; switch from the first flow path **150** to a second flow path **160** including the second reservoir **120**, the junction **180**, and the common line **140**; drive the second fluid **122** at the first rate along the second flow path **160**; monitor volume of the second fluid **122** driven at the first rate; and drive the second fluid **122** at a second rate along the second flow path **160** when the monitored volume is equal to or greater than the common line flush volume value. In one example, the infusion pump **130** can be a fluid displacement pump employing a cassette, such as the Plum 360™ infusion pump available from Hospira, Inc. of Lake Forest, Illinois. Those skilled in the art will appreciate that the infusion pump **130** can be any type of pump operable to drive fluid through the common line **140**.

[00025]   In one embodiment, the infusion pump **130** can be operably connected to a medication management unit (MMU) **170** to receive a drug library including the desired common flush volume value from the MMU **170**. In one embodiment, the infusion pump **130** can be further operable to increment a first fluid displayed volume by the monitored volume when the second fluid **122** is driven at the first rate along the second flow path **160**. The infusion pump **130** can be further operable to increment a second fluid displayed volume by the monitored volume when the monitored volume is equal to or greater than an internal volume of the common line. In one embodiment, the infusion pump **130** can be operable to stop infusing the first fluid **112** before driving the second fluid **122** at the first rate along the second flow path **160**. In one embodiment, the infusion pump **130** can be operable to monitor the volume of the first fluid and switch to delivery of the flush volume when the volume of the first fluid is equal to the received Volume to be Infused (VTBI) for the first fluid. In another embodiment, the infusion pump **130** can be operable to monitor the first fluid path and switch to delivery of the flush volume when the infusion pump detects a given threshold of air (as a single bubble, accumulated bubbles, or by percentage volume) in the first fluid path.

[00026]   The infusion pump **130** can be operable to receive the common line flush volume value for the common line **140** automatically from the drug library stored in a memory locally in the infusion pump system 100 or remotely on a server. In one

example, the drug library associates the common flush volume value with a particular therapeutic agent. In another example, the drug library associates the common flush volume value with a particular clinical care area (CCA), such as general care, an intensive care unit (ICU), a neonatal ICU, or the like. In yet another example, the drug library associates the common flush volume value with a particular consumable infusion set, which directly provides the common line volume. The drug library can include upper and lower dosing limits with hard and soft limits for a number of therapeutic agents. In another embodiment, the infusion pump **130** can be operable to receive the common line flush volume value for the common line **140** from a caregiver via an input on a user interface of the infusion pump. In another embodiment, the infusion pump **130** can be operable to receive the second rate at which the second fluid is delivered when the monitor volume is equal to or greater than the common line flush volume value.

[00027]   The common line **140** as illustrated includes the line between the junction **180** and the terminal fluid delivery end **140B** that is generally connectable at the patient **102**, and includes any fluid path common to the first flow path **150** and the second flow path **160**. Thus, the common line **140** can include flow paths within the infusion pump **130** (including the associated consumable infusion set, when applicable) common to the first flow path **150** and the second flow path **160**, and is not limited to tubing external to the infusion pump **130**. The common line **140** is any portion of the infusion pump system **100** through which the first fluid **112** or the second fluid **122** can alternately flow when switched. In one embodiment, the common line flush volume value is an internal volume of the common line **140**. Those skilled in the art will appreciate that the common line flush volume value can include an associated consumable infusion set volume, extension sets, filters, patient access devices, catheters, and the like, as required for a particular setup of the infusion pump system **100.** In another embodiment, the common line flush volume value is an internal volume of the common line **140** plus an adjustment volume. The adjustment volume can be any volume desired as a safety factor to assure that the common line **140** is free of the first fluid **112** before the second fluid **122** is infused at the second rate.

[00028]   The infusion pump system **100'** of **Fig. 1B** has a junction **180'** external to the infusion pump **130'**. The infusion pump system **100'** includes a first reservoir **110'** containing a first fluid **112'**; a second reservoir **120'** containing a second

fluid **122'**; a junction **180'** in fluid communication with the first reservoir **110'** and the second reservoir **120'**; a common line **140'** in fluid communication between the junction **180'** and the terminal fluid delivery end **140B'** that is generally connectable at the patient **102'**, and an infusion pump **130'** operable to drive fluid through the common line **140'**. The infusion pump **130'** is operable to: infuse the first fluid **112'** at a first rate along a first flow path **150'** including the first reservoir **110'**, the junction **180'**, and the common line **140'**; receive a common line flush volume value for the common line **140'**; switch from the first flow path **150'** to a second flow path **160'** including the second reservoir **120'**, the junction **180'**, and the common line **140'**; drive the second fluid **122'** at the first rate along the second flow path **160'**; monitor volume of the second fluid **122'** driven at the first rate; and drive the second fluid **122'** at a second rate along the second flow path **160'** when the monitored volume is equal to or greater than the common line flush volume value. In one embodiment, the junction **180'** can include a two-way valve to manually or automatically switch the infusion pump system **100'** between the first flow path **150'** and the second flow path **160'**. In one example, the infusion pump **130'** can be a peristaltic pump, such as the pump used in the Sapphire™ infusion system available from Hospira, Inc. of Lake Forest, Illinois. Those skilled in the art will appreciate that the infusion pump **130'** can be any type of pump operable to drive fluid through the common line **140'**.

[00029]   **Fig. 2** is a block diagram of an embodiment of an infusion pump with common line auto flush. The infusion pump **230** is operably connected to a common line **240** in fluid communication with a junction **280** at one end **240A** and having a terminal fluid delivery end **240B** (not shown due to truncation), the junction **280** being in fluid communication with a first reservoir (not shown) containing a first fluid and a second reservoir (not shown) containing a second fluid. In this example, a first reservoir line **211** provides fluid communication between the first reservoir and the junction **280** and a second reservoir line **221** provides fluid communication between the second reservoir and the junction **280**.

[00030]   The infusion pump **230** includes a memory **233** operable to store programming code; a flow controller **235** operably connected to the memory **233**; and a fluid driver **232** operably connected to receive a control signal **231** from the flow controller **235**, the fluid driver **232** being operable to drive fluid through the common line

240. The flow controller **235** is operable to execute the programming code and provide the control signal **231** to the fluid driver **232** in response to the programming code. The fluid driver **232** is responsive to the control signal **231** to infuse the first fluid at a first rate along a first flow path **211** including the first reservoir, the junction **280**, and the common line **240**; receive a common line flush volume value for the common line **240**; switch from the first flow path **250** to a second flow path **260** including the second reservoir, the junction **280**, and the common line **240**; drive the second fluid at the first rate along the second flow path **260**; monitor volume of the second fluid driven at the first rate; and drive the second fluid at a second rate along the second flow path **260** when the monitored volume is equal to or greater than the common line flush volume value. In an embodiment, the flow controller 235 monitors the volume based on a time elapsed and a rate of delivery. The flow controller 235 can also monitor volume based on measurements, such as number of turns of a motor or signals from a sensor.

[00031]   The flow controller **235** can be any hardware processor, microprocessor, or the like responsive to the programming code to generate the control signal **231**. The fluid driver **232** can be any metered pump, such as a cartridge pump, syringe pump, peristaltic pump, or the like, operable to drive fluid at a desired rate in response to the control signal **231**. In one embodiment, the fluid driver **232** can be further responsive to the control signal **231** to increment a first fluid displayed volume by the monitored volume when the second fluid is driven at the first rate along the second flow path **260**. The fluid driver **232** can be further responsive to the control signal **231** to increment a second fluid displayed volume by the monitored volume when the monitored volume is equal to or greater than an internal volume of the common line **240**. The first fluid displayed volume and/or the second fluid displayed volume can be displayed on a user interface **236**. In another embodiment, the fluid driver **232** can be responsive to the control signal **231** to stop infusing the first fluid before driving the second fluid at the first rate along the second flow path **260**.

[00032]   The memory **233** can also be operable to store data, such as a drug library **234** including the common flush volume value, which can optionally be associated with a particular therapeutic agent, a particular clinical care area, and/or a particular consumable infusion set. Different therapeutic agents may have different fluid properties and thus it may be advantageous in some embodiments to associate particular common

flush volume value with particular therapeutic agents. In one embodiment, the infusion pump **230** can receive the common line flush volume value for the common line **240** automatically from the drug library **234**. In another embodiment, the infusion pump **230** can receive the common line flush volume value manually via direct entry of the value on a user interface **236**. The manual entry can be accomplished using a manufacturer provided volume value based upon the length and internal diameter of the common line **240** or a list number or other identifier that is used to access an associated volume value from a lookup table in the pump memory **233**, drug library or MMU. The possibility for manual typographical errors can be reduced by use of a barcode, radio frequency (RFID), optical, touch memory reader, near field communicator, or the like to input or scan a machine readable identifier on the infusion set, common line, or its package to obtain the volume value, the list number or other identifier associated with the volume value.

[00033]   The infusion pump **230** can include human and/or machine interfaces as desired for a particular application. A user interface **236** operably connected to the flow controller **235** can provide input from and/or output to a caregiver or other user to the infusion pump **230**. Exemplary user interfaces can include display screens, soft keys or fixed keys, touchscreen displays, and the like. An I/O interface **237** operably connected to the flow controller **235** can provide input from and/or output to hardware associated with the infusion pump **230**. Exemplary I/O interfaces can include a wired and/or wireless interface to an electronic network, medication management unit (MMU), medication management system (MMS), or the like.

[00034]   The common line flush volume value can be selected as desired for a particular application. The common line **240** includes the line between the junction **280** and the terminal fluid delivery end **240B**, and includes any fluid path common to the first flow path **250** and the second flow path **260** and so can include any portion of the infusion pump **230** (including the associated consumable infusion set, when applicable) through which the first fluid or the second fluid can alternately flow. In one embodiment, the common line flush volume value is equal to the internal volume of the common line **240**, so that the second fluid is infused at the second rate along the second flow path as soon as the first fluid has been cleared from the common line **240**. In another embodiment, the common line flush volume value is equal to the internal volume of the common line **240** plus an adjustment volume (to take into account the added/subtracted

volume of other connectors or components), so that the second fluid is infused at the second rate along the second flow path after the first fluid has been cleared from the common line **240** plus the adjustment volume of the second fluid has been delivered at the first rate. In another embodiment, the common line flush volume value is equal to the internal volume of the common line modified by a percentage, which could provide a desired overage or underage. The adjustment volume can be used as a safety factor to assure that the common line **240** is free of the first fluid before the second fluid is infused at the second rate.

[00035]   **Fig. 3** is a schematic diagram of an infusion pump with common line auto flush in accordance with the present invention. In this example, the infusion pump **330** includes a display **340**, soft keys **350**, and fixed keys **360** as a user interface. The display **340** provides operational and/or programming information to the user. The soft keys **350** perform different functions depending on the command displayed on an adjacent command portion **342** of the display **340**. The fixed keys **360** are labeled with an input or function which functions the same, regardless of whatever is displayed on the display **340**. In this example, the infusion pump **330** also includes a pump mechanism **370** operable to communicate with the first reservoir line and the second reservoir line and to move the first fluid or the second fluid to the terminal fluid delivery end of the common line.

[00036]   **Figs. 4A-4O** illustrate schematic diagrams of user interfaces or screens for an infusion pump system with common line auto flush. In this embodiment, the user can manually edit the common line flush volume value, i.e., the flush volume. In this example, the infusion pump is infusing a first fluid to the terminal fluid delivery end of the common line on Channel A at a first rate, switches to infusing a second fluid to the terminal fluid delivery end of the common line on Channel B at a second rate, then switches back to infusing the first fluid on Channel A but maintains the second rate long enough to clear the remaining second fluid from the common line before changing to the first rate. The flow controller can control the switching using one or more control signals. In some embodiments, the reservoirs may be arranged to switch automatically based on fluid dynamics and arrangement of the reservoirs with respect to each other.

[00037]   Referring to **Fig. 4A**, the screen **440** indicates that the infusion pump is in Standby, awaiting programming. The user actuates the soft key associated

with Channel A at the bottom of the screen **440** to access a new screen to program Channel A parameters starting with **Fig. 4B**. Referring to **Fig. 4B**, the user highlights one of the drugs from a displayed drug list (in this example, Normal Saline) and actuates the soft key associated with Choose at the bottom of the screen **440** to access a new screen to program infusion parameters for the highlighted drug. Referring to **Fig. 4C**, the user enters values for the Rate, Volume to Be Infused (VTBI), and/or Duration parameters for the infusion of the selected drug (in this example, Normal Saline) for Channel A. Those skilled in the art will appreciate that the parameters can be interrelated, such that the infusion pump automatically fills in the values for some of the parameters once values for other parameters have been entered. Referring to **Fig. 4D**, the program infusion parameters entered for Channel A are displayed, with a Rate of 125 mL/hr, VTBI of 100 mL and Duration of 00:48 hh:mm. The user actuates the START fixed key to confirm the values entered and to access the Confirm Program screen of **Fig. 4E**. To start delivery on Channel A, the user actuates the soft key associated with Yes at the bottom of the screen **440** of **Fig. 4E,** which switches the screen **440** to **Fig. 4F** indicating that Channel A is infusing the Channel A drug (in this example, Normal Saline) at the Channel A Rate of 125 mL/hr with a Volume Infused of 0 mL.

[00038]   Referring to **Fig. 4F**, the user actuates the soft key associated with Channel B at the bottom of the screen **440** to access a new screen to program Channel B parameters starting with **Fig. 4G**. In this embodiment, the pumping of the first fluid on Channel A continues until the pumping of the second fluid on Channel B is initiated. In another embodiment, the pumping of the first fluid on Channel A can be stopped before pumping the second fluid on Channel B, e.g., while the common line auto flush is being programmed.

[00039]   Referring to **Fig. 4G**, the user highlights one of the drugs from a displayed drug list (in this example, NIVOlumab) and actuates the soft key associated with Choose at the bottom of the screen **440** to access a new screen **440** on **Fig. 4H** to program infusion parameters for the highlighted drug. The user enters values for the Dose, Rate, Volume to Be Infused (VTBI), and/or Duration parameters for the infusion of the selected drug (in this example, NIVOlumab) for Channel B. Those skilled in the art will appreciate that the parameters can be interrelated, such that the infusion pump automatically fills in the values for some of the parameters once values for other

parameters have been entered. Referring to **Fig. 4I**, the program infusion parameters entered for Channel B are displayed, with a Dose of 100 mcg/kg/min, a Rate of 375 mL/hr, a VTBI of 500 mL, and a Duration of 1:20 hh:mm.

[00040]   To proceed from the screen **440** of **Fig. 4I** to **Fig. 4J** to program the common line auto flush parameters, the user actuates the soft key associated with Flush Line (in this example, Auto Flush) at the bottom of the screen **440**. In one embodiment, the Flush Line only appears at the bottom of the screen **440** when a first and second fluid are to be infused sequentially through a common line, i.e. for a piggyback infusion and another prior or subsequent infusion. Accordingly, in an embodiment, the flow controller 235 can detect a piggyback infusion and automatically generate a user interface as illustrated to provide an option to select flush parameters. The flow controller 235 may also automatically select flush parameters, such as the common line flush volume from the drug library based on the detection of instructions to switch infusion from the first fluid to the second fluid.

[00041]   Referring to **Fig. 4J**, the user can enter the Flush Volume. In this example, the Flush Volume is limited to a maximum flush volume value, such as 30 mL. Those skilled in the art will appreciate that the maximum flush volume value can be selected as desired for a particular therapeutic agent, particular clinical care area, or the like and can be provided through a drug library as desired. Referring to **Fig. 4K**, the user has entered a value of 20 mL for the Flush Volume. The Rate remains at the previously entered Channel B Rate of 375 mL/hr as shown on **Fig. 4I**. In this example, the Rate is not editable and the Duration is calculated from the Rate and the Flush Volume. Referring to **Fig. 4K**, the user actuates the START fixed key to confirm the values entered and to access the Confirm Program screen of **Fig. 4L**, which shows the Channel B parameters.

[00042]   In this embodiment, the Flush Volume can be edited by the user. In one example, the initial editable Flush Volume is displayed as a zero value as shown in **Fig. 4J**. In another example, the initial editable Flush Volume is displayed as a predetermined value, e.g., as a predetermined value provided through a drug library. In another embodiment, the Flush Volume is predetermined and cannot be edited by the user. The Flush Volume can be displayed as in **Fig. 4K**, but cannot be changed.

[00043]   Referring to **Fig. 4L**, the user actuates the soft key associated with Yes at the bottom of the screen **440** to switch from the present Channel A infusion to the Channel B infusion. When the channel is switched, the Channel A drug (in this example, Normal Saline) remaining in the common volume is infused to the terminal fluid delivery end of the common line at the Channel B Rate of 375 mL/hr until the Channel A drug is cleared from the common volume and the Channel B drug (in this example, NIVOlumab) is infused at the Channel B Rate of 375 mL/hr. Referring to **Fig. 4M**, the Channel A infusion is on hold and Pending and Channel B is infusing the Channel B drug (in this example, NIVOlumab). In this example, the Volume Infused of Channel A drug (in this example, Normal Saline) of 3 mL was infused while the Channel B and flush volume parameters were being set.

[00044]   Referring to **Fig. 4N**, Channel B has infused the desired VTBI of 500mL so Channel B has stopped and Channel A has begun the common line auto flush, continuing the Channel B Rate of 375 mL/hr. When the infusion channel is switched (on reaching the desired Channel B VTBI), the Channel B drug (in this example, NIVOlumab) remaining in the common volume or common line is infused at the Channel B Rate of 375 mL/hr until the Channel B drug is cleared from the common volume or common line. Referring to **Fig. 4O**, Channel A has delivered the Flush Volume of 20mL to the patient, clearing the Channel B drug remaining in the common volume or common line. The Channel A drug (in this example, Normal Saline) is then infused at the Channel A Rate of 125 mL/hr. The Volume Infused of Channel A drug (in this example, Normal Saline) has been increased by the Flush Volume of 20mL (from 3 to 23 mL) to account for the Channel A drug remaining in the common volume or common line previously when switching from Channel A to Channel B.

[00045]   In this example, the indicated Channel A Volume Infused is lower than the actual Channel A Volume Infused and the indicated Channel B Volume Infused is higher than the actual Channel A Volume Infused from the time of switching the infusion from Channel A to Channel B until the Flush Volume is added to the Channel A Volume Infused following the common line auto flush, the difference between indicated the and the actual being the Flush Volume. The difference is typically small relative to the indicated Volume infused, but those skilled in the art will appreciate that the indicated Volume Infused can be corrected as desired for a particular application.

[00046]   **Figs. 5A & 5B** are graphs of fluid volume delivered at the terminal end of the common line or patient versus time for a method of use for an infusion pump with common line auto flush in accordance with the present invention. **Fig. 5A** illustrates the common line auto flush as described for **Figs. 4A-4O**. **Fig. 5B** illustrates the common line auto flush as described for **Fig. 6**.

[00047]   Referring to **Fig. 5A**, graph **510** is the fluid volume delivered at the terminal fluid delivery end of the common line for a first fluid versus time and graph **520** is the fluid volume delivered at the terminal fluid delivery end of the common line for a second fluid versus time. From T1 to T2, the first fluid is being infused at a first rate along a first flow path including the first reservoir and the second fluid is not being infused. From T2 to T3, the first fluid is being infused at a second rate along a second flow path including the second reservoir as the internal volume of the common line is cleared. The second fluid cannot be infused until the internal volume is cleared of the first fluid. From T3 to T4, the internal volume has been cleared of the first fluid so that no more first fluid is infused and the second fluid is infused at the second rate along the second flow path including the second reservoir. From T4 to T5, the auto flush is performed: the second fluid is infused at the second rate along the first flow path including the first reservoir as the internal volume of the common line is cleared. The first fluid cannot be infused until the internal volume is cleared of the second fluid. After T5, the first fluid is infused at the first rate along the first flow path including the first reservoir after the internal volume of the common line has been cleared of the second fluid. In this example, no additional second fluid is infused after T5.

[00048]   Those skilled in the art will appreciate that the transition between the two fluids can be selected as desired for a particular application. In the example of **Fig. 5A**, a common line auto flush is performed from T4 to T5, but not from T2 to T3. As long as the common line flush volume value is known, the common line auto flush maintaining the first rate between T2 and T3 can be performed as desired.

[00049]   Referring to **Fig. 5B**, graph **530** is the fluid volume delivered at the terminal fluid delivery end of the common line for a first fluid versus time and graph **540** is the fluid volume delivered at the terminal fluid delivery end of the common line for a second fluid versus time. From T1 to T2, the first fluid is infused at the first rate along a first flow path including the first reservoir and the second fluid is not being infused.

From T2 to T3, the flow path is switched from the first flow path including the first reservoir to the second flow path including the second reservoir, and the second fluid is driven at a first rate along the second flow path to perform the common line auto flush. The first fluid is infused, driven or displaced until the internal volume of the common line has been cleared of the first fluid. After T3, the second fluid is infused, driven or displaced at the second rate along the second flow path including the second reservoir after the internal volume of the common line has been cleared of the first fluid. In one embodiment, the common line has been cleared of the second fluid when the monitored volume of the second fluid driven at the first rate between T2 and T3 is equal to or greater than the common line flush volume value. In this example, no additional second fluid is infused after T3.

[00050]   **Fig. 6** is a flowchart of an embodiment of a method for common line auto flush. The method **600** to infuse with an infusion pump system can use an infusion pump system having a first reservoir containing a first fluid, a second reservoir containing a second fluid, a junction in fluid communication with the first reservoir and the second reservoir, a common line in fluid communication with the junction at one end and having a terminal fluid delivery end, and an infusion pump operable to drive fluid through the common line. The method 600 can be performed by any of the systems discussed above. In an embodiment, some or all aspects of the method 600 are stored as programmed instructions to be executed by the flow controller 235. The method **600** can be used with an infusion pump system and infusion pump as described in **Figs. 1A, 1B, & 2** above. In this example, the infusion pump is infusing a first fluid on a first flow path at a first rate and switches to infusing a second fluid on second flow path, maintaining the first rate long enough to clear the remaining first fluid from the common line before changing to a second rate for infusing the second fluid.

[00051]   Referring to **Fig. 6**, at block 602, the infusion of the first fluid can be begin at a first rate along a first flow path including the first reservoir, the junction, and the common line. The infusion of the first fluid can be controlled by the flow controller 235 based on a control signal to activate the pump or other mechanical system. In some embodiments, the infusion of the first fluid can also be based on a user input or user control of the pump or the mechanical system. At block 604, the flow controller 235 can receive a common line flush volume value. As discussed above, the common line

flush value can be received based on a user input via the user interfaces discussed above. In an embodiment, the flow controller 235 can automatically retrieve the common line flush volume value from the memory 233 or over a network. The common line flush volume may be predetermined for particular fluids. The common line flush volume may also depend on the VTBI or rate of the infusion.

[00052]   At block 606, the flow controller 235 can determine to switch infusion from the first reservoir to the second reservoir. As discussed above, the infusion may also be switched based on the function of fluid dynamics and arrangement of the respective reservoirs without any determination from the flow controller 235. Switching changes the flow path from the first flow path to a second flow path, which includes the second reservoir, the junction, and the common line. In an embodiment, the flow controller 235 can control a valve to switch the flow path. At block 606, the second fluid is infused at the first rate **608** along the second flow path. The flow controller 235 can use control signals for the infusion of the second fluid and controlling the rate of delivery. By driving the second fluid at the first rate, the first fluid remaining in the common line is flushed and delivered to the patient at the same rate as therapeutically required. In some embodiments, the flow controller 235 obviates the need to specifically arrange the reservoirs by caregivers as the flow controller 235 can control the delivery instead of relying on fluid dynamics and gravity.

[00053]   At block 610, the flow controller 235 can monitor volume of the second fluid **610** driven at the first rate. The flow controller 235 can determine that the monitored volume is equal to the common line flush volume value. When it's determined that common line flush volume value has been delivered, the flow controller 235 can begin infusion of the second fluid at a second rate along the second flow path as shown in block 612. In some embodiments, the flow controller 235 can track an amount of time before changing the rate of the second fluid delivery to the second rate. In one embodiment, the flow controller 235 can further include incrementing a second fluid displayed volume by the monitored volume when the monitored volume is equal to or greater than an internal volume of the common line. The flow controller 235 can thus accurately track the rate, time, and an amount of fluid delivered to the patient. In some embodiments, the flow controller 235 executes only some of the steps described above

with respect to **Fig. 6**. Furthermore, the flow controller 235 can change the order of the steps, include additional steps, or modify some of the steps discussed above.

[00054]   The common line flush volume value can be selected as desired for a particular application. In one embodiment, the common line flush volume value is an internal volume of the common line. In another embodiment, the common line flush volume value is an internal volume of the common line plus or minus an adjustment volume. The adjustment volume can be any volume desired as a safety factor to assure that the common line is free of the first fluid before the second fluid is infused at the second rate.

[00055]   In one embodiment, the method **600** further includes incrementing a first fluid displayed volume by the monitored volume during the infusing the second fluid at the first rate along a second flow path, which can further include incrementing a second fluid displayed volume by the monitored volume when the monitored volume is equal to or greater than an internal volume of the common line.

[00056]   Entering a common line flush volume value **604** for the common line can be performed manually or automatically. In one embodiment, the entering **604** includes manually entering the common line flush volume value on a user interface of the infusion pump. In another embodiment, the entering **604** includes automatically entering the desired common flush volume value from a drug library. The drug library can associate the desired common flush volume value with a particular therapeutic agent, a particular clinical care area, and/or a particular consumable infusion set.

[00057]   In one embodiment, the switching from the first flow path to a second flow path **606** including the second reservoir, the junction, and the common line further includes stopping the infusing the first fluid before the driving the second fluid at the first rate along the second flow path.

[00058]   **Figs. 7A-7E** are schematic diagrams of use for an infusion pump system with common line auto flush in accordance with the present invention. **Figs. 7A-7E** illustrate switching from infusing a first fluid to infusing a second fluid, then switching back to infusing the first fluid, while accounting for the previously infused fluid in the common line. In this example, the infusion pump is infusing a first fluid on a first flow path at a first rate and switches to infusing a second fluid on a second flow path, maintaining the first rate long enough to clear the remaining first fluid from the common

line before changing to a second rate for infusing the second fluid. The infusion pump then switches to infusing a first fluid on the first flow path, maintaining the second rate long enough to clear the remaining second fluid from the common line before changing to a first rate for infusing the first fluid.

[00059]   Referring to **Fig. 7A**, the first fluid **712** is being delivered to the terminal end **740B** at a first rate along a first flow path **750** including the first reservoir **710**, the junction **780**, and the common line **740**. The first fluid **712** is indicated by the diagonal lines. Referring to **Fig. 7B**, flow has been switched from the first flow path **750** to the second flow path **760** including the second reservoir **720**, the junction **780**, and the common line **740**. The common line **740** contains first common line fluid **741** remaining from the initial infusion and indicated by the diagonal lines, and second common line fluid **742** indicated by the circles. The flow rate remains at the first rate because the remaining first common line fluid **741** is being delivered to the terminal fluid delivery end **740B** or to the patient when connected. Referring to **Fig. 7C**, none of the first fluid remains in the common line **740**, so the second common line fluid **743** is driven at a second rate along the second flow path **760**.

[00060]   The use of the infusion pump system can also include switching back to infusing the first fluid. Referring to **Fig. 7D**, flow has been switched from the second flow path **760** to the first flow path **750**. The common line **740** contains second common line fluid **744** remaining from the previous infusion indicated by the circles, and first common line fluid **745** indicated by the diagonal lines. The flow rate remains at the second rate because the remaining second common line fluid **744** is being delivered. Referring to **Fig. 7E**, none of the second fluid remains in the common line **740**, so the first common line fluid **746** is driven at a first rate along the first flow path **750**.

[00061]   While the embodiments of the invention disclosed herein are presently considered to be preferred, various changes, rearrangement of steps, and modifications can be made without departing from the scope of the invention. The scope of the invention is indicated in the appended claims, and all changes that come within the meaning and range of equivalents are intended to be embraced therein.

WHAT IS CLAIMED IS:

1.   A control system for controlling operation of an infusion pump system, the infusion pump system comprising a first reservoir configured to hold a first fluid, a second reservoir configured to hold a second fluid, a junction in fluid communication with the first reservoir and the second reservoir, a common line in fluid communication with the junction and having a terminal fluid delivery end, and an infusion pump operable to drive fluid through the common line toward the terminal fluid delivery end, the control system comprising one or more hardware processors configured to:

receive instructions for delivery of a first fluid at a first rate followed by a second
        fluid at a second rate;

infuse a first fluid at a first rate along a first flow path;

determine a first volume to clear the first fluid from a common line;

infuse a second fluid at the first rate along a second flow path;

monitor a second volume of the second fluid infused at the first rate;

determine when the monitored volume of the second fluid meets or exceeds the
        first volume; and

change infusion of the second fluid to a second rate along the second flow path
        based on the determination when the monitored volume of the second fluid
        meets or exceeds the first volume.

2.   The control system of Claim 1, wherein the first volume is received from a user input.

3.   The control system of Claim 1, wherein the first volume is stored in a memory.

4.   The control system of Claim 1, wherein the first volume is retrieved over a network.

5.   The control system of Claim 1, wherein the first volume is predetermined.

6.   The control system of Claim 1, wherein the first volume is based on the first fluid.

7.   The control system of Claim 1, wherein the first rate is different than the second rate.

8.   The control system of Claim 1, wherein the instructions for the delivery are received from an input via a user interface.

9.   The control system as in any of Claims 1 - 8, wherein the one or more hardware processors are further configured to automatically generate a user interface configured to receive an input for the first volume based on a determination of sequential delivery of two different fluids.

10.   The control system of Claim 9, wherein the one or more hardware processors are further configured to control a valve, wherein the valve is configured to switch the infusion of the first fluid along the first flow path to the infusion of the second fluid along the second path.

11.   The control system of Claim 1, wherein the one or more hardware processors are configured to transmit a control signal to begin the infusion.

12.   The control system of Claim 11, wherein the one or more hardware processors are configured to transmit a control signal to stop the infusion.

13.   A method for controlling operation of an infusion pump system, the infusion pump system comprising a first reservoir configured to hold a first fluid, a second reservoir configured to hold a second fluid, a junction in fluid communication with the first reservoir and the second reservoir, a common line in fluid communication with the junction and having a terminal fluid delivery end, and an infusion pump operable to drive fluid through the common line toward the terminal fluid delivery end, the method comprising:

> receiving instructions for delivery of a first fluid at a first rate followed by a
>> second fluid at a second rate;
>
> infusing a first fluid at a first rate along a first flow path;
>
> determining a first volume to clear the first fluid from a common line;
>
> infusing a second fluid at the first rate along a second flow path;
>
> monitoring a second volume of the second fluid infused at the first rate;
>
> determining when the monitored volume of the second fluid meets or exceeds the
>> first volume; and
>
> changing infusion of the second fluid to a second rate along the second flow path
>> based on the determination when the monitored volume of the second fluid
>> meets or exceeds the first volume.

14.   The method of Claim 13, wherein the first volume is received from a user input.

15.   The method of Claim 13, wherein the first volume is stored in a memory.

16.   The method of Claim 13, wherein the first volume is retrieved over a network.

17.   The method of Claim 13, wherein the first volume is predetermined.

18.   The method of Claim 13, wherein the first volume is based on the first fluid.

19.   The method of Claim 13, wherein the first rate is different than the second rate.

20.   The method of Claim 13, wherein the instructions for the delivery are received from an input via a user interface.

21.   The method as in any of Claims 13 - 20, further comprising automatically generating a user interface configured to receive an input for the first volume based on a determination of sequential delivery of two different fluids.

22.   The method of Claim 21, further comprising controlling a valve, wherein the valve is configured to switch the infusion of the first fluid along the first flow path to the infusion of the second fluid along the second path.

23.   The method of Claim 13, further comprising transmitting a control signal to begin the infusion.

24.   The method of Claim 23, further comprising transmitting a control signal to stop the infusion.

25.   A method to infuse fluids with an infusion pump system, the infusion pump system having a first reservoir containing a first fluid, a second reservoir containing a second fluid, a junction in fluid communication with the first reservoir and the second reservoir, a common line in fluid communication with the junction and having a terminal fluid delivery end, and an infusion pump operable to drive fluid through the common line toward the terminal fluid delivery end, the method comprising:

    infusing the first fluid at a first rate along a first flow path including the first
        reservoir, the junction, and the common line;

    entering a common line flush volume value for the common line;

    switching from the first flow path to a second flow path including the second
        reservoir, the junction, and the common line;

    driving the second fluid at the first rate along the second flow path;

    monitoring volume of the second fluid driven at the first rate; and

driving the second fluid at a second rate along the second flow path when the monitored volume is equal to or greater than the common line flush volume value.

26.   The method of claim 25 wherein the entering further comprises entering the second rate.

27.   The method of claim 25 wherein the entering comprises manually entering a common line internal volume value as the common line flush volume value on a user interface of the infusion pump.

28.   The method of claim 25 further comprising incrementing a first fluid displayed volume by the monitored volume during the infusing the second fluid at the first rate along a second flow path, and incrementing a second fluid displayed volume by the monitored volume when the monitored volume is equal to or greater than the common line flush volume value.

29.   The method of claim 25 wherein the switching flow path from the first flow path to a second flow path further comprises stopping the infusing the first fluid before the driving the second fluid at the first rate along the second flow path.

30.   The method of claim 29 wherein the switching flow path from the first flow path to a second flow path further comprises of one of detecting a given threshold of air in the first fluid path as a trigger to stop infusing the first fluid before the driving the second fluid at the first rate along the second flow path and detecting a VTBI complete signal from the infusion pump as the trigger.

31.   An infusion pump system, the infusion pump system comprising:

a first reservoir containing a first fluid;

a second reservoir containing a second fluid;

a junction in fluid communication with the first reservoir and the second reservoir;

a common line in fluid communication with the junction and having a terminal fluid delivery end; and

an infusion pump operable to drive fluid through the common line;

wherein the infusion pump is operable to:

infuse the first fluid at a first rate along a first flow path including the first reservoir, the junction, and the common line;

receive a common line flush volume value for the common line;

switch from the first flow path to a second flow path including the second
reservoir, the junction, and the common line;

drive the second fluid at the first rate along the second flow path;

monitor volume of the second fluid driven at the first rate; and

drive the second fluid at a second rate along the second flow path when the
monitored volume is equal to or greater than the common line flush
volume value.

32.   The infusion pump system of claim 31 wherein the common line flush
volume value is one of an internal volume of the common line, an internal volume of the
common line plus an adjustment, and an internal volume of the common line modified by
an adjustment percentage.

33.   The infusion pump system of claim 31 wherein the infusion pump being
operable to receive a common line flush volume value for the common line further
comprises the infusion pump being operable to receive the second rate.

34.   The infusion pump system of claim 31 wherein the infusion pump being
operable to receive a common line flush volume value for the common line comprises the
infusion pump being operable to receive the common line flush volume value for the
common line manually on a user interface of the infusion pump.

35.   The infusion pump system of claim 31 wherein the infusion pump being
operable to receive a common line flush volume value for the common line comprises the
infusion pump being operable to receive the common line flush volume value for the
common line automatically from one of a drug library and via receipt by the infusion
pump of a machine readable common line identifier associated with the common line.

36.   The infusion pump system of claim 35 wherein the drug library associates
the common flush volume value with a parameter selected from the group consisting of a
particular therapeutic agent, a particular clinical care area, and a particular consumable
infusion set.

37.   The infusion pump system of claim 31 wherein the infusion pump is
further operable to increment a first fluid displayed volume by the monitored volume
when the second fluid is driven at the first rate along the second flow path and increment
a second fluid displayed volume by the monitored volume when the monitored volume is
equal to or greater than an internal volume of the common line.

38. The infusion pump system of claim 31 wherein the infusion pump being operable to switch from the first flow path to a second flow path further comprises the infusion pump being operable to stop infusing the first fluid before driving the second fluid at the first rate along the second flow path.

39. The infusion pump system of claim 38 wherein the infusion pump being operable to switch from the first flow path to a second flow path further consists of one of the infusion pump being operable to detect a given threshold of air in the first fluid path as a trigger to stop infusing the first fluid before the driving the second fluid at the first rate along the second flow path and the infusion pump being operable to detect a VTBI complete signal as the trigger.

40. An infusion pump, the infusion pump being operably connected to a common line in fluid communication with a junction and having a terminal fluid delivery end, the junction being in fluid communication with a first reservoir containing a first fluid and a second reservoir containing a second fluid, the infusion pump comprising:

a memory operable to store programming code;

a flow controller operably connected to the memory; and

a fluid driver operably connected to receive a control signal from the flow controller, the fluid driver being operable to drive fluid through the common line;

wherein the flow controller is operable to execute the programming code and provide the control signal to the fluid driver in response to the programming code;

wherein the fluid driver is responsive to the control signal to:

infuse the first fluid at a first rate along a first flow path including the first reservoir, the junction, and the common line;

receive a common line flush volume value for the common line;

switch from the first flow path to a second flow path including the second reservoir, the junction, and the common line;

drive the second fluid at the first rate along the second flow path;

monitor volume of the second fluid driven at the first rate; and

drive the second fluid at a second rate along the second flow path when the monitored volume is equal to or greater than the common line flush volume value.

41.   The infusion pump of claim 40 wherein the fluid driver being responsive to the control signal to receive a common line flush volume value for the common line further comprises the fluid driver being responsive to the control signal to receive the second rate.

42.   The infusion pump of claim 40 wherein the fluid driver being responsive to the control signal to receive a common line flush volume value for the common line comprises the fluid driver being responsive to the control signal to receive the common line flush volume value for the common line automatically from a drug library.

43.   The infusion pump of claim 42 wherein the fluid driver is further responsive to the control signal to increment a first fluid displayed volume by the monitored volume when the second fluid is driven at the first rate along the second flow path and to increment a second fluid displayed volume by the monitored volume when the monitored volume is equal to or greater than an internal volume of the common line.

44.   The infusion pump of claim 42 wherein the fluid driver being responsive to the control signal to switch from the first flow path to a second flow path further comprises the fluid driver being responsive to the control signal to stop infusing the first fluid before driving the second fluid at the first rate along the second flow path.
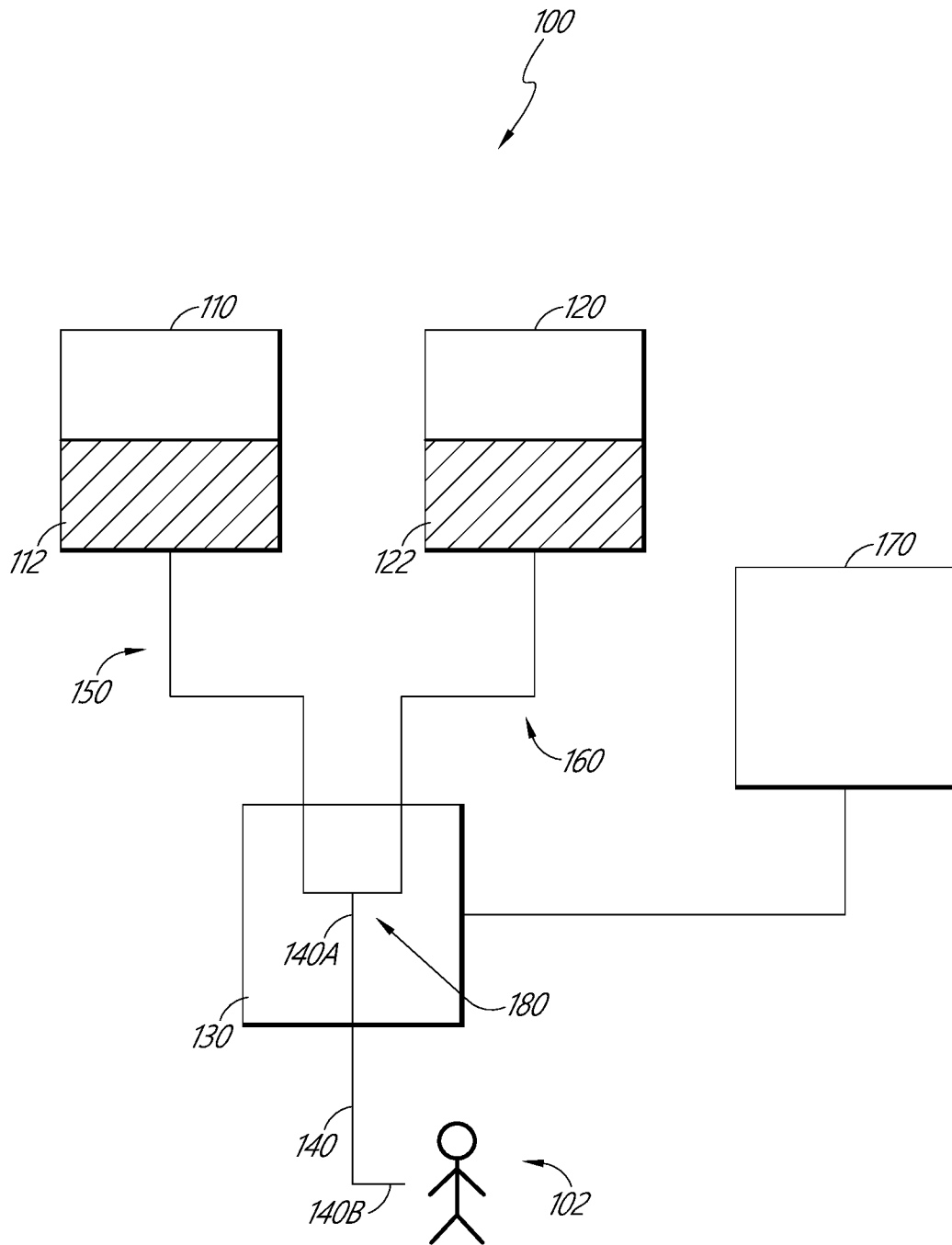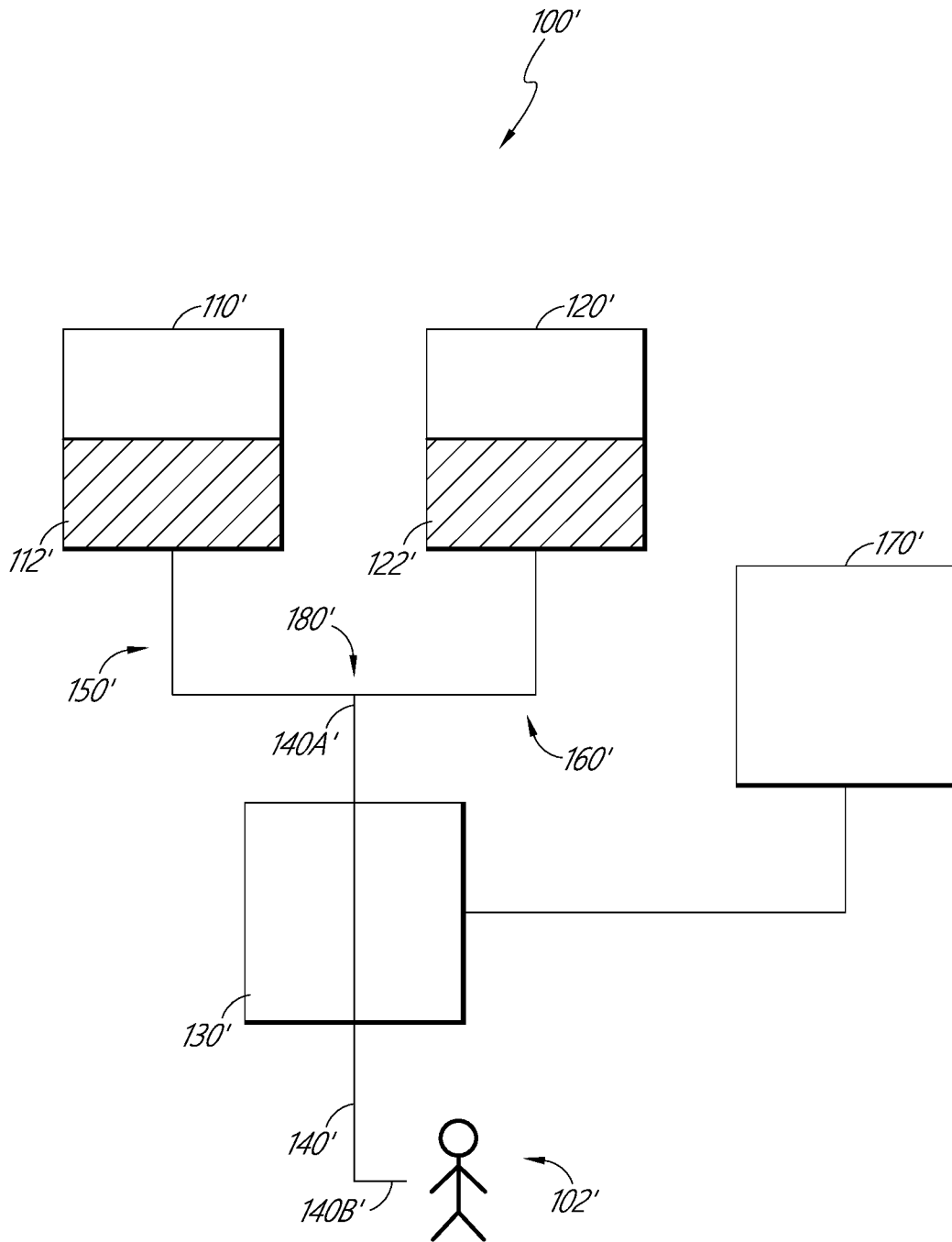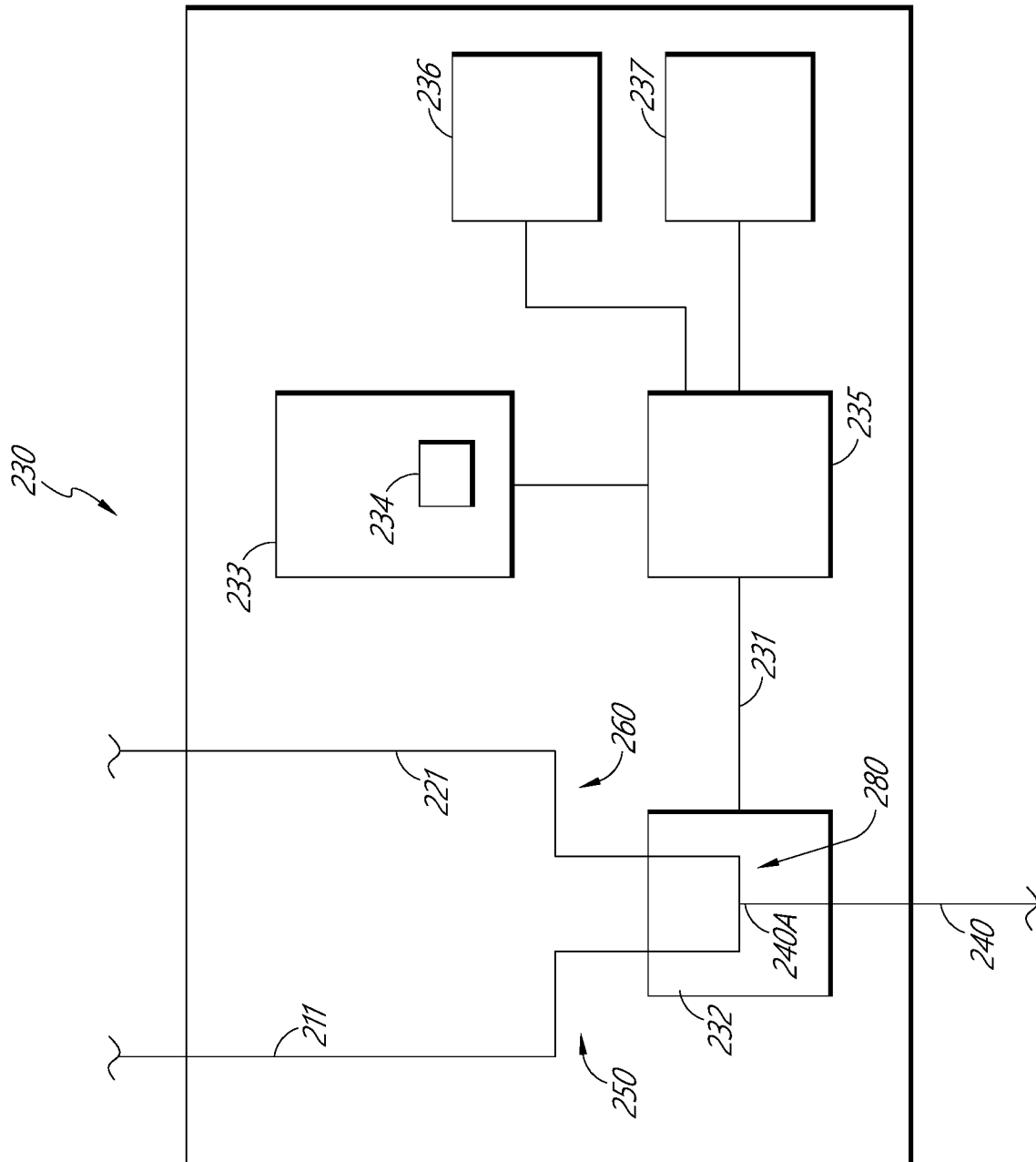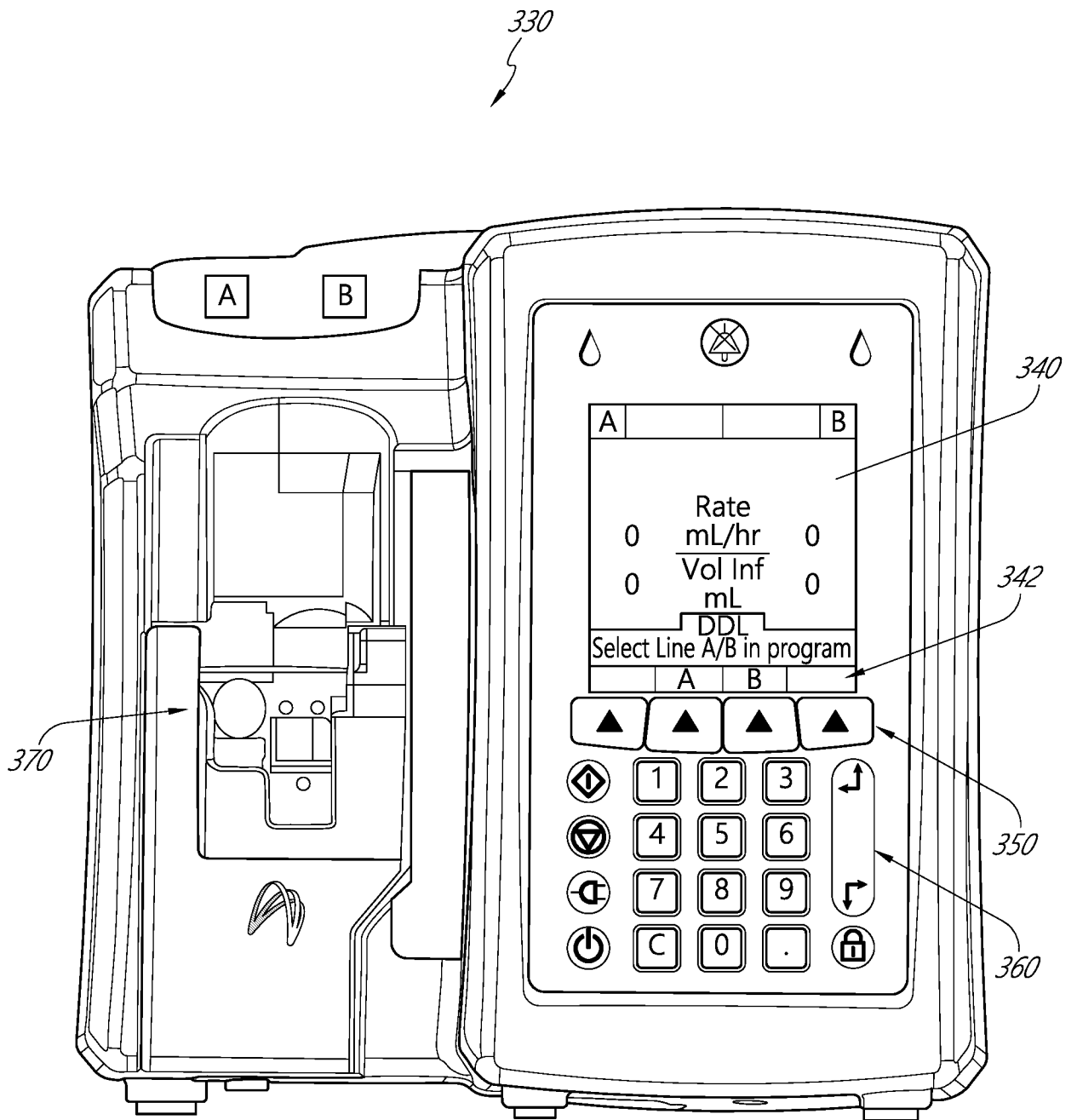
FIG. 1A

FIG. 1B

FIG. 2

FIG. 3

S33		
A	Oncology (1 of 3)	
	Change CCA	
No Drug Selected		
DOPamine	40mg/500mL	
Felicium	25mg/750mL	
Metazine	25mg/20mL	
locaine	30mg/30mL	
NIVOlumab	100mg/510mL	
Normal Sanine	100mL	
Select then press to Choose		
Press 0-9 to Sort this list		
Page Up	Page Down	Choose	Previous Screen

FIG. 4B

S22		B
A		
0	Rate mL/hr	0
0	Vol Inf mL	0
Callback	Oncology	Piggyback
Press A to Cancel Standby		
Select STOP key to Clear?		
Standby	A	B	Settings/ Vols/CCA

FIG. 4A

440

S30		
A	Program	
	Normal Saline 100mL	
Container Volume 100mL		
Rate		0 mL/hr
VTBI		0 mL
Duration		00:00 hh:min
Callback Oncology Piggyback		
START confirmation		Return to A/B
Delay		

FIG. 4C

440

S30		
A	Program	
	Normal Saline 100mL	
Container Volume 100mL		
Rate		125 mL/hr
VTBI		100 mL
Duration		00:48 hh:min
Callback Oncology Piggyback		
START confirmation		Return to A/B
Delay		

FIG. 4D

440

S22	A	PUMPING		B
	Normal Saline			

Dose

125   Rate   0
          mL/hr

0   Vol Inf   0
          mL

Callback   Oncology   Piggyback

Press A to Cancel Standby
Select STOP key to Clear?

Standby	A	B	Settings/Vols/CCA

FIG. 4F

440

S43	A		Confirm Program	

Normal Saline

Container Volume   100mL

Rate   125 mL/hr
VTBI   100 mL
Duration   00:48 hh:min

Callback   Oncology   Piggyback

Yes   Start delivery   No   Edit

Yes			No

FIG. 4E

440

| S30	Program	B
	NIVOlumab	

Conc   100 mg 510 mL
Weight   50 kg

Dose   0 mcg/kg/min
Rate   0 mL/hr
VTBI   0 mL
Duration 00:00 hh:min

Callback   Oncology   Piggyback

START confirmation
Flush Line: To flush line when Complete

| Delay | | | Return to A/B |

FIG. 4H

440

S39	Oncology (1 of 3)	B
	Change CCA	

No Drug Selected

Ephemerol   1mg/10mL
DOPamine   40mg/500mL
Felicium   25mg/750mL
Metazine   25mg/20mL
locaine   30mg/30mL
NIVOlumab   100mg/510mL

Select then press to Choose
Press 0-9 to Sort this list

| Page Up | Page Down | Choose | Previous Screen |

FIG. 4G

_440_

S146	Flush Volume		
A	Normal Saline		
Rate			375 mL/hr
Flush Volume			0 mL
Duration			00:00 hh:min
Maximum Flush Volume			30 mL
Enter Value			Cancel

FIG. 4J

_440_

S30	Program		B
	NIVOlumab		
Conc	100 mg 510 mL		
Weight	50 kg		
Dose			100 mcg/kg/min
Rate			375 mL/hr
VTBI			500 mL
Duration	01:20 hh:min		
Callback	Oncology		Piggyback
START confirmation			
Flush Line: To flush line when Complete			
Delay	Auto Flush		Return to A/B

FIG. 4I

440

S43		
A	Confirm Program	B
	Normal Saline	NIVOlumab
	Flush Solution	400mg 500mL
Weight	50 kg	
Dose		100 mcg/kg/min
Rate		375 mL/hr
VTBI		500 mL (20 mL Flush)
Duration		01:20 hh:min
Callback	Oncology	Piggyback
Yes Start delivery No Edit		
Yes	Standby	No

FIG. 4L

440

S146		
A	Flush Volume	
	Normal Saline	
Rate		375 mL/hr
Flush Volume		20 mL
Duration		00:00 hh:min
Maximum Flush Volume		30 mL
Enter Value		
		Cancel

FIG. 4K

S22	A	FLUSH	STOPPED	B
	Normal Saline		NIVOlumab	
			400mg 500mL	
		Dose	100 mcg/kg/min	
	375	Rate mL/hr	0	
	3	Vol Inf mL	500	
	Callback		Piggyback	
	Select STOP key to Clear?			
	Standby	A	B	Settings/Vols/CCA

440

FIG. 4N

S22	A	PENDING	PUMPING	B
	Normal Saline		NIVOlumab	
			100mg 510mL	
		Dose	100 mcg/kg/min	
	125	Rate mL/hr	375	
	3	Vol Inf mL	0	
	Callback	Oncology	Piggyback	
	Select STOP key to Clear?			
	Standby	A	B	Settings/Vols/CCA

440

FIG. 4M

440

A	PUMPING	STOPPED	B

Normal Saline

NIVOlumab
400mg 500mL

Dose   100
mcg/kg/min

125   Dose   0

Rate
mL/hr

23   Vol Inf   500
mL

Callback   Piggyback

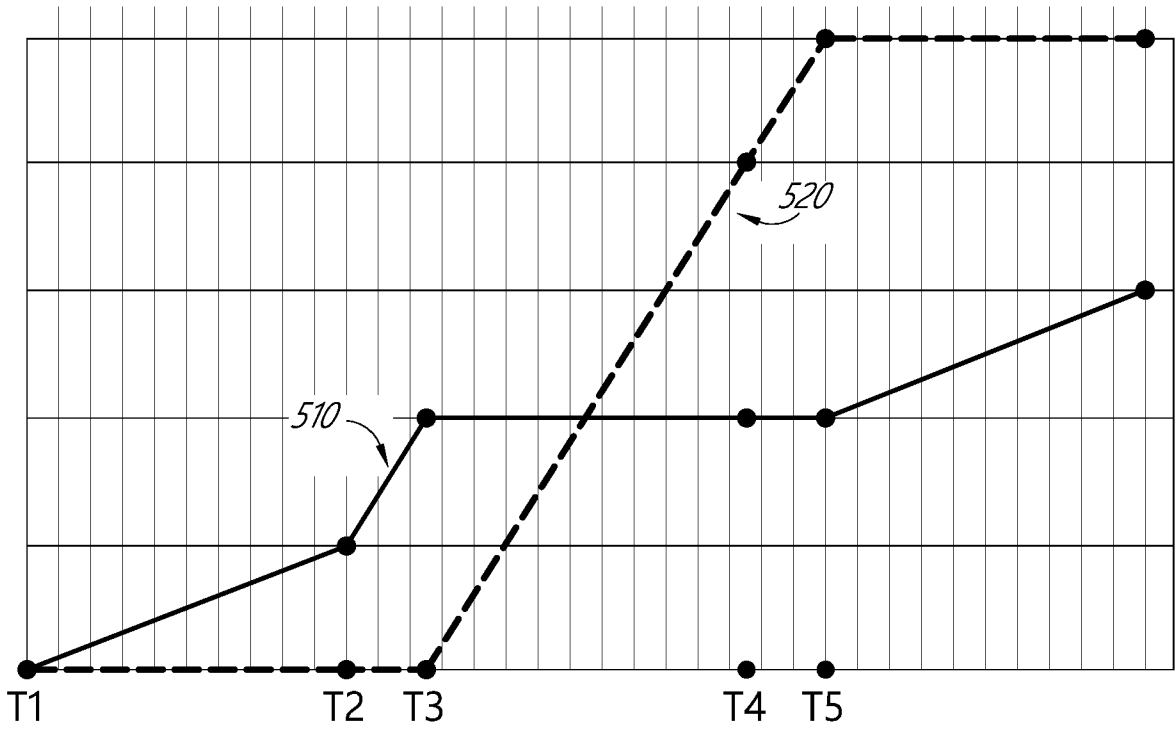Select STOP key to Clear?

Standby	A	B	Settings/Vols/CCA

FIG. 4O

FIG. 5A

FIG. 5B

600

Infusing the first fluid at a
first rate
602

Entering a common line flush
volume value
604

Switching from the first flow path
to a second flow path
606

Driving the second fluid at the
first rate
608

Monitoring volume of the
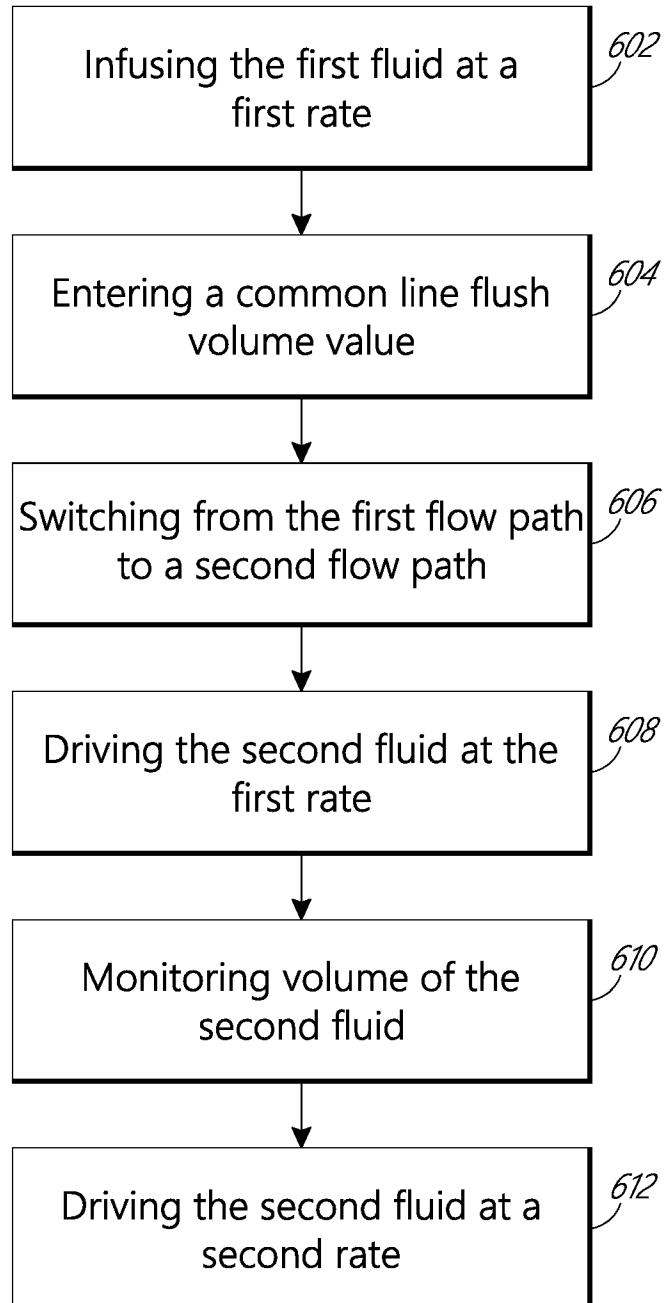second fluid
610

Driving the second fluid at a
second rate
612
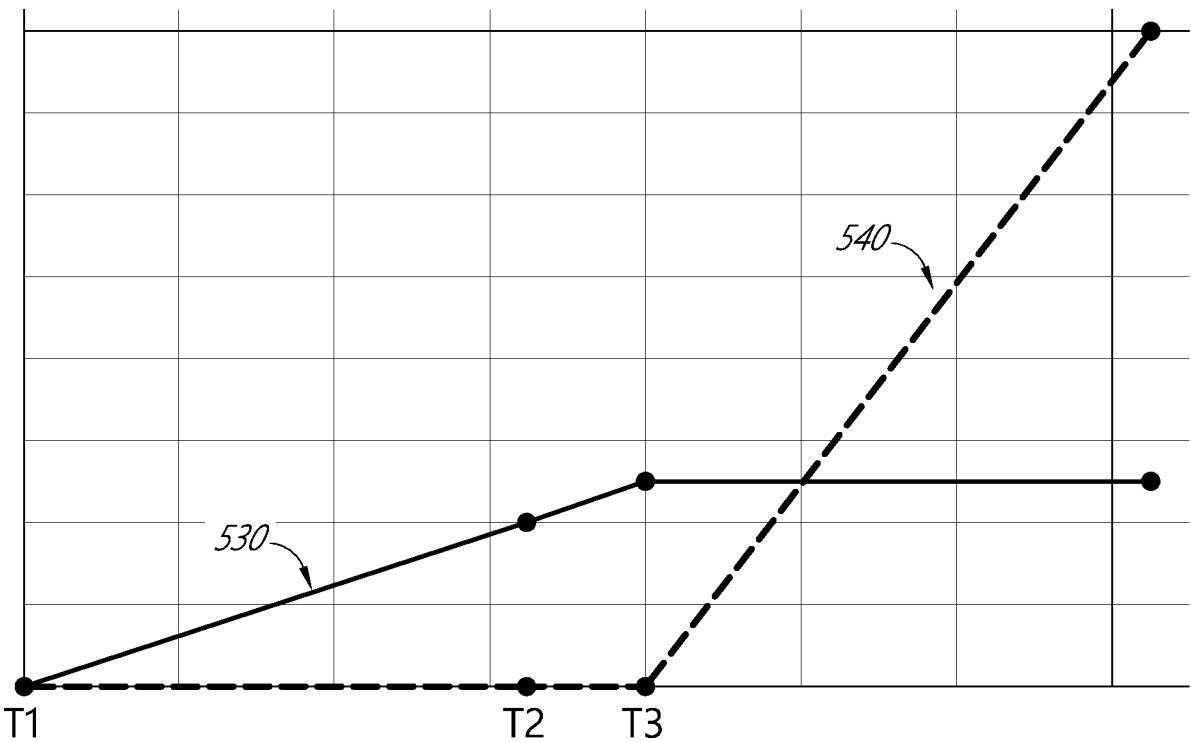
FIG. 6
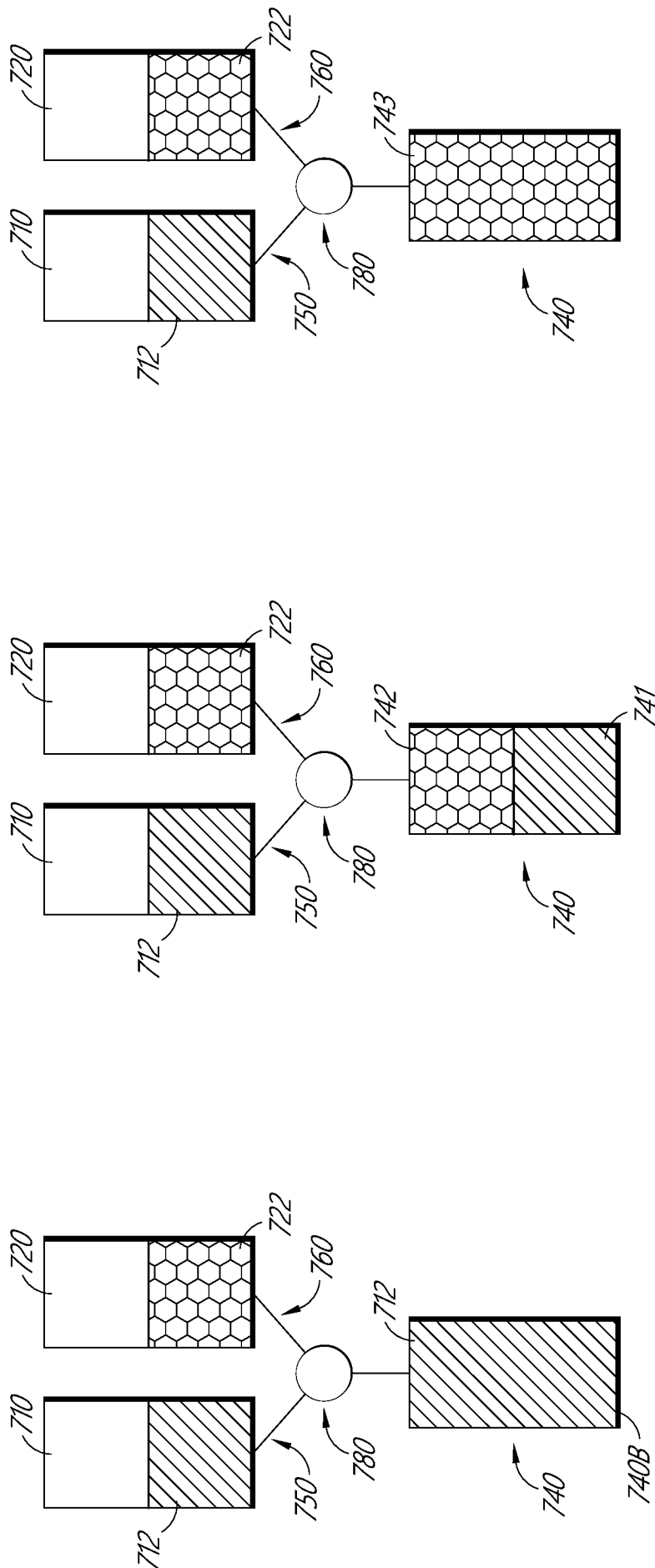
FIG. 7A

FIG. 7B

FIG. 7C
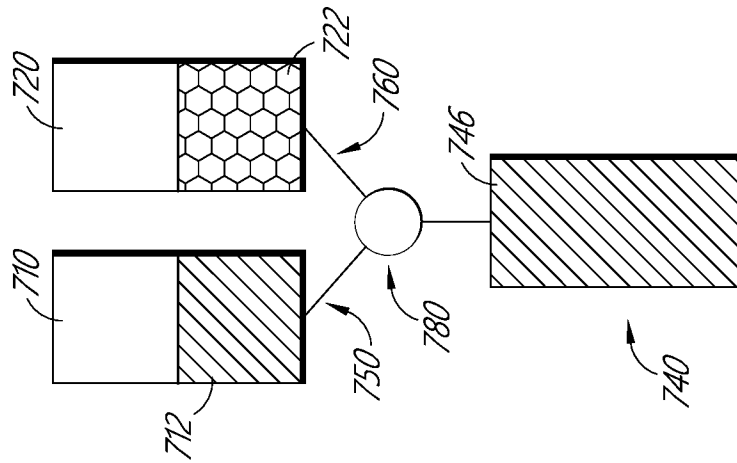
FIG. 7E
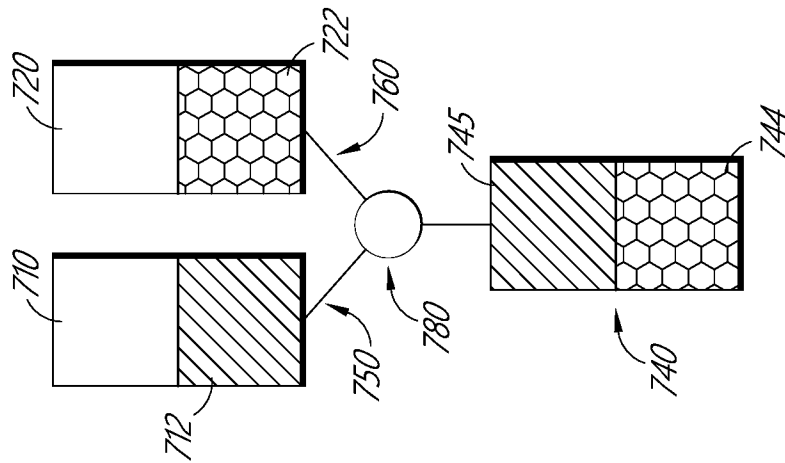
FIG. 7D

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A61M5/14, A61M5/142, A61M5/145, A61M5/168, A61M5/172 (2017.01)

CPC -
A61M5/14, A61M5/1407, A61M5/1409, A61M5/145, A61M5/168, A61M5/16804, A61M5/16827, A61M5/16877, G06F19/3468

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

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

See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---------------- Y	US 5,304,126 A (EPSTEIN, P et al.) 19 April 1994; figures 1, 3A-B; column 2, lines 3-9; column 5, lines 41-68; column 6, lines 1-9, 34-68; column 7, lines 48-58; column 8, lines 5-29, 53-68; column 9, lines 1-36, 54-68; column 10, lines 1-14, 62-68; column 11, lines 1-10, 22-28, 56-68; column 20, lines 57-68; column 22, lines 21-46	1-3,5-8,9/1-9/3,9/5-9/8,10 /9/1-10/9/3,10/9/5-10/9/8, 11, 12, 31-34, 37-41 ------------------------------- 4, 9/4, 10/9/4, 13-30, 35, 36, 42-44
Y	WO 2015/134478 A1 (SMITHS MEDICAL ASD, INC.) 11 September 2015; page 7, lines 22-28; page 10, lines 6-15; page 14, lines 8-17; page 17, lines 1-13	4, 9/4, 10/9/4, 16, 21/16, 22/21/16
Y	US 2008/0177254 A1 (SHELTON, B et al.) 24 July 2008; figure 4; paragraphs 5, 22-24	13-30
Y	US 2015/0025453 A1 (LEDFORD, R et al.) 22 January 2015; paragraphs 7, 23, 25, 29, 41, 44	28, 35, 36, 42-44
A	US 4,705,506 A (ARCHIBALD, G) 10 November 1987; entire document	1-44
A	US 2006/0064053 A1 (BOLLISH, S et al.) 23 March 2006; entire document	1-44
A	US 2008/0119822 A1 (KNAUPER, C) 22 May 2008; entire document	1-44

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

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"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 July 2017 (20.07.2017)	1 4 AUG 2017

Name and mailing address of the ISA/	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774