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(54) Title: PRELOADING OF CONTRAST INJECTION PROTOCOLS INTO THE ADMINISTRATION LINE

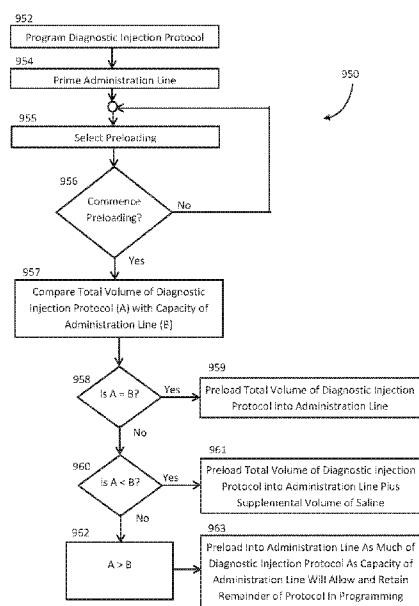


FIG. 9

(57) Abstract: A fluid injector system includes a control device operably associated with at least one drive component for use in actuating a plurality of fluid containers in fluid communication with a patient through an administration line. The control device includes at least one processor programmed or configured to enable programming of a diagnostic injection protocol comprising one or more phases according to which at least one of the first and the second fluid containers are selectively actuatable by the at least one drive component to enable injection of at least one of a first fluid and a second fluid into the patient. The control device is further programmed or configured to enable selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
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PRELOADING OF CONTRAST INJECTION PROTOCOLS INTO THE ADMINISTRATION LINE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/655,368, filed on April 10, 2018, the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE DISCLOSURE

Field of the Disclosure

[0002] The present disclosure relates to a fluid injector system having a control device for enabling at least a partial preloading into an administration line of at least one of a first fluid and a second fluid in accordance with one or more phases of a diagnostic injection protocol. The present disclosure also relates to a computer program product and a computer-implemented method of enabling at least a partial preloading into the administration line of the first and/or second fluids in accordance with one or more phases of a diagnostic injection protocol of the type capable of being carried out by such a fluid injector system.

Description of the Related Art

[0003] In many medical diagnostic and therapeutic procedures, a medical practitioner, such as a physician, injects a patient with one or more medical fluids. In recent years, a number of medical fluid delivery systems for pressurized injection of fluids, such as a contrast solution (often referred to simply as “contrast”), a flushing agent, such as saline, and other medical fluids, have been developed for use in procedures such as angiography, computed tomography (CT), ultrasound, magnetic resonance imaging (MRI), positron emission tomography (PET), and other molecular imaging procedures. In general, these medical fluid delivery systems are designed to deliver a preset amount of fluid at a preset flow rate.

[0004] A medical fluid delivery system is generally connected to the patient via an administration line. The administration line, however, must be primed with fluid to remove or flush air from the administration line before being attached to the patient to remove air from the administration line. Once the air is removed, the fluid remains in the administration line and is ready to be injected into the patient during the initial stage of the injection procedure. Medical fluid delivery systems are generally calibrated to account for the fluid volume of the administration line and thereby ensure that the proper amount of medical fluid is injected into the patient despite the initial volume of the fluid used to prime the line.

However, the relatively large diameter and length of some administration lines results may result in a significant amount of extra fluid being injected into the patient. Particularly if the patient is a child, the volume of the fluid used to prime the administration line may represent a clinically significant amount of fluid relative to the patient's body size and blood volume. Certain adult patients may also be particularly sensitive to the injection of extra fluid for a variety of clinical reasons. Additionally, the volume of the fluid used for priming the administration line may represent a significant amount of the total fluid delivered. Particularly, in MRI procedures, where the total volume of contrast solution may be as low as 2 to 5 milliliters (ml), a typical administration line volume of 8 ml may result in the injection of well over twice the amount of flushing/priming fluid as contrast solution.

SUMMARY OF THE DISCLOSURE

[0005] In view of the foregoing, there exists a need for methods of operating medical fluid delivery systems without delivering unnecessary fluids to a patient.

[0006] The present disclosure is generally directed to systems, methods, and computer program products for enabling at least partial preloading into an administration line of a fluid injector system in accordance with one or more phases of a diagnostic injection protocol.

[0007] In accordance with some aspects and examples of the present disclosure, fluid injector system may include a control device operably associated with at least one drive component for use in actuating a plurality of fluid containers. The plurality of fluid containers may be capable of being placed in fluid communication with a patient through an administration line with a first of the fluid containers capable of being filled with a first fluid including a contrast solution and a second of the fluid containers capable of being filled with a second fluid including a flushing agent. The control device may include at least one processor programmed or configured to enable programming of a diagnostic injection protocol comprising one or more phases according to which at least one of the first and the second fluid containers are selectively actuatable by the at least one drive component to enable injection of at least one of the first fluid and the second fluid via the administration line into the patient so as to effect enhancement of at least one region of interest thereof over a scan duration of a diagnostic imaging procedure. The control device may be further programmed or configured to, upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enable selection and commencement of at least partial preloading into the administration line of at

least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0008] In accordance with some aspects and examples of the present disclosure, the fluid injector system may further include a user interface operably associated with the at least one processor. The user interface may be configured to accept a plurality of user inputs associated with control of a plurality of operations of the fluid injector system. A set of the plurality of user inputs may be associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0009] In accordance with some aspects and examples of the present disclosure, the set of the plurality of user inputs may include: a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line; a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

[0010] In accordance with some aspects and examples of the present disclosure, the control device may be further programmed or configured to calculate a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol. As such, upon entry of the commence preloading command into the user interface, the control device, upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the administration line a volume of the second fluid used in the priming of the administration line therewith. The control device, upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection

protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith. The control device, upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line as much of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

[0011] In accordance with some aspects and examples of the present disclosure, the user interface may be configured to display information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0012] In accordance with some aspects and examples of the present disclosure, the user interface may be configured to display at least one of a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol, and for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

[0013] In accordance with some aspects and examples of the present disclosure, the first of the fluid containers may include a syringe and the second of the fluid containers may include a syringe.

[0014] In accordance with some aspects and examples of the present disclosure, a computer program product is disclosed for enabling at least partial preloading into an administration line of at least one of a first fluid and a second fluid in accordance with a one or more phases of a diagnostic injection protocol. The computer program product may include at least one non-transitory computer-readable medium including one or more

instructions that, when executed by at least one processor, cause the at least one processor to enable programming of the diagnostic injection protocol into a control device of a fluid injector system. The control device may be operably associated with at least one drive component for use in selectively actuating a plurality of fluid containers. The plurality of fluid containers may be capable of being placed in fluid communication with a patient through the administration line with a first of the fluid containers capable of being filled with the first fluid including a contrast solution and a second of the fluid containers capable of being filled with the second fluid including a flushing agent. The one or more instructions, when executed by at least one processor, may further cause the at least one processor to, upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enable selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0015] In accordance with some aspects and examples of the present disclosure, the one or more instructions, when executed by at least one processor, may further cause the at least one processor to receive, from a user interface operably associated with the at least one processor, at least one of a plurality of user inputs associated with control of a plurality of operations of the fluid injector system. A set of the plurality of user inputs may be associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0016] In accordance with some aspects and examples of the present disclosure, the set of the plurality of user inputs includes: a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line; a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

[0017] In accordance with some aspects and examples of the present disclosure, the one or more instructions, when executed by at least one processor, may further cause the at least one processor to calculate a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol. As such, upon entry of the commence preloading command into the user interface, the at least one processor, upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the administration line a volume of the second fluid used in the priming of the administration line therewith. The at least one processor, upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith. The at least one processor, upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line as much of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

[0018] In accordance with some aspects and examples of the present disclosure, the one or more instructions, when executed by at least one processor, may further cause the at least one processor to display, via the user interface, information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0019] In accordance with some aspects and examples of the present disclosure, the one or more instructions, when executed by at least one processor, may further cause the at least one processor to display, via the user interface, at least one of a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol, and for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

[0020] In accordance with some aspects and examples of the present disclosure, the first of the fluid containers may include a syringe and the second of the fluid containers may include a syringe.

[0021] In accordance with some aspects and examples of the present disclosure, a computer-implemented method is disclosed for enabling at least partial preloading into an administration line of at least one of a first fluid and a second fluid in accordance with a one or more phases of a diagnostic injection protocol. The method includes programming, via at least one processor, the diagnostic injection protocol into a control device of a fluid injector system, the control device operably associated with at least one drive component for use in selectively actuating a plurality of fluid containers. The plurality of fluid containers may be capable of being placed in fluid communication with a patient through an administration line with a first of the fluid containers capable of being filled with the first fluid including a contrast solution and a second of the fluid containers capable of being filled with the second fluid including a flushing agent. The method further includes, upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enabling, via the at least one processor, selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0022] In accordance with some aspects and examples of the present disclosure, the method may further include receiving, from a user interface operably associated with the at least one processor, at least one of a plurality of user inputs associated with control of a plurality of operations of the fluid injector system. A set of the plurality of user inputs may be associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0023] In accordance with some aspects and examples of the present disclosure, the set of the plurality of user inputs may include: a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line; a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

[0024] In accordance with some aspects and examples of the present disclosure, the method may further include calculating, with the at least one processor, a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol. As such, upon entry of the commence preloading command into the user interface, the control device, upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the administration line a volume of the second fluid used in the priming of the administration line therewith.. The control device, upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith. The control device, upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the

administration line as much of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

[0025] In accordance with some aspects and examples of the present disclosure, the method may further include displaying, with the user interface, information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0026] In accordance with some aspects and examples of the present disclosure, the method may further include displaying, with the user interface, at least one of: a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol; and for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

[0027] In accordance with some aspects and examples of the present disclosure, the first of the fluid containers may include a syringe and the second of the fluid containers may include a syringe.

[0028] Further examples of the present disclosure are described in the following non-limiting clauses:

[0029] Clause 1. A fluid injector system comprising: a control device operably associated with at least one drive component for use in actuating a plurality of fluid containers, the plurality of fluid containers capable of being placed in fluid communication with a patient through an administration line with a first of the fluid containers capable of being filled with a first fluid comprising a contrast solution and a second of the fluid containers capable of being filled with a second fluid comprising a flushing agent; and the control device including at least one processor programmed or configured to enable programming of a diagnostic injection protocol comprising one or more phases according to which at least one of the first and the second fluid containers are selectively actuatable by the at least one drive component to enable injection of at least one of the first fluid and the second fluid via the administration line into the patient so as to effect enhancement of at least

one region of interest thereof over a scan duration of a diagnostic imaging procedure; wherein the control device is further programmed or configured to, upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enable selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0030] Clause 2. The fluid injector system of clause 1, further including a user interface operably associated with the at least one processor, the user interface being configured to accept a plurality of user inputs associated with control of a plurality of operations of the fluid injector system, wherein a set of the plurality of user inputs is associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0031] Clause 3. The fluid injector system of clause 1 or 2, wherein the set of the plurality of user inputs includes: a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line; a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

[0032] Clause 4. The fluid injector system of any of clauses 1-3, wherein the control device is further programmed or configured to calculate a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol such that, upon entry of the commence preloading command into the user interface, the control device: upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the

administration line a volume of the second fluid used in the priming of the administration line therewith; upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith; and upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line as much of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

[0033] Clause 5. The fluid injector system of any of clauses 1-4, wherein the user interface is configured to display information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0034] Clause 6. The fluid injector system of any of clauses 1-5, wherein the user interface is configured to display at least one of: a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol; and for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

[0035] Clause 7. The fluid injector system of any of clauses 1-6, wherein the first of the fluid containers comprises a syringe and the second of the fluid containers comprises a syringe.

[0036] Clause 8. A computer program product for enabling at least partial preloading into an administration line of at least one of a first fluid and a second fluid in accordance with a one or more phases of a diagnostic injection protocol, the computer program product

comprising at least one non-transitory computer-readable medium comprising one or more instructions that, when executed by at least one processor, cause the at least one processor to: enable programming of the diagnostic injection protocol into a control device of a fluid injector system, the control device operably associated with at least one drive component for use in selectively actuating a plurality of fluid containers, the plurality of fluid containers capable of being placed in fluid communication with a patient through the administration line with a first of the fluid containers capable of being filled with the first fluid comprising a contrast solution and a second of the fluid containers capable of being filled with the second fluid comprising a flushing agent; and upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enable selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0037] Clause 9. The computer program product of clause 8, wherein the one or more instructions, when executed by at least one processor, further cause the at least one processor to: receive, from a user interface operably associated with the at least one processor, at least one of a plurality of user inputs associated with control of a plurality of operations of the fluid injector system, wherein a set of the plurality of user inputs is associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0038] Clause 10. The computer program product of clause 8 or 9, wherein the set of the plurality of user inputs includes: a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line; a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

[0039] Clause 11. The computer program product of any of clauses 8-10, wherein the one or more instructions, when executed by at least one processor, further cause the at least one processor to: calculate a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol such that, upon entry of the commence preloading command into the user interface, the at least one processor: upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the administration line a volume of the second fluid used in the priming of the administration line therewith; upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith; and upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line as much of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

[0040] Clause 12. The computer program product of any of clauses 8-11, wherein the one or more instructions, when executed by at least one processor, further cause the at least one processor to: display, via the user interface, information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0041] Clause 13. The computer program product of any of clauses 8-12, wherein the one or more instructions, when executed by at least one processor, further cause the at least one processor to: display, via the user interface, at least one of: a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol; and for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

[0042] Clause 14. The computer program product of any of clauses 8-13, wherein the first of the fluid containers comprises a syringe and the second of the fluid containers comprises a syringe.

[0043] Clause 15. A computer-implemented method for enabling at least partial preloading into an administration line of at least one of a first fluid and a second fluid in accordance with a one or more phases of a diagnostic injection protocol, the method comprising: programming, with at least one processor, the diagnostic injection protocol into a control device of a fluid injector system, the control device operably associated with at least one drive component for use in selectively actuating a plurality of fluid containers, the plurality of fluid containers capable of being placed in fluid communication with a patient through an administration line with a first of the fluid containers capable of being filled with the first fluid comprising a contrast solution and a second of the fluid containers capable of being filled with the second fluid comprising a flushing agent; and upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enabling, with at least one processor, selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0044] Clause 16. The computer-implemented method of clause 15, further comprising: receiving, from a user interface operably associated with the at least one processor, at least one of a plurality of user inputs associated with control of a plurality of operations of the fluid injector system, wherein a set of the plurality of user inputs is associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0045] Clause 17. The computer-implemented method of clause 15 or 16, wherein the set of the plurality of user inputs includes: a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line; a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

[0046] Clause 18. The computer-implemented method of any of clauses 15-17, further comprising: calculating, with the at least one processor, a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol such that, upon entry of the commence preloading command into the user interface, the control device: upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the administration line a volume of the second fluid used in the priming of the administration line therewith; upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith; and upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line as much of the at least one

of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

[0047] Clause 19. The computer-implemented method of any of clauses 15-18, further comprising: displaying, with the user interface, information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

[0048] Clause 20. The computer-implemented method of any of clauses 15-19, further comprising: displaying, with the user interface, at least one of: a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol; and for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

[0049] Clause 21. The computer-implemented method of any of clauses 15-20, wherein the first of the fluid containers comprises a syringe and the second of the fluid containers comprises a syringe.

[0050] These and other features and characteristics of fluid injector systems, as well as computer program products and methods of operation and functions of the related elements of structures and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims with reference to the accompanying drawings, all of which form a part of this specification. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only.

BRIEF DESCRIPTION OF THE DRAWINGS

[0051] **FIG. 1** is a perspective view of a multi-fluid delivery system, according to one example;

[0052] **FIG. 2** is schematic view of various fluid paths within the multi-fluid delivery system of **FIG. 1**;

[0053] FIG. 3A is a perspective view of a connection interface prior to connecting a single-use disposable set (SUDS) connector with a multi-fluid delivery system;

[0054] FIG. 3B is a perspective view of the connection interface of FIG. 3A showing the SUDS connector connected with the multi-fluid delivery system;

[0055] FIG. 4A is an enlarged, perspective view of the SUDS connector shown in FIGS. 3A and 3B;

[0056] FIG. 4B is a longitudinal cross-sectional view of the SUDS connector shown in FIG. 4A;

[0057] FIG. 4C is a partial cross-sectional view of the SUDS connector shown in FIGS. 4A-4B connected to a port of a multi-fluid delivery system;

[0058] FIG. 5 is a perspective view of the SUDS connector shown in FIG. 4C with a portion of the multi-fluid delivery system and a multi-patient disposable set (MUDS) connected thereto cutaway;

[0059] FIG. 6 is a schematic view of an electronic control system of a multi-fluid delivery system in accordance with another example;

[0060] FIG. 7A is a schematic diagram of a partially preloaded single-use disposable set connector in accordance with one example;

[0061] FIG. 7B is a schematic diagram of a fully preloaded single-use disposable set connector in accordance with the example of FIG. 7A;

[0062] FIG. 8 is a schematic diagram of a fully preloaded single-use disposable set connector in accordance with another example; and

[0063] FIG. 9 is a flow chart illustrating a method of showing a preloading operation in accordance with one example.

DETAILED DESCRIPTION

[0064] For purposes of the description hereinafter, the terms “upper”, “lower”, “right”, “left”, “vertical”, “horizontal”, “top”, “bottom”, “lateral”, “longitudinal”, and derivatives thereof shall relate to the disclosure as it is oriented in the drawing figures. When used in relation to a syringe of a multi-patient disposable set, the term “proximal” refers to a portion of a syringe nearest a piston element for delivering fluid from a syringe. When used in relation to a single-use disposable set connector, the term “distal” refers to a portion of a single-use disposable set connector nearest to a user or patient when a single-use disposable set connector is oriented for connecting with a multi-fluid injector system. When used in relation to a syringe of a fluid injector system, the term “distal” refers to a portion of a

syringe nearest to a delivery nozzle. When used in relation to a single-use disposable set connector, the term “proximal” refers to a portion of a single-use disposable set connector nearest to a multi-fluid injector system when a single-use disposable set connector is oriented for connecting with a multi-fluid injector system.

[0065] It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification, are simply exemplary examples of the disclosure. Hence, specific dimensions and other physical characteristics related to the examples disclosed herein are not to be considered as limiting.

[0066] Although the present disclosure is described primarily in the context of the MEDRAD® Centargo CT Injection System, it will be apparent to persons of ordinary skill in the art that the present invention can be applied to a variety of injection systems inclusive of their associated disposables (e.g., syringes, tubing, etc.). Examples of such injection systems include the MEDRAD® Stellant CT Injection System, the MEDRAD® Stellant FLEX CT Injection System, the MEDRAD® MRXperion MR Injection System and the MEDRAD® Mark 7 Arterion Injection System offered by Bayer HealthCare LLC.

[0067] Referring to the drawings in which like reference characters refer to like parts throughout the several views thereof, the present disclosure is generally directed to a multi-fluid medical injector/injection system **100** (hereinafter “fluid injector system **100**”) having a multi-patient disposable set (MUDS) **130** configured for delivering fluid to a patient using a single-use disposable set (SUDS) **190** connector. The fluid injector system **100** includes multiple components as individually described herein. Generally, the fluid injector system **100** has a powered injector or other administration device and a fluid delivery set intended to be associated with the injector to deliver one or more fluids from one or more multi-dose containers under pressure into a patient, as described herein. The various devices, components, and features of the fluid injector system **100** and the fluid delivery set associated therewith are likewise described in detail herein.

[0068] With reference to **FIG. 1**, the fluid injector system **100** includes an injector housing **102** having opposed lateral sides **104**, a distal or upper end **106**, and a proximal or lower end **108**. In some examples, the housing **102** may be supported on a base **110** having one or more wheels **112** for rotatable and movable support of the housing **102** on a floor surface. The one or more wheels **112** may be lockable to prevent the housing **102** from inadvertently moving once positioned at a desired location. At least one handle **114** may be provided to facilitate moving and positioning the fluid injector system **100**. In other examples, the housing **102** may be removably or non-removably secured to a fixed surface,

such as a floor, ceiling, wall, or other structure. The housing **102** encloses the various mechanical drive components, electrical and power components necessary to drive the mechanical drive components, and control components, such as electronic memory and electronic control devices (hereinafter electronic control device(s)), used to control operation of reciprocally movable piston elements **103** (shown in **FIG. 2**) associated with the fluid injector system **100** described herein. Such piston elements **103** may be reciprocally operable via electro-mechanical drive components such as a ball screw shaft driven by a motor, a voice coil actuator, a rack-and-pinion gear drive, a linear motor, and the like. In some examples, at least some of the mechanical drive components, electrical and power components, and control components may be provided on the base **110**.

[0069] With continued reference to **FIG. 1**, the fluid injector system **100** has at least one door **116** that encloses at least some of the MUDS, the mechanical drive components, electrical and power components, and control components. The door **116** is desirably movable between an open position and a closed position (shown in **FIG. 1**). In some examples, the door **116** may be lockable.

[0070] The fluid injector system **100** further includes at least one bulk fluid connector **118** for connection with at least one bulk fluid source **120**. In some examples, a plurality of bulk fluid connectors **118** may be provided. For example, as shown in **FIG. 1**, three bulk fluid connectors **118** may be provided in a side-by-side or other arrangement. In some examples, the at least one bulk fluid connector **118** may be a spike configured for removably connecting to the at least one bulk fluid source **120**, such as a vial, a bottle, or a bag. The at least one bulk fluid connector **118** may have a reusable or non-reusable interface with each new bulk fluid source **120**. The at least one bulk fluid connector **118** may be formed on the multi-patient disposable set, as described herein. The at least one bulk fluid source **120** may be configured for receiving a medical fluid, such as saline, contrast solution, or other medical fluid, for delivery to the fluid injector system **100**. The housing **102** may have at least one support member **122** for supporting the at least one bulk fluid source **120** once it is connected to the fluid injector system **100**.

[0071] With continued reference to **FIG. 1**, the fluid injector system **100** includes one or more user interfaces **124**, such as a graphical user interface (GUI) display window. The user interface **124** may display information pertinent to a fluid injection procedure involving fluid injector system **100**, such as current flow rate, fluid pressure, and volume remaining in the at least one bulk fluid source **120** connected to the fluid injector system **100** and may be a touch screen GUI that allows an operator to input commands and/or data for operation of fluid

injector system **100**. While the user interface **124** is shown on the injector housing **102**, such user interface **124** may also be in the form of a remote display that is wired or wirelessly linked to the housing **102** and control and mechanical elements of fluid injector system **100**. In some examples, the user interface **124** may be a tablet computer that is detachably connected to the housing **102** and is in wired or wirelessly linked communication with the housing **102** and control and mechanical elements of the fluid injector system **100**. Additionally, the fluid injector system **100** and/or user interface **124** may include at least one control button **126** for tactile operation by an attendant operator of the fluid injector system **100**. In certain examples, the at least one control button **126** may be part of a keyboard for inputting commands and/or data by the operator. The at least one control button **126** may be hard-wired to the electronic control device(s) associated with the fluid injector system **100** to provide direct input to the electronic control device(s). The at least one control button **126** may also be a graphical part of the user interface **124**, such as a touch screen. In either arrangement, the at least one control button **126** desirably provides certain individual control features to the attendant operator of the fluid injector system **100**, such as, but not limited to: (1) acknowledging that a multi-patient disposable set has been loaded or unloaded; (2) locking/unlocking of the multi-patient disposable set; (3) filling/purging of the fluid injector system **100**; (4) inputting information and/or data related to the patient and/or injection procedure; (5) preloading the fluid injector system **100**; and (6) initiating/stopping an injection procedure. The user interface **124** and/or any electronic processing units associated with the fluid injector system **100** may be wired or wirelessly connected to an operation and/or data storage system such as a hospital network system.

[0072] With reference to **FIG. 2**, the fluid injector system **100** includes a MUDS **130** that is removably connected to the fluid injector system **100** for delivering one or more fluids from the one or more bulk fluid sources **120** to the patient. Examples and features of the MUDS are further described in International Patent Application Publication No. WO 2016/112163, filed on January 7, 2016 and entitled “Multiple Fluid Delivery System with Multi-Use Disposable Set and Features Thereof”, the disclosure of which is incorporated herein by reference in its entirety. The MUDS **130** may include one or more syringes or pumps **132**. In some examples, the number of syringes **132** may correspond to the number of bulk fluid sources **120**. For example, with reference to **FIG. 2**, the MUDS **130** has three syringes **132** in a side-by-side arrangement such that each syringe **132** is fluidly connectable to one or more of the bulk fluid sources **120**. In some examples, one or two bulk fluid sources **120** may be connected to one or more syringes **132** of the MUDS **130**. Each syringe

132 may be fluidly connectable to one of the bulk fluid sources **120** by a corresponding bulk fluid connector **118** and an associated MUDS fluid path **134**. The MUDS fluid path **134** may have a spike element that connects to the bulk fluid connector **118**. In some examples, the bulk fluid connector **118** may be provided directly on the MUDS **130**.

[0073] With further reference to **FIG. 2**, the MUDS **130** is removably connectable to the housing **102** of the fluid injector system **100**. As will be appreciated by one having ordinary skill in the art, it may be desirable to construct at least a portion of the MUDS **130** from a clear medical grade plastic in order to facilitate visual verification that a fluid connection has been established with the fluid injector system **100**. Visual verification is also desirable for confirming that no air bubbles are present within various fluid connections. Alternatively, at least a portion of the MUDS **130** and/or door **116** may include windows (not shown) for visualization of the connection between various components. Various optical sensors (not shown) may also be provided to detect and verify the connections. Additionally, various lighting elements (not shown), such as light emitting diodes (LEDs), may be provided to actuate one or more optical sensors and indicate that a suitable connection has been established between the various components.

[0074] With specific reference to **FIG. 2**, a schematic view of various fluid paths of the fluid injector system **100** is provided. The MUDS **130** may include one or more valves **136**, such as stopcock valves, for controlling which medical fluid or combinations of medical fluids are withdrawn from the multi-dose bulk fluid source **120** and/or are delivered to a patient through each syringe **132**. In some examples, the one or more valves **136** may be provided on a distal end of the plurality of syringes **132** or on a manifold **148**. The manifold **148** may be in fluid communication via valves **136** and/or syringes **132** with a first end of the MUDS fluid path **134** that connects each syringe **132** to the corresponding bulk fluid source **120**. The opposing second end of the MUDS fluid path **134** may be connected to the respective bulk fluid connector **118** that is configured for fluidly connecting with the bulk fluid source **120**. Depending on the position of the one or more valves **136**, fluid may be drawn into the one or more syringes **132** or it may be delivered from the one or more syringes **132**. In a first position, such as during the filling of the syringes **132**, the one or more valves **136** are oriented such that fluid flows from the bulk fluid source **120** into the desired syringe **132** through a fluid inlet line **150**, such as a MUDS fluid path. During the filling procedure, the one or more valves **136** are positioned such that fluid flow through one or more fluid outlet lines **152** or manifold **148** is blocked. In a second position, such as during a fluid delivery procedure, fluid from one or more syringes **132** is delivered to the

manifold **148** through the one or more fluid outlet lines **152** or syringe valve outlet ports. During the delivery procedure, the one or more valves **136** are positioned such that fluid flow through one or more fluid inlet lines **150** is blocked. The one or more valves **136**, fluid inlet lines **150**, and/or fluid outlet lines **152** may be integrated into the manifold **148**. The one or more valves **136** may be selectively positioned to the first or second position by manual or automatic handling. For example, the operator may position the one or more valves **136** into the desired position for filling or fluid delivery. In other examples, at least a portion of the fluid injector system **100** is operable for automatically positioning the one or more valves **136** into a desired position for filling or fluid delivery based on input by the operator, as described herein.

[0075] With continued reference to **FIG. 2**, in some examples, the fluid outlet line **152** may also be connected to a waste reservoir **156** of the fluid injector system **100**. The waste reservoir **156** is desirably separate from the syringes **132** to prevent contamination. In some examples, the waste reservoir **156** is configured to receive waste fluid expelled from the syringes **132** during, for example, a flushing, priming, or preloading operation. The waste reservoir **156** may be removable from the housing **102** in order to dispose of the contents of the waste reservoir **156**. In other examples, the waste reservoir **156** may have a draining port (not shown) for emptying the contents of the waste reservoir **156** without removing the waste reservoir **156** from the housing **102**. In some examples, the waste reservoir **156** is provided as a separate component from the MUDS **130**.

[0076] Having generally described the components of the fluid injector system **100** and the MUDS **130**, the structure and method of use of a single-use disposable set (SUDS) **190** and its interaction with MUDS **130** will now be described.

[0077] With reference to **FIGS. 3A and 3B**, the fluid injector system **100** has a connection port **192** that is configured to form a releasable fluid connection with at least a portion of the SUDS **190**. In some examples, the connection port **192** may be formed on the MUDS **130**. The connection port **192** may be shielded by at least a portion of the housing **102** of the fluid injector system **100**. For example, recessing the connection port **192** within the interior of the housing **102** may preserve the sterility of the connection port **192** by preventing or limiting a user or patient from touching and contaminating the portions of the connection port **192** that contact the fluid to be injected into the patient. In some examples, the connection port **192** is recessed within an opening **194** formed on the housing **102** of the fluid injector system **100**, or the connection port **192** may have a shielding structure (not shown) that surrounds at least a portion of the connection port **192**. In other examples, the

connection port **192** may be formed directly on the housing **102** and connected to the MUDS **130** by a fluid path (not shown). As described herein, the SUDS **190** may be connected to the connection port **192**, formed on at least a portion of the MUDS **130** and/or the housing **102**. Desirably, the connection between the SUDS **190** and the connection port **192** is a releasable connection to allow the SUDS **190** to be selectively disconnected from the connection port **192** (**FIG. 3A**) and connected to the connection port **192** (**FIG. 3B**). In some examples, the SUDS **190** may be disconnected from the connection port **192** and disposed after each fluid delivery procedure, and a new SUDS **190** may be connected to the connection port **192** for a subsequent fluid delivery procedure.

[0078] With continued reference to **FIGS. 3A and 3B**, a waste inlet port **196** may be provided separately from the connection port **192**. The waste inlet port **196** is in fluid communication with the waste reservoir **156**. In some examples, the waste reservoir **156** is provided separately from the SUDS **190** such that the fluid from the waste inlet port **196** can be delivered to the waste reservoir **156**. At least a portion of the SUDS **190** may be releasably connected to or associated with the waste inlet port **196** for introducing waste fluid into the waste reservoir **156** during, for example, a priming operation that expels air from the SUDS **190**. The waste reservoir **156** may have a viewing window **198** with indicia **200**, such as graduated markings, that indicate the fill level of the waste reservoir **156**.

[0079] With reference to **FIG. 4A**, the SUDS **190** has a fluid inlet port **202** that is configured for releasable connection with the connection port **192** (shown in **FIG. 3A**). The fluid inlet port **202** receives fluid delivered from the fluid injector system **100**. The fluid inlet port **202** is desirably a hollow, tubular structure, as shown in **FIG. 4B**. The SUDS **190** further has a waste outlet port **204** that is configured for releasable connection or association with the waste inlet port **196** (shown in **FIG. 3A**). The waste outlet port **204** receives waste fluid and delivers such waste fluid to the waste reservoir **156** during, for example, a priming or flushing operation of the SUDS **190**. The waste outlet port **204** is desirably a hollow, tubular structure, as shown in **FIG. 4B**. The waste outlet port **204** may be connected to, inserted into, or located in the waste inlet port **202** so that the waste fluid may flow through the waste inlet port **202** and continue into waste reservoir **156**. The fluid inlet port **202** and the waste outlet port **204** may be spaced apart from each other by a spacer **206**. In some examples, the spacer **206** is dimensioned to position the fluid inlet port **202** and the waste outlet port **204** for alignment with the connection port **192** and the waste inlet port **196**, respectively. It is noted that the SUDS **190** is shown in **FIG. 4A** in a state after removal from packaging (not shown). Prior to use, the SUDS **190** is desirably packaged in a pre-sterilized,

sealed package that protects the SUDS **190** from contamination with airborne or surface-borne contaminants. Alternatively, the sealed package and the SUDS **190** may be sterilized after packaging.

[0080] The SUDS **190** desirably has an asymmetrical structure, so that the user can only attach the SUDS **190** to the MUDS **130** in one orientation. In this manner, the user is prevented from attaching the fluid inlet port **202** to the waste inlet port **196**. In some examples, a fin **207** may be provided on at least a portion of the SUDS **190** to prevent erroneous insertion of the SUDS **190** in the connection port **192**. In certain examples, the fin **207** may be formed on the spacer **206** proximate to the waste outlet port **204**. In this manner, the fin **207** may interfere with the incorrect insertion of the SUDS **190** into the connection port **192**. Structures and shapes other than fin **207** may be used to prevent erroneous insertion of the SUDS **190** into connection port **192**.

[0081] In some examples, tubing **208**, also referred to as an administration line, may be connected at its proximal end **210** to the fluid inlet port **202**. The tubing **208** is configured to deliver fluid received from the fluid inlet port **202**. The distal end **212** of the tubing **208** may have a connector **214**, which may include a one-way check valve, that is configured for connection with the waste outlet port **204** or a fluid path connected to the patient (not shown). The tubing **208** may be made from a flexible material, such as a medical grade plastic material, that allows the tubing **208** to be coiled. The connector **214** may be a luer-lock connector (either a male luer-lock connector or a female luer-lock connector depending on the desired application) or other medical connector configuration. In some examples, the connector **214** may include at least one one-way check valve **280** therein, as shown in **FIG. 4C**, to prevent backflow of fluid. Alternatively, a one-way check valve may be located elsewhere in the SUDS **190** between fluid inlet port **202** and connector **214**.

[0082] With continued reference to **FIG. 4A**, the SUDS **190** may have a locking tab **216** that is configured for selectively locking the SUDS **190** with the fluid injector system **100** depending on the engagement of the locking tab **216** with at least a portion of the fluid injector system **100**. In some examples, the locking tab **216** may be a flexible tab that is deflectable between an engaged position and a disengaged position by deflecting at least a portion of the locking tab **216**. The locking tab **216** may have a pressing surface **218** that, when pressed, causes the locking tab **216** to be deflected from the engaged position to the disengaged position for insertion and removal of the SUDS **190** from the fluid injector system **100**. In some examples, the locking tab **216** may be configured for releasable locking engagement with a receiving slot **217** on the MUDS **130** (shown in **FIG. 4C**).

[0083] With reference to **FIG. 4B**, the SUDS **190** may have a first annular skirt **224** extending circumferentially around a proximal end **226** of the fluid inlet port **202** and a second annular skirt **220** extending circumferentially around a distal end **222** of the fluid inlet port **202**. The first and second annular skirts **224**, **220** surround the fluid inlet port **202** to prevent inadvertent contact and contamination. The first annular skirt **224** may have one or more recesses **228** (shown in **FIG. 4A**) extending through a sidewall thereof. The one or more recesses **228** may provide a locking interface with a corresponding locking element (not shown) on the fluid injector system **100**. The second annular skirt **220** may have at least one indentation **230** (shown in **FIG. 4A**) to facilitate grasping and handling of the SUDS **190**. In some examples, the second annular skirt **220** may have a textured surface having one or more ribs to facilitate gripping and handling of the SUDS **190**.

[0084] With continued reference to **FIG. 4B**, at least one annular seal **234** may be provided around the proximal end **226** of the fluid inlet port **202**. The at least one annular seal **234** may seal the fluid inlet port **202** to prevent fluid from leaking through the SUDS **190**. The at least one annular seal **234** may provide a fluid seal between the SUDS **190** and the MUDS **130** when they are fluidly connected with one another to allow fluid to flow from the MUDS **130** to the SUDS **190** without leaking. A one-way check valve **236** may be provided within a lumen of the fluid inlet port **202** to prevent fluid from flowing in a reverse direction from the SUDS **190** into the MUDS **130**.

[0085] With reference to **FIG. 4C**, the SUDS **190** shown in **FIG. 4A** is shown connected to the fluid injector system **100**. While **FIG. 4C** illustrates the connection port **192** formed on the MUDS **130**, in other examples, the connection port **192** may be formed on a portion of the housing **102** (shown in **FIG. 1**). The fluid inlet port **202** of the SUDS **190** is connected to the connection port **192** to establish a fluid path in a direction of arrow **F** shown in **FIG. 4C**. Fluid passing through the fluid inlet port **202** flows through the one-way valve **236** and into tubing **208**. Any fluid that may drip from the interface between the fluid inlet port **202** and the connection port **192** is collected in the waste reservoir **156**. The waste reservoir **156** may be shaped to collect any fluid that may drip from the SUDS **190** when it is removed from the MUDS **130**. Additionally, when the SUDS **190** is connected to the connection port **192**, the outlet of the waste outlet port **204** is positioned within the waste inlet port **196** such that waste fluid from the tubing **208** may be discharged into the waste reservoir **156**. The spacer **206** may define an insertion stop surface to define the depth of insertion of the SUDS **190** into the connection port **192**.

[0086] With reference to **FIG. 5**, the fluid injector system **100** may have a sensor system **238** adapted to identify when the SUDS **190** is in fluid communication with the MUDS **130**. The sensor system **238** may include at least one sensing element, such as a sensor fin **240**, on the SUDS **190** and a corresponding sensor **242** on the fluid injector system **100** or MUDS **130**. The sensor **242** may be configured to detect the presence and absence of the at least one sensor fin **240** or other sensing element. In some examples, the sensing element, such as the at least one sensor fin **240**, is formed on the locking tab **216** of the SUDS **190**, such as shown in **FIG. 4A**. In other examples, the sensing element, such as the at least one sensor fin **240**, may be formed on any portion of the SUDS **190**. The sensor **242** may be an optical sensor that is seated and secured within a respective mount formed on the housing **102** of the fluid injector system **100**. As will be appreciated by those versed in the field of powered medical fluid injectors, the sensor **242** may be electronically coupled to an electronic control device used to discretely control operation of the fluid injector system, such as the operation of the one or more piston elements, based, at least in part, on input from the sensor **242**. The sensing element, such as the sensor fin **240** may have one or more reflective surfaces that reflect visible or infrared light to be detected by the sensor **242**. In other examples, mechanical interaction between the sensing element and the sensor **242** may be used.

[0087] In some examples, the SUDS **190** may further include reuse prevention features. For example, the SUDS **190** may include one or more breakable sensor elements, tabs, or structures that fold or break when the SUDS **190** is removed from the MUDS **130**. Absence of these features may prevent reinsertion and reuse of the SUDS **190** after removal. In this manner, it can be assured that the SUDS **190** is only used for one fluid delivery procedure.

[0088] Other examples and features of the SUDS **190** are described in U.S. Patent Application Publication No. 2016/0331951, filed July 7, 2016 and entitled “Single-Use Disposable Set Connector”, the disclosure of which is incorporated herein by reference in its entirety.

[0089] Having generally described the components of the fluid injector system **100**, the MUDS **130**, and the SUDS **190**, a method of operation of using the SUDS **190** will now be described in detail. In use, a medical technician or user removes the disposable SUDS **190** from its packaging (not shown) and inserts the fluid inlet port **202** into the connection port **192** on the MUDS **130**. As described above, the SUDS **190** must be inserted in the correct orientation such that the fluid inlet port **202** is aligned for connection with the connection port **192** and the waste outlet port **204** is aligned for connection with the waste

inlet port **196**. The SUDS **190** may be secured to the MUDS **130** by inserting the locking tab **216** into the receiving slot **217** on the MUDS **130**. Once the SUDS **190** is securely connected to the MUDS **130**, for example as sensed by the sensor **242**, the fluid injector system **100** (shown in **FIG. 1**) draws fluid into one or more of the plurality of syringes **132** of the MUDS **130** and performs an automatic priming or flushing operation for removing air from the MUDS **130** and the SUDS **190**. During such priming or flushing operation, fluid from the MUDS **130** is injected through the connection port **192** and into the tubing **208** of the SUDS **190**. The fluid flows through the tubing **208**, the connector **214** and through the waste outlet port **204** and into the waste reservoir **156**. Once the automatic priming or flushing operation is completed, the tubing **208** may optionally be preloaded by injecting fluid from the MUDS **130** through the connection port **192**. Additional details of the preloading operation will be described later in greater detail. After the automatic priming or flushing operation and, optionally, the preloading operation are completed, the medical technician disconnects the connector **214** from the waste outlet port **204**. The connector **214** may then be connected to the patient via a catheter, vascular access device, needle, or additional fluid path set to facilitate fluid delivery to the patient. Once the fluid delivery is completed, the SUDS **190** is disconnected from the patient and the MUDS **130** by disengaging the locking tab **216** of the SUDS **190** from the receiving slot **217** on the MUDS **130**. The medical technician may then dispose of the SUDS **190**. In certain examples, removing the SUDS **190** from the MUDS **130** causes reuse prevention features (not shown) to activate, thereby preventing reinsertion and reuse of the SUDS **190**.

[0090] With reference to **FIG. 6**, an electronic control device **900** may be associated with fluid injector system **100** to control the filling and delivery operations. In some examples, the electronic control device **900** may control the operation of various valves, piston members, and other elements to effect a desired filling or delivery procedure. For example, the electronic control device **900** may include a variety of discrete computer-readable media components. For example, this computer-readable media may include any media that can be accessed by the electronic control device **900**, such as volatile media, non-volatile media, removable media, non-removable media, transitory media, non-transitory media, etc. As a further example, this computer-readable media may include computer storage media, such as media implemented in any method or technology for storage of information, such as computer-readable instructions, data structures, program modules, or other data; random access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), flash memory, or other memory technology; CD-ROM, digital

versatile disks (DVDs), or other optical disk storage; magnetic cassettes, magnetic tape, magnetic disk storage, or other magnetic storage devices; or any other medium which can be used to store the desired information and which can be accessed by the electronic control device **900**. Further, this computer-readable media may include communications media, such as computer-readable instructions, data structures, program modules, or other data in a modulated data signal, such as a carrier wave or other transport mechanism and include any information delivery media, wired media (such as a wired network and a direct-wired connection), and wireless media (such as acoustic signals, radio frequency signals, optical signals, infrared signals, biometric signals, bar code signals, etc.). Of course, combinations of any of the above should also be included within the scope of computer-readable media.

[0091] The electronic control device **900** further includes a system memory **908** with computer storage media in the form of volatile and non-volatile memory, such as ROM and RAM. A basic input/output system (BIOS) with appropriate computer-based routines assists in transferring information between components within the electronic control device **900** and is normally stored in ROM. The RAM portion of the system memory **908** typically contains data and program modules that are immediately accessible to or presently being operated on by a processor **904**, e.g., an operating system, application programming interfaces, application programs, program modules, program data, and other instruction-based computer-readable codes.

[0092] With continued reference to **FIG. 6**, the electronic control device **900** may also include other removable or non-removable, volatile or non-volatile, transitory or non-transitory computer storage media products. For example, the electronic control device **900** may include a non-removable memory interface **910** that communicates with and controls a hard disk drive **912**, e.g., a non-removable, non-volatile magnetic medium; and a removable, non-volatile memory interface **914** that communicates with and controls a magnetic disk drive unit **916** (which reads from and writes to a removable, non-volatile magnetic disk **918**), an optical disk drive unit **920** (which reads from and writes to a removable, non-volatile optical disk **922**, such as a CD ROM), a Universal Serial Bus (USB) port **921** for use in connection with a removable memory card, etc. However, it is envisioned that other removable or non-removable, volatile or non-volatile computer storage media can be used in an exemplary computing system environment **902**, including, but not limited to, magnetic tape cassettes, DVDs, digital video tape, solid state RAM, solid state ROM, etc. These various removable or non-removable, volatile or non-volatile magnetic media are in communication with the processor **904** and other components of the electronic control device

900 via a system bus **906**. The drives and their associated computer storage media, discussed above and illustrated in **FIG. 6**, provide storage of operating systems, computer-readable instructions, application programs, data structures, program modules, program data, and other instruction-based, computer-readable code for the electronic control device **900** (whether duplicative or not of this information and data in the system memory **908**).

[0093] A user may enter commands, information, and data into the electronic control device **900** through certain attachable or operable input devices, such as the user interface **124** shown in **FIG. 1**, via a user input interface **928**. A variety of such input devices may be utilized, e.g., a microphone, a trackball, a joystick, a touchpad, a touch-screen, a scanner, etc., including any arrangement that facilitates the input of data and information to the electronic control device **900** from an outside source. As discussed, these and other input devices are often connected to the processor **904** through the user input interface **928** coupled to the system bus **906**, but may be connected by other interface and bus structures, such as a parallel port, game port, or a USB. Still further, data and information can be presented or provided to a user in an intelligible form or format through certain output devices, such as a monitor **930** (to visually display this information and data in electronic form), a printer **932** (to physically display this information and data in print form), a speaker **934** (to audibly present this information and data in audible form), etc. All of these devices are in communication with the electronic control device **900** through an output interface **936** coupled to the system bus **906**. It is envisioned that any such peripheral output devices be used to provide information and data to the user.

[0094] The electronic control device **900** may operate in a network environment **938** through the use of a communications device **940**, which is integral to the electronic control device **900** or remote therefrom. This communications device **940** is operable by and in communication with the other components of the electronic control device **900** through a communications interface **942**. Using such an arrangement, the electronic control device **900** may connect with or otherwise communicate with one or more remote computers, such as a remote computer **944**, which may be a personal computer, a server, a router, a network personal computer, a peer device, or other common network nodes, and typically includes many or all of the components described above in connection with the electronic control device **900**. Using appropriate communication devices **940**, e.g., a modem, a network interface or adapter, etc., the computer **944** may operate within and communicate through a local area network (LAN) and a wide area network (WAN), but may also include other

networks such as a virtual private network (VPN), an office network, an enterprise network, an intranet, the Internet, etc.

[0095] As used herein, the electronic control device **900** includes or is operable to execute appropriate custom-designed or conventional software to perform and implement the processing steps of the method and system of the present disclosure, thereby forming a specialized and particular computing system. Accordingly, the method and system may include one or more electronic control devices **900** or similar computing devices having a computer-readable storage medium capable of storing computer-readable program code or instructions that cause the processor **904** to execute, configure, or otherwise implement the methods, processes, and transformational data manipulations discussed hereinafter in connection with the present disclosure. Still further, the electronic control device **900** may be in the form of a personal computer, a personal digital assistant, a portable computer, a laptop, a palmtop, a mobile device, a mobile telephone, a server, or any other type of computing device having the necessary processing hardware to appropriately process data to effectively implement the fluid injector system, the computer program product and the computer-implemented method of the present disclosure.

[0096] It will be apparent to one skilled in the relevant arts that the system may utilize databases physically located on one or more computers which may or may not be the same as their respective servers. For example, programming software on electronic control device **900** can control a database physically stored on a separate processor of the network or otherwise.

[0097] In some examples, the electronic control device **900** may be programmed so that automatic refill occurs based upon a preprogrammed trigger minimum volume in the respective syringes **132**. For example, when the volume of fluid remaining in at least one of the syringes **132** is less than a programmed volume, a syringe refill procedure is automatically initiated by the electronic control device **900**. The electronic control device **900** associated with the fluid injector system **100** may determine that the preprogrammed trigger minimum volume has been reached by tracking the fluid volume dispensed from the respective syringes **132** during operation of the fluid injector system **100**. Alternatively, fluid level sensors may be incorporated into the fluid injector system **100** and inputs from these fluid level sensors may be provided to the electronic control device **900** so that the electronic control device **900** may determine when the preprogrammed trigger minimum volume has been reached in at least one of the syringes **132**. The fill volume and rate of refill can be preprogrammed in the electronic control device **900**. The automatic refill procedure can be

stopped either automatically by the electronic control device **900** or may be manually interrupted. In addition, an automatic refill procedure may be initiated when, at the completion of a fluid injection procedure, there is not enough fluid in at least one of the syringes **132** to perform the next programmed fluid injection procedure.

[0098] During a refill procedure it is possible that one or more of the bulk fluid sources **120** associated with the respective syringes **132** may become empty (e.g., initially lack sufficient fluid to complete a full refill of the one or more syringes **132**). A replacement bulk fluid source **120** is, therefore, necessary and replacement of such bulk fluid source **120** is desirably made quickly. The fluid injector system **100** may have an indicator, such as an audible and/or visual indicator, to indicate to the operator that a change of the bulk fluid source **120** is necessary before the fluid injector system **100** may be used.

[0099] As described above, the fluid injector system **100** may automatically prime the MUDS **130** and the SUDS **190** once the SUDS **190** is securely connected to the MUDS **130**, for example, as sensed by the sensor **242**. During such a priming operation, saline, or another suitable flushing agent, from the MUDS **130** is injected through the connection port **192**, into the tubing **208** of the SUDS **190**, and into the waste reservoir **156**. Saline flow toward the waste reservoir **156** purges air from the fluid injector system by forcing any air in the MUDS **130** and the SUDS **190** out the distal end **212** of the tubing **208**. Saline thus displaces any air in the tubing **208** such that the tubing **208** becomes filled with saline.

[00100] After priming the tubing **208** with saline, the tubing **208** may be preloaded according to an injection protocol with one or more medical fluids associated with a clinical or therapeutic fluid delivery procedure to be performed on the patient. The one or more medical fluids may be drawn into a first of the plurality of syringes **132** during a filling procedure as described above with reference to **FIG. 2**, and then saline may be delivered to the SUDS **190** and used to prime the tubing **208** as described above with reference to **FIGS. 3A-3B**. Delivery of the one or more medical fluids to the SUDS **190** during the preloading operation will then partially or entirely displace the saline from the tubing **208** by pushing the saline through the waste outlet port **204** and into the waste reservoir **156**. At this point, the tubing **208** may be connected to the patient and the injection protocol may be initiated. Because the tubing **208** is, at this stage, partially or entirely filled with the one or more medical fluids rather than saline, needless injection of saline into the patient as part of the fluid delivery procedure may be avoided. In some examples, a catheter, vascular access device, needle, or additional fluid path set to facilitate fluid delivery to the patient may be connected to the

tubing **208** prior to preloading of the tubing **208** such that the one or more medical fluids are also preloaded into the vascular access device, needle, or additional fluid path set.

[00101] An exemplary method of preloading the SUDS **190** for performing an injection protocol will now be described with reference to **FIGS. 7A-7B**. In the presently described exemplary case, the tubing **208** of the SUDS **190** has an internal volume of 8 milliliters. The injection protocol, in this exemplary case an MR injection, calls for delivery of 5 milliliters of contrast solution followed by delivery of 20 milliliters of flushing agent. Prior to the preloading, the contrast solution may be drawn into a first of the plurality of syringes **132** from a first of the bulk fluid sources **120**, and the flushing agent may be drawn into a second of the plurality of syringes **132** from a second of the bulk fluid sources **120**. The valves **136** of the MUDS **130** may then be closed such that subsequent actuation of the syringes **132** will direct the fluid contained therein to the SUDS **190**, as described above. During preloading, the first of the syringes **132** is actuated to advance a first bolus **710** of 5 milliliters of contrast solution into a proximal end of the tubing **208**, as shown in **FIG. 7A**. If a priming operation was performed prior to preloading, advancement of the first bolus **710** in the tubing **208** displaces an equal volume of residual fluid from the priming operation and ejects that residual fluid from the distal end of the tubing **208**. The second of the syringes **132** is then actuated to advance a second bolus **720** of the flushing agent into a proximal end of the tubing **208**, as shown in **FIG. 7B**. Advancement of the second bolus **720** consequently pushes the first bolus **710** toward the distal end of the tubing **208** and ejects further residual fluid from the priming operation, if present, from the tubing **208**. In this example, because the total volume of contrast solution (5 milliliters) and flushing agent (20 milliliters) for the injection protocol exceeds the capacity of the tubing **208** (8 milliliters), the initial volume of the second bolus **720** is substantially equal to capacity of the tubing **208** (8 milliliters) minus the volume of the first bolus **710** (5 milliliters). Thus, the initial volume of the second bolus **720** is 3 milliliters. Once the second bolus **720** is advanced into the tubing **208**, the preloading is complete, and actuation of the second of the syringes **132** is halted.

[00102] At this stage, the first bolus **710** occupies the tubing **208** immediately adjacent the distal end of the tubing **208**, and the second bolus **720** occupies the tubing **208** adjacent the first bolus **710** and the proximal end of the tubing **208**, as may be appreciated from **FIG. 7B**. No residual fluid from the flushing/priming operation, or a negligible amount thereof, is present in the tubing **208**. The distal end of the tubing **208** may then be connected to the patient, and the injection protocol may be initiated. The second of the syringes **132** is again actuated to advance the remaining volume of flushing agent called for in the injection

protocol into the tubing **208**. That is, an additional 17 milliliters of flushing agent is injected into the patient, equal to the total volume (20 milliliters) called for in the injection protocol minus the initial volume (3 milliliters) of the second bolus **720**. As the remaining volume of flushing agent called for in the injection protocol is advanced into the tubing **208**, the first bolus **710** and the second bolus **720** are subsequently displaced from the tubing **208** and injected into the patient. The injection protocol is then complete. In this exemplary case, the patient receives a total injection volume of 25 milliliters of fluid, equal to the preloaded volume of 8 milliliters (i.e., 5 milliliters of the first bolus **710** plus 3 milliliters of the second bolus **720**), plus the 17-milliliter remaining volume of flushing agent injected after the tubing **208** is connected to the patient. Upon injection of the total volume (25 milliliters), 8 milliliters of the flushing agent will remain in the tubing **208** after the injection protocol is completed.

[00103] As is apparent from the above description of the exemplary case shown in **FIGS. 7A-7B**, preloading the tubing **208** allows the injection protocol to be performed without needlessly injecting residual fluid from the priming operation into the patient. Additionally, the contrast solution is injected into the patient with minimal delay, since the first bolus **710** is immediately adjacent the distal end of the tubing **208**, and no flushing/priming fluid must be evacuated from the tubing **208** before the first bolus **710** reaches the patient. Moreover, in distinction from simply priming the tubing **208** with contrast solution, preloading the tubing **208** allows for the first bolus **710** to contain a volume of less than the total capacity of the tubing **208**. As such, the patient is not injected with extra contrast solution beyond that called for in the injection protocol.

[00104] Of course, the exemplary case described above with reference to **FIGS. 7A-7B** is not limiting to the variety of injection protocols that may be accomplished by preloading the SUDS **190**. With reference to **FIG. 8**, a generic case shows that any number or boluses **800a-800n** may be preloaded into the tubing **208** in the same manner as described for the first and second boluses **710**, **720** of **FIGS. 7A-7B**. The number of boluses **800a-800n** is limited only by the capacity of the tubing **208**. Some of the boluses **800a-800n** may contain the same fluid. For example, if the injection protocol calls for alternating injections of contrast solution and flushing agent, first and third boluses **800a**, **800c** may contain contrast solution, while second and fourth boluses **800b**, **800d** may contain flushing agent. This may be achieved by alternatively actuating and de-actuating the syringes **132** respectively containing the contrast solution and the flushing agent. In some examples, an individual one of the boluses **800a-800n** may contain multiple types of fluids in whatever ratio the injection

protocol requires. This may be achieved by actuating multiple of the syringes **132** simultaneously. In some examples, the boluses **800a-800n** may have different volumes from one another, or the same volumes as one another. In some examples, only a single bolus **800a** may be preloaded, resulting in essentially the same effect as priming the tubing **208** with the fluid contained in the single bolus **800a** would produce.

[00105] With continued reference to **FIG. 8** and further reference to **FIG. 1**, an operator may design and/or initiate a preloading procedure, including the quantities, volumes, and fluid contents of the boluses **800a-800n**, utilizing the at least one control button **126** of the fluid injector system **100** and/or the user interface **124**. Additionally, the operator may utilize the at least one control button **126** of the fluid injector system **100** and/or the user interface **124** to cancel a preloading procedure. The user interface **124** may include a sensory indicator of preloading status so that the operator is alerted when the preloading is completed and the tubing **208** may be connected to the patient. The sensory indicator may include, for example, a light, icon, status bar, audible sound, or a combination thereof. The sensory indicator may also indicate that, because the tubing **208** is preloaded, there is minimal delay in the contrast solution (or other medical fluid called for by the injection protocol) being delivered to the patient. The operator may thus utilize the sensory indicator to adjust other portions of a therapeutic procedure, such as the timing of an MR or CT scan, to match the timing of contrast solution delivery to the patient.

[00106] Now referring again to **FIGS. 6** through **8**, the operator may enter a command including an injection protocol via the user input interface **928** of the electronic control device **900**. The processor **904** of the electronic control device **900** may be programmed or configured to preload the SUDS **190** based on information contained in the injection protocol, such as the number of boluses, the medical fluid of each bolus, and the volume of each bolus. The processor **904** of the electronic control device **900** may be programmed or configured to actuate the syringes **132** in the manner required to achieve the preloading injection protocol. For example, referring to the exemplary case shown in **FIGS. 7A-7B**, the processor **904** may be programmed or configured to actuate the first of the syringes **132** to advance 5 milliliters of contrast solution into the tubing **208** to form the first bolus **710**. The processor **904** may be further programmed or configured to actuate the second of the syringes **132** to advance 3 milliliters of flushing agent into the tubing **208** to form the second bolus **720**. In some examples, the processor **904** may be configured to calculate the available capacity of the tubing **208** after the first bolus **710** is advanced to determine the volume of the second bolus **720**. In the example of **FIGS. 7A-7B**, the processor **904** may calculate that after

advancing the 5 milliliters of contrast solution called for by the injection protocol, the tubing **208** has 3 milliliters of remaining capacity. The processor **904** may then determine that of the 20 milliliters of flushing agent called for in the injection protocol, only 3 milliliters can be advanced to the tubing **208** without ejecting the first bolus **710**. The processor **904** thus advances only 3 milliliters of flushing agent from the second of the syringes **132**. The processor **904** then advances the remaining 17 milliliters of flushing agent called for by the injection protocol, plus an additional 8 milliliters of flushing agent to account for the capacity of the tubing **208** after the SUDS **190** has been connected to the patient in order to inject the entirety of the 20 milliliters of flushing agent called for in the injection protocol. More generally, the processor **904** may be programmed or configured to calculate the available capacity of the tubing **208**, i.e., the total capacity of the tubing **208** minus the volume of any already advanced boluses **710**, **720**, **800a-800n**, and to size subsequent boluses **710**, **720**, **800a-800n** to have a volume of no more than the available capacity.

[00107] Referring now to **FIG. 9**, an example of a method **950** relating to the at least partial preloading of an administration line will now be described with regard to method steps **952-963**. The method illustrated in **FIG. 9** may be utilized, in some examples, to preload the tubing **208** as described above with respect to **FIGS. 7A-8**. The method **950**, as performed by the fluid injector system **100**, may be implemented by a computer program product. The computer program product may include at least one non-transitory computer-readable medium having one or more instructions executable by at least one processor to cause the at least one processor to execute all or part of the diagnostic injection procedure. In some examples or aspects, the at least one non-transitory computer-readable medium and the at least one processor may include or correspond to the memory **908** and processor **904**, respectively, as described above with reference to **FIG. 6**.

[00108] Throughout the execution of steps **952-963** of the method **950**, the at least one processor **904** may be in operative communication with the user interface **124** to facilitate entry of one or more user inputs associated with control of a plurality of operations of the fluid injector system **100**. For example, a set of the one or more user inputs may be associated with control of a corresponding set of the plurality of operations involved with enabling the selection and commencement of the at least partial preloading of the administration line with the first and/or the second fluids in accordance with the one or more phases of the diagnostic injection protocol. The user inputs may include, for example, a “Select Preloading” command, a “Commence Preloading” command, and a “Disable Preloading” command. Each of these user input commands will be discussed in greater detail

below in conjunction with the method step associated with each of the user inputs. The user inputs may be entered into the user interface **124** via a user input interface **928**, as discussed above with reference to **FIG. 6**. A variety of input devices of the user input interface **928** may be utilized to receive the user inputs such as, for example, a microphone, a trackball, a joystick, a touchpad, a touch-screen, a scanner, a keyboard, a mouse, and combinations thereof.

[00109] With continued reference to **FIG. 9**, at step **952** the at least one processor **904** of the fluid injector system **100** may be programmed with a diagnostic injection protocol. The diagnostic injection protocol may include one or more phases according to which at one of a first fluid container and a second container may be selectively actuatable by at least one drive component. In some examples, each of the first and second fluid containers may be one or more of the syringes **132**, with the first fluid container configured to be filled with a first fluid (e.g. a contrast solution) and the second fluid container configured to be filled with a second fluid (e.g. a flushing agent). The at least one drive component may be, for example, one or more of the piston elements **103**. The diagnostic injection protocol, when executed by the at least one processor **904**, may cause the at least one drive component to actuate one or more of the fluid containers via piston elements **103** and thereby inject at least one of the first fluid and the second fluid into the patient via the administration line. As noted above, the administration line may be, for example, the tubing **208**.

[00110] With continued reference to **FIG. 9**, at step **954** the at least one processor **904** of the fluid injector system **100** may actuate the second fluid container to prime the administration line, as described above. That is, the flushing agent, from the MUDS **130** is injected through the connection port **192** into the tubing **208** of the SUDS **190**, and eventually flows to connector **214** at the distal end of SUDS **190**. Any excess flushing agent can then drip from connector **214** into the waste reservoir **156** to which connector **214** is typically connected during the priming operation. This purges air from the fluid injector system **100** by forcing air in the MUDS **130** and the SUDS **190** out the distal end **212** of the tubing **208**. The flushing agent thus displaces any air in the tubing **208** such that the tubing **208** becomes filled with the flushing agent.

[00111] With continued reference to **FIG. 9**, at step **955** the at least one processor **904** of the fluid injector system **100** may be programmed or configured to enable selection of at least partial preloading of into the administration line. The at least partial preloading may include at least one of the first fluid and second fluid in accordance with the one or more phases of the diagnostic injection protocol. The at least partial preloading may be determined, or

selected by, the at least one processor **904** based on the diagnostic injection protocol. In particular, the volume of the first fluid and/or the volume of the second fluid to be preloaded into the administration line may be determined, by the at least one processor **904**, based on a volume of the first fluid and/or a volume of the second fluid prescribed in one or more phases of the diagnostic injection protocol. Step **955** may be initiated by the user entering the “Select Preloading” command as a user input into the user interface **124**. Once the diagnostic injection protocol has been programmed and the administration line primed, entry of the “Select Preloading” command will cause the at least one processor **904** to ready the fluid injector system **100** for at least partial preloading of the diagnostic injection protocol into the administration line. For example, entry of the “Select Preloading” command will cause the at least one processor **904** to ready the fluid injector system **100** to accept user input of the “Commence Preloading” command at step **956** of the method **950**.

[00112] With continued reference to **FIG. 9**, at step **956**, the at least one processor **904** determines whether to commence preloading in accordance with the diagnostic injection protocol. In some examples, the at least one processor **904** may await entry of the “Commence Preloading” command from the user into the user interface **124**. If the “Commence Preloading” command is received subsequent to the “Select Preloading” command, the at least one processor **904** determines to commence preloading and advances the method to step **957**. If the “Commence Preloading” command is not received subsequent to the “Select Preloading” command, or if the user instead enters the “Disable Preloading” command, the at least one processor returns to step **955** and awaits the user to re-enter the “Select Preloading” command.

[00113] With continued reference to **FIG. 9**, at step **957**, after determining to commence the preloading operation, the at least one processor **904** compares the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) to the volume capacity of the administration line (B).

[00114] At step **958**, the at least one processor determines whether the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) is equal to the capacity of the administration line (B). If the at least one processor **904** determines that the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) is equal to the capacity of the administration line (B), the at least one processor **904**, at step **959**, actuates one or more of the fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof. For example, if the

administration line has a capacity of 8 milliliters, and the total volume of the first and second fluid prescribed by the diagnostic injection protocol is 8 milliliters, the at least one processor **904** preloads the 8 milliliters of the fluid prescribed by the fluid injection protocol into the administration line. In some examples, actuating one or more of the fluid containers includes actuating the piston elements **103** associated with the syringes **132** to advance at least a portion of the fluid contained within the syringes **132** into the tubing **208**. As a consequence of the preloading, the volume of the second fluid used in the priming of the administration line is expelled therefrom. In step **959**, because the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, the entirety of the fluid required by the diagnostic injection protocol is advanced into the administration line during preloading.

[00115] If, at step **958**, the at least one processor **904** determines that the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) is not equal the capacity of the administration line (B), the at least one processor **904** then determines, at step **960**, whether the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) is less than the capacity of the administration line (B). If the at least one processor **904** determines that the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) is less than the capacity of the administration line (B), the at least one processor **904**, at step **961**, actuates one or more of the fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof. In some examples, the at least one processor **904** then actuates the second fluid container to preload the administration line with a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol. For example, if the administration line has a capacity of 8 milliliters, and the total volume of the first and second fluid prescribed by the diagnostic injection protocol is 5 milliliters, the at least one processor **904** preloads the 5 milliliters of the fluid prescribed by the fluid injection protocol into the administration line, followed by a supplemental volume of 3 milliliters to bring the total preloaded volume to 8 milliliters, or equal to the capacity of the administration line. This readies the diagnostic injection protocol for immediate injection into the patient. In some examples, actuating one or more of the fluid containers includes actuating the piston elements **103** associated with the syringes **132** to advance at least a portion of the fluid contained within the syringes **132** into the tubing **208**. As a consequence of the preloading, the volume of the second fluid used in

the priming of the administration line is expelled therefrom. In step **961**, because the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, the entirety of the fluid required by the diagnostic injection protocol is advanced into the administration line during preloading. The supplement volume of the second fluid is preloaded in order to advance the total volume of the diagnostic injection protocol to the distal end of the administration line, and thereby expel the fluid used in priming the administration line.

[00116] If, at step **960**, the at least one processor **904** determines that the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) is not less than the capacity of the administration line (B), the at least one processor **904** determines that the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) is greater than the capacity of the administration line (B). The at least one processor **904** then, at step **963**, actuates one or more of the fluid containers and thereby preloads into the administration line as much of the first and second fluid, in accordance with the one or more phases of the diagnostic injection protocol, as a capacity of the administration line will allow. For example, if the administration line has a capacity of 8 milliliters, and the total volume of the first and second fluid prescribed by the diagnostic injection protocol is 25 milliliters, the at least one processor **904** preloads the first 8 milliliters of the fluid prescribed by the fluid injection protocol into the administration line. As a consequence of the preloading, the volume of the second fluid used in the priming of the administration line is expelled therefrom. In some examples, actuating one or more of the fluid containers includes actuating the piston elements **103** associated with the syringes **132** to advance at least a portion of the fluid contained within the syringes **132** into the tubing **208**. After preloading up to the capacity of the administration line, the at least one processor **904** retains within the programming a remaining portion of the diagnostic injection protocol. For example, if 8 milliliters of fluid is preloaded into the administration line out of a total of 25 milliliters prescribed by the diagnostic injection protocol, the programming retains a log of the remaining 17 milliliters not preloaded into the administration line. The at least one processor **904** will then inject the remaining portion of the diagnostic injection protocol when the diagnostic injection protocol is performed on the patient. That is, when the diagnostic injection protocol is performed on the patient, the 8 milliliters of fluid preloaded into the administration line will be injected into the patient first followed by the 17 milliliters that, prior to the diagnostic injection procedure being performed, had been retained within the programming.

[00117] For each diagnostic injection protocol programmed into the fluid injector system 100, the method 950 will include only one of steps 959, 961, and 963. In subsequent diagnostic injection procedures, the same step may be carried out or another one of steps 959, 961, and 963 may be performed as part of the method 950, based on the determinations made by the at least one processor 904 at steps 958, 960, and 962. It is to be understood that the order of steps 958, 960, and 962 may be altered without departing from the scope of the present disclosure. For example, the at least one processor 904 may perform step 962 first, and, if it is determined that the total volume of the first fluid and the second fluid to be injected according to the diagnostic injection protocol (A) is not greater than the capacity of the administration line (B), the at least one processor 904 may subsequently perform steps 958 and/or 960.

[00118] With continued reference to FIG. 9, after preloading the administration line according to either step 959, 961, or 963, the at least one processor 904 of the fluid injector system 100 may be programmed or configured to perform the diagnostic injection protocol on the patient. In particular, the at least one processor 904 actuates one or more of the fluid containers to inject the total volume of the first and second fluid prescribed by the protocol into the patient. If the total volume of the first and second fluids prescribed by the protocol is fully preloaded into the administration line as in step 959, the at least one processor 904 will actuate the second fluid container to push a flushing agent into the administration line behind the preloaded fluid only when the diagnostic injection procedure is being performed on the patient. If the total volume of the first and second fluids prescribed by the protocol is preloaded into the administration line along with the supplemental volume of saline as in step 961, the at least one processor 904 will similarly actuate the second fluid container to push flushing agent into the line so as to push the total volume of the diagnostic injection protocol into the patient. When a remaining portion of the diagnostic injection protocol is retained by the programming as in step 963, the remaining portion will be injected into the patient immediately after the portion of the protocol that was actually preloaded into the administration line. This is accomplished by actuating the second fluid container via the at least one processor 904 to push additional flushing agent, in a volume equal to the capacity of the administration line, into the administration line and thereby push the entirety of the diagnostic injection protocol into the patient.

[00119] Throughout the execution of steps 952-963 of the method 950, the at least one processor 904 may be in operative communication with the user interface 124 to cause the user interface 124 to display information associated with a status of the at least partial

preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol. The information associated with the status may include, for example, a total volume of the first and/or the second fluid to be injected according to the diagnostic injection protocol, a volume of the first and/or the second fluid which has been injected at any time during performance of the diagnostic injection protocol, a volume of the first and/or the second fluid which remains to be injected at any time during performance of the diagnostic injection protocol, and/or a flow rate at which the first and/or the second fluid is being injected at any time during performance of the diagnostic injection protocol. The at least one processor **904** may further cause the user interface **124** to display information relating to each of the one or more phases of the diagnostic injection protocol, such as a particular volume and/or flow rate of the first and/or the second fluid to be injected during each phase, and a particular volume and/or flow rate of the first and/or the second fluid being injected during the present phase.

[00120] While several examples of fluid delivery systems, computer program products, and methods for preloading a single-use disposable set connector are shown in the accompanying drawings and described hereinabove in detail, other examples will be apparent to, and readily made by, those skilled in the art without departing from the scope and spirit of the disclosure. For example, it is to be understood that this disclosure contemplates that, to the extent possible, one or more features of any example can be combined with one or more features of any other example. Accordingly, the foregoing description is intended to be illustrative rather than restrictive.

WE CLAIM:

1. A fluid injector system comprising:

a control device operably associated with at least one drive component for use in actuating a plurality of fluid containers, the plurality of fluid containers capable of being placed in fluid communication with a patient through an administration line with a first of the fluid containers capable of being filled with a first fluid comprising a contrast solution and a second of the fluid containers capable of being filled with a second fluid comprising a flushing agent; and

the control device including at least one processor programmed or configured to enable programming of a diagnostic injection protocol comprising one or more phases according to which at least one of the first and the second fluid containers are selectively actuatable by the at least one drive component to enable injection of at least one of the first fluid and the second fluid via the administration line into the patient so as to effect enhancement of at least one region of interest thereof over a scan duration of a diagnostic imaging procedure;

wherein the control device is further programmed or configured to, upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enable selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

2. The fluid injector system of claim 1, further including a user interface operably associated with the at least one processor, the user interface being configured to accept a plurality of user inputs associated with control of a plurality of operations of the fluid injector system, wherein a set of the plurality of user inputs is associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

3. The fluid injector system of claim 2, wherein the set of the plurality of user inputs includes:

a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line;

a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and

a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

4. The fluid injector system of claim 3, wherein the control device is further programmed or configured to calculate a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol such that, upon entry of the commence preloading command into the user interface, the control device:

upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the administration line a volume of the second fluid used in the priming of the administration line therewith;

upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith; and

upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than

the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line as much of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

5. The fluid injector system of claim 2, wherein the user interface is configured to display information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

6. The fluid injector system of claim 2, wherein the user interface is configured to display at least one of:

a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol; and

for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

7. The fluid injector system of claim 1, wherein the first of the fluid containers comprises a syringe and the second of the fluid containers comprises a syringe.

8. A computer program product for enabling at least partial preloading into an administration line of at least one of a first fluid and a second fluid in accordance with a one or more phases of a diagnostic injection protocol, the computer program product comprising at least one non-transitory computer-readable medium comprising one or more instructions that, when executed by at least one processor, cause the at least one processor to:

enable programming of the diagnostic injection protocol into a control device of a fluid injector system, the control device operably associated with at least one drive component for use in selectively actuating a plurality of fluid containers, the plurality of fluid containers capable of being placed in fluid communication with a patient through the

administration line with a first of the fluid containers capable of being filled with the first fluid comprising a contrast solution and a second of the fluid containers capable of being filled with the second fluid comprising a flushing agent; and

upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enable selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

9. The computer program product of claim 8, wherein the one or more instructions, when executed by at least one processor, further cause the at least one processor to:

receive, from a user interface operably associated with the at least one processor, at least one of a plurality of user inputs associated with control of a plurality of operations of the fluid injector system,

wherein a set of the plurality of user inputs is associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

10. The computer program product of claim 9, wherein the set of the plurality of user inputs includes:

a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line;

a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and

a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

11. The computer program product of claim 9, wherein the one or more instructions, when executed by at least one processor, further cause the at least one processor to:

calculate a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol such that, upon entry of the commence preloading command into the user interface, the at least one processor:

upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the administration line a volume of the second fluid used in the priming of the administration line therewith;

upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith; and

upon determining that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line as much of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

12. The computer program product of claim 9, wherein the one or more instructions, when executed by at least one processor, further cause the at least one processor to:

display, via the user interface, information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

13. The computer program product of claim 9, wherein the one or more instructions, when executed by at least one processor, further cause the at least one processor to:

display, via the user interface, at least one of:

a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol; and

for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

14. The computer program product of claim 8, wherein the first of the fluid containers comprises a syringe and the second of the fluid containers comprises a syringe.

15. A computer-implemented method for enabling at least partial preloading into an administration line of at least one of a first fluid and a second fluid in accordance with a one or more phases of a diagnostic injection protocol, the method comprising:

programming, via at least one processor, the diagnostic injection protocol into a control device of a fluid injector system, the control device operably associated with at least one drive component for use in selectively actuating a plurality of fluid containers, the plurality of fluid containers capable of being placed in fluid communication with a patient through an administration line with a first of the fluid containers capable of being filled with the first fluid comprising a contrast solution and a second of the fluid containers capable of being filled with the second fluid comprising a flushing agent; and

upon completion of the programming of the diagnostic injection protocol and priming of the administration line with the second fluid, enabling, via the at least one

processor, selection and commencement of at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

16. The computer-implemented method of claim 15, further comprising:
receiving, from a user interface operably associated with the at least one processor, at least one of a plurality of user inputs associated with control of a plurality of operations of the fluid injector system,

wherein a set of the plurality of user inputs is associated with the control of a corresponding set of the plurality of operations involved with the enabling of the selection and the commencement of the at least partial preloading into the administration line of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

17. The computer-implemented method of claim 16, wherein the set of the plurality of user inputs includes:

a select preloading command upon entry of which into the user interface the control device readies the fluid injector system for the at least partial preloading of the diagnostic injection protocol into the administration line;

a commence preloading command upon entry of which into the user interface after the select preloading command the control device actuates the plurality of fluid containers and thereby commences the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol; and

a disable preloading command upon entry of which into the user interface after the select preloading command the control device disables an effect of the select preloading command.

18. The computer-implemented method of claim 16, further comprising:
calculating, with the at least one processor, a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol such that, upon entry of the commence preloading command into the user interface, the control device:

upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic

injection protocol is equal to the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof and thereby expels from the administration line a volume of the second fluid used in the priming of the administration line therewith;

upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is less than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line the total volume of the diagnostic injection protocol in accordance with the one or more phases thereof followed by a supplemental volume of the second fluid equal to the capacity of the administration line minus the total volume of the diagnostic injection protocol and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith; and

upon determining, with the at least one processor, that the total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol is greater than the capacity of the administration line, actuates one or more of the plurality of fluid containers and thereby preloads into the administration line as much of the at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol as a capacity of the administration line will allow and retains within the programming a remaining portion of the diagnostic injection protocol until the diagnostic injection protocol is performed on the patient and thereby expels from the administration line the volume of the second fluid used in the priming of the administration line therewith.

19. The computer-implemented method of claim 16, further comprising:
displaying, with the user interface, information associated with a status of the at least partial preloading into the administration line of at least one of the first fluid and the second fluid in accordance with the one or more phases of the diagnostic injection protocol.

20. The computer-implemented method of claim 16, further comprising:
displaying, with the user interface, at least one of:
a total volume of the at least one of the first fluid and the second fluid to be injected according to the diagnostic injection protocol; and

for each of the one or more phases of the diagnostic injection protocol, a particular volume of the at least one of the first fluid and the second fluid therein and a flow rate at which the particular volume is to be injected into the patient during administration thereof.

21. The computer-implemented method of claim 15, wherein the first of the fluid containers comprises a syringe and the second of the fluid containers comprises a syringe.

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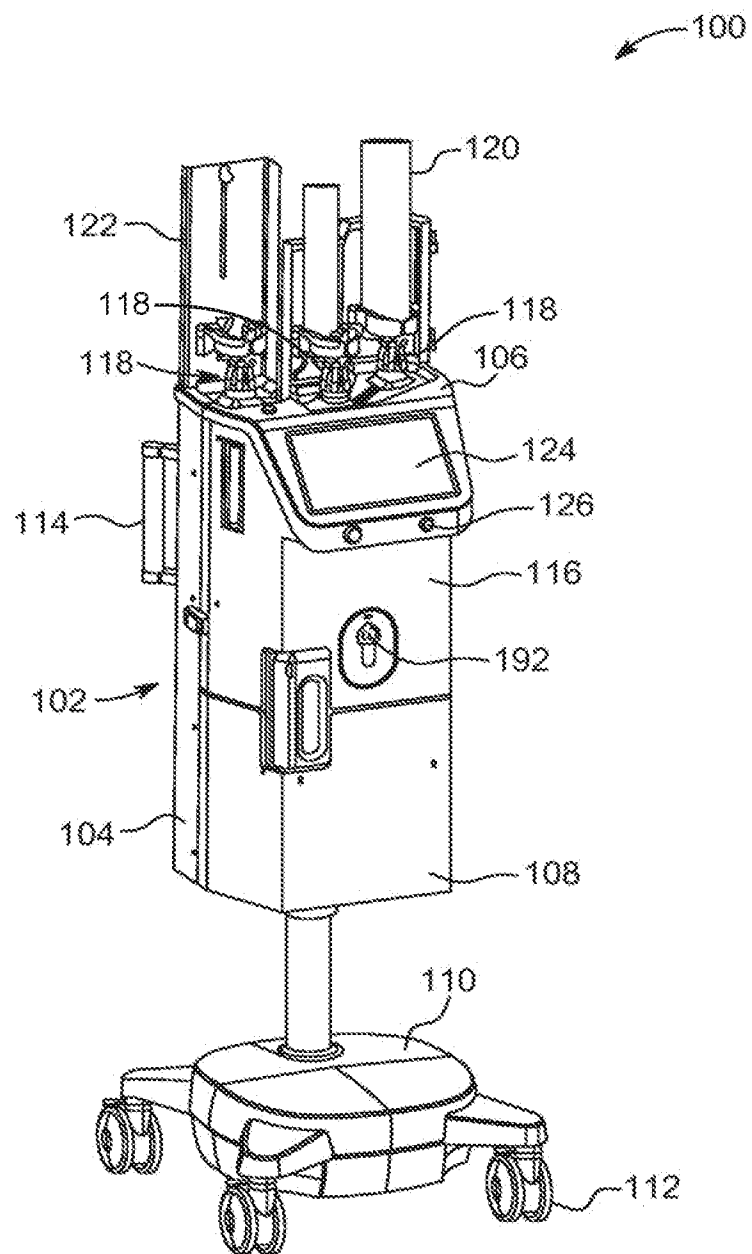


FIG. 1

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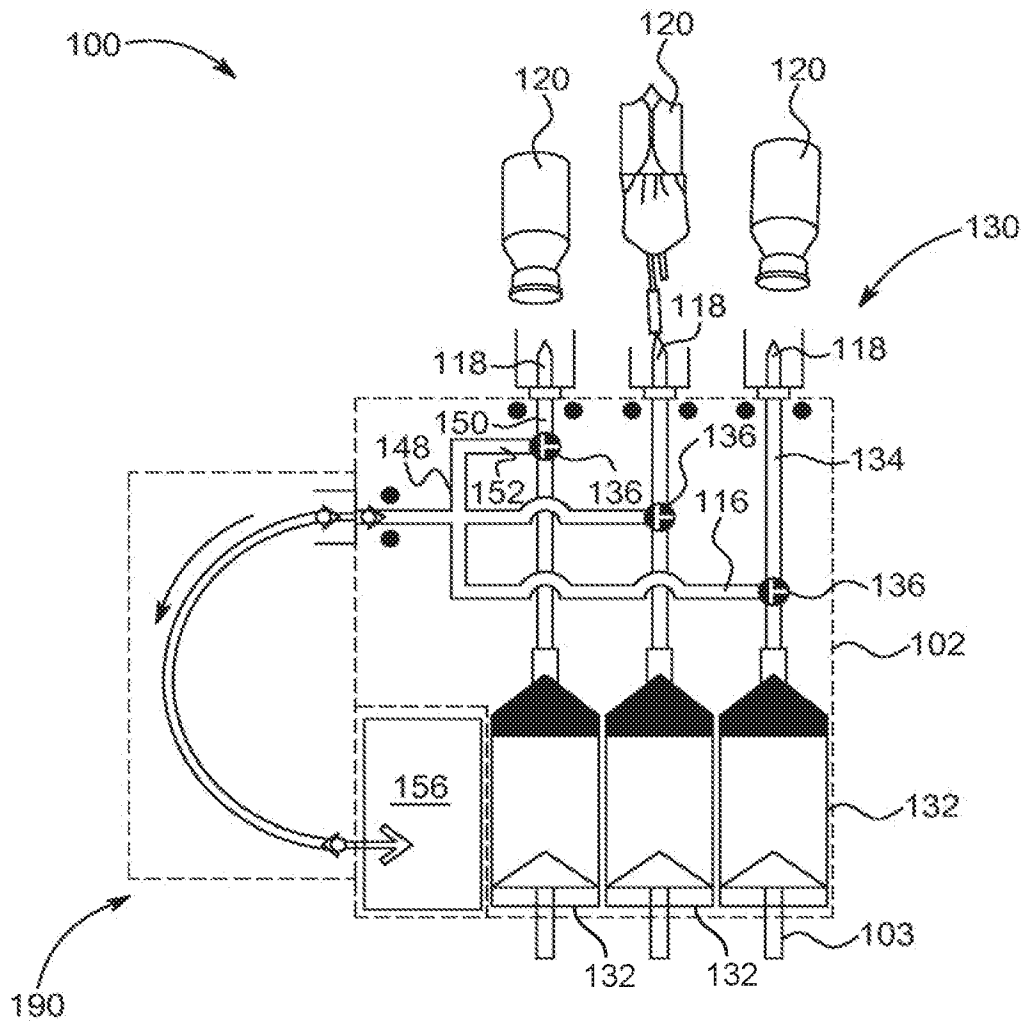


FIG. 2

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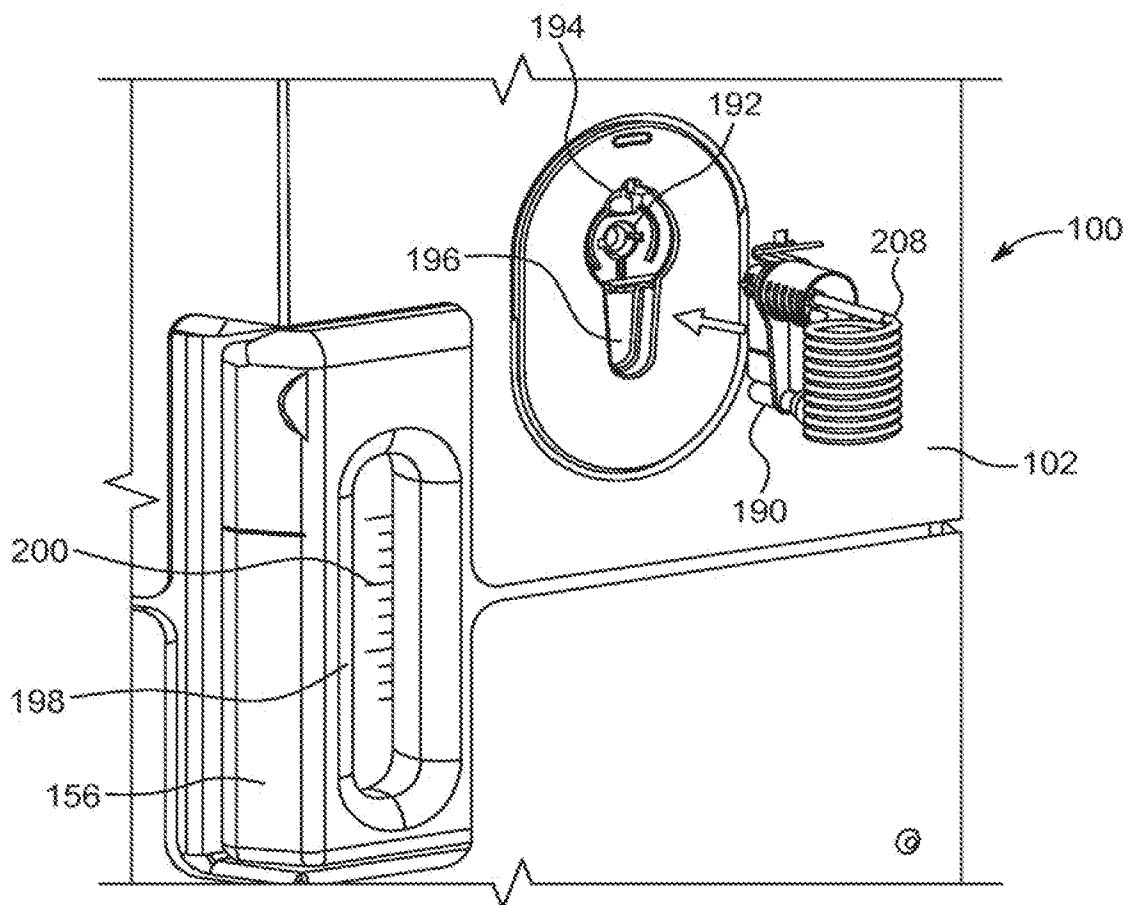


FIG. 3A

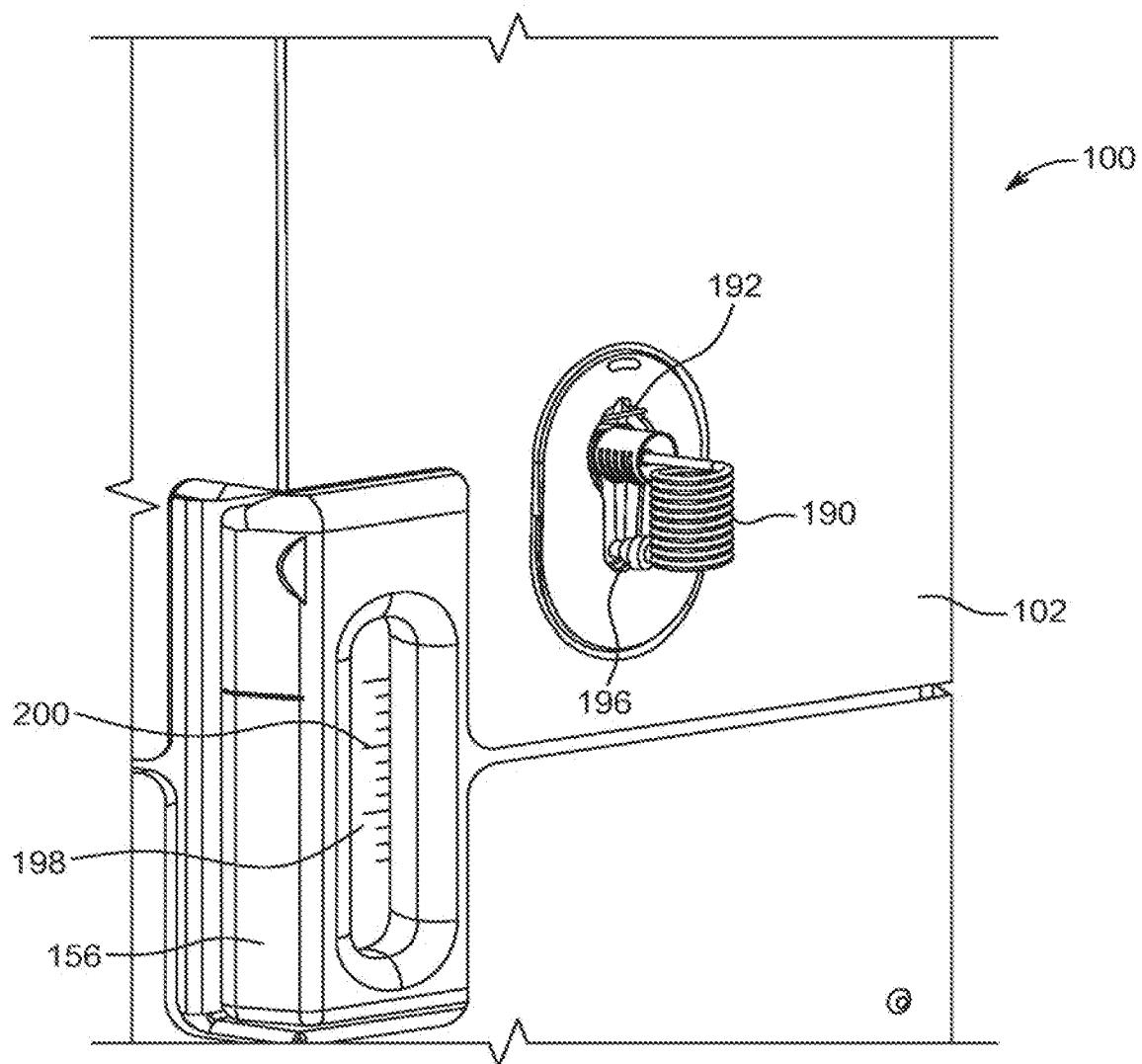


FIG. 3B

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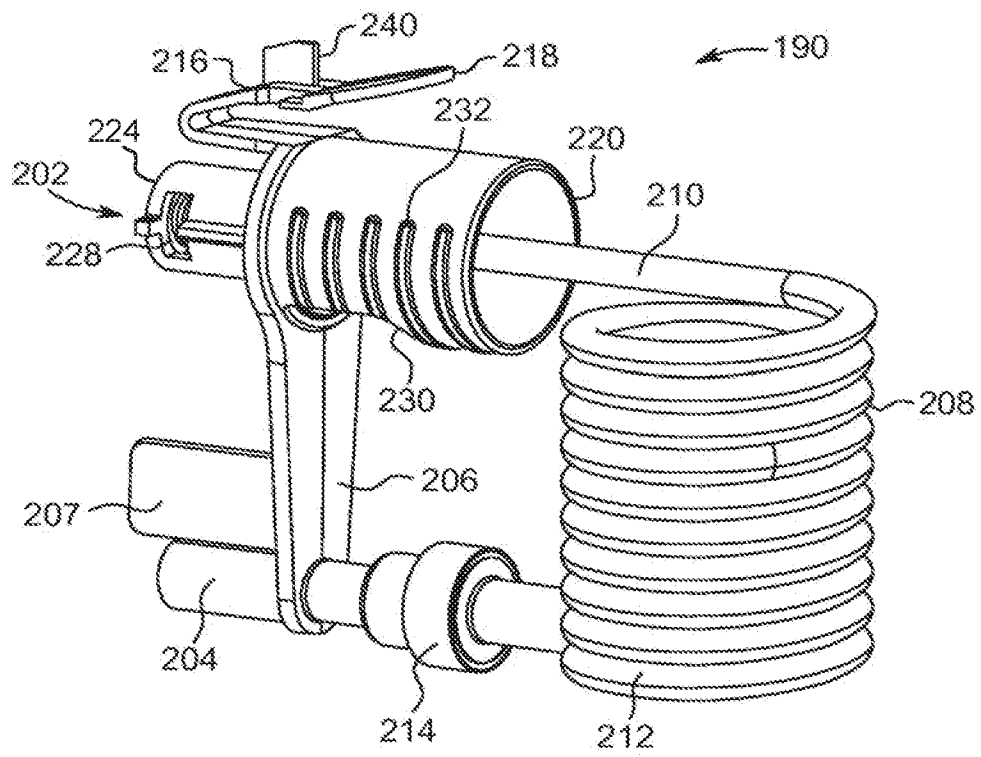


FIG. 4A

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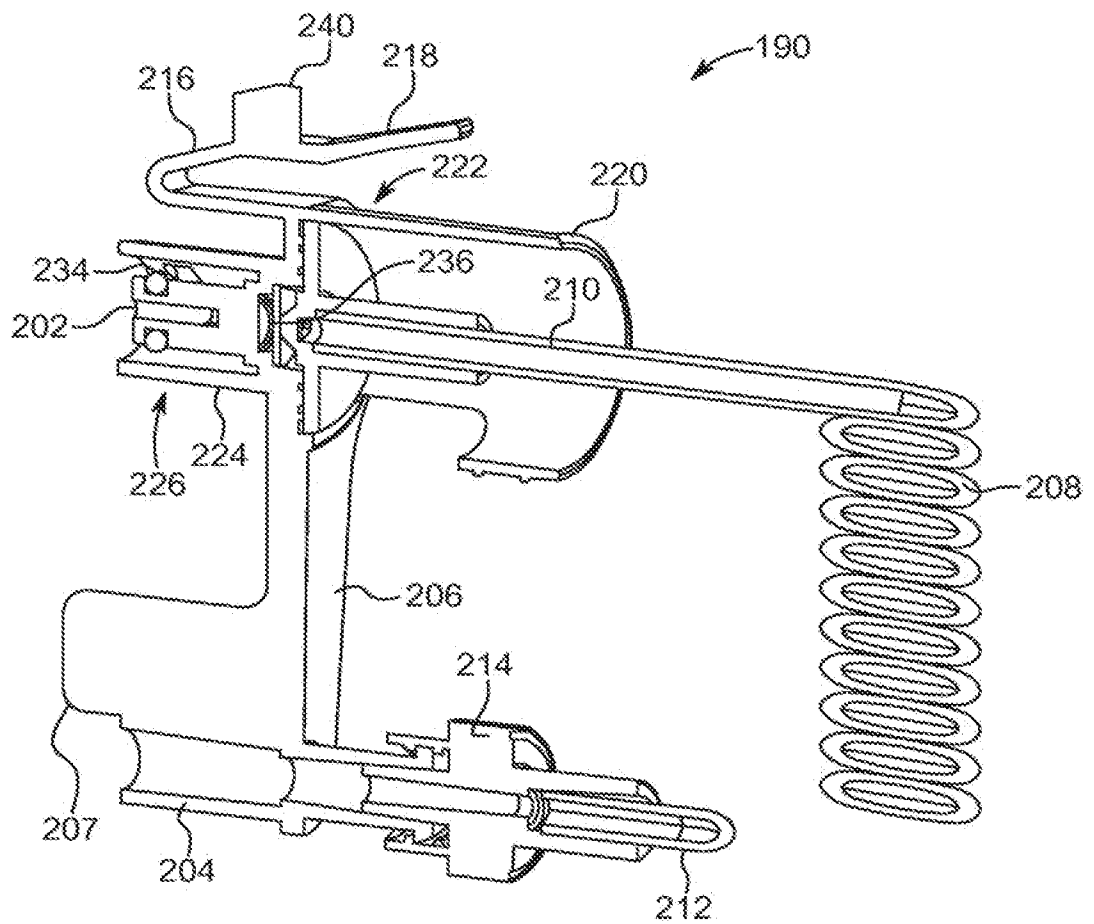


FIG. 4B

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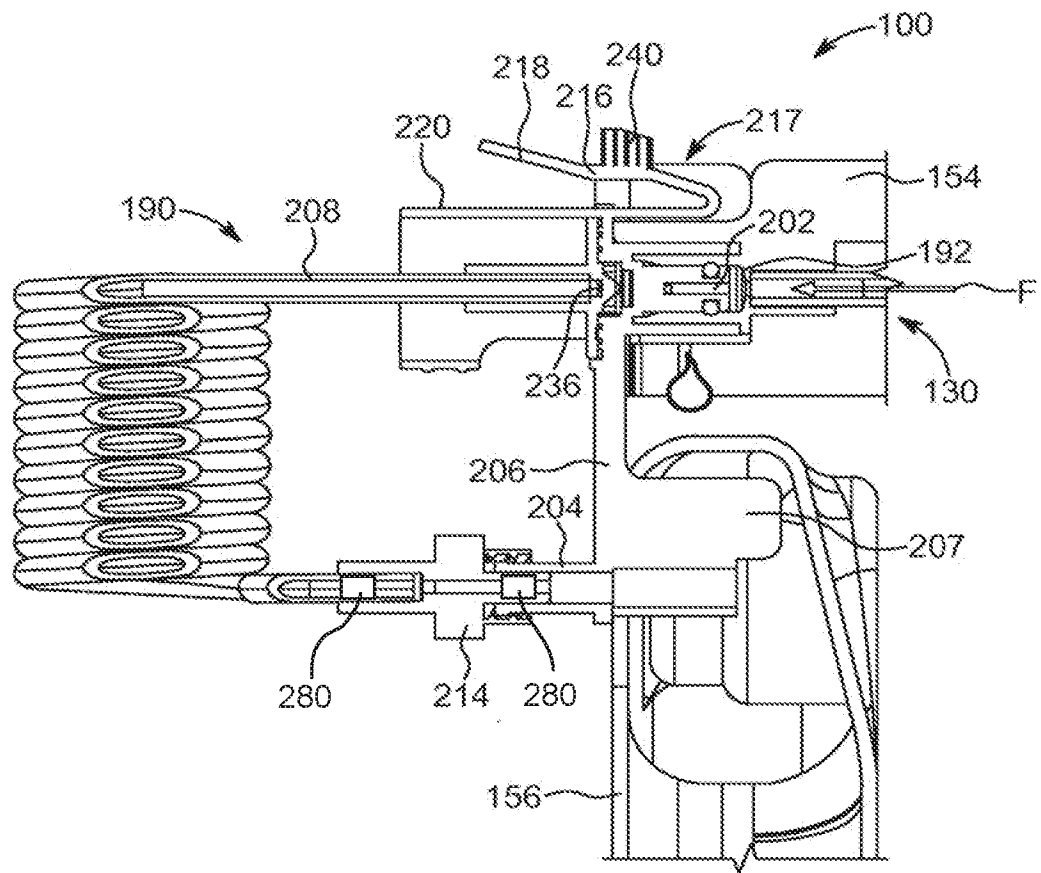


FIG. 4C

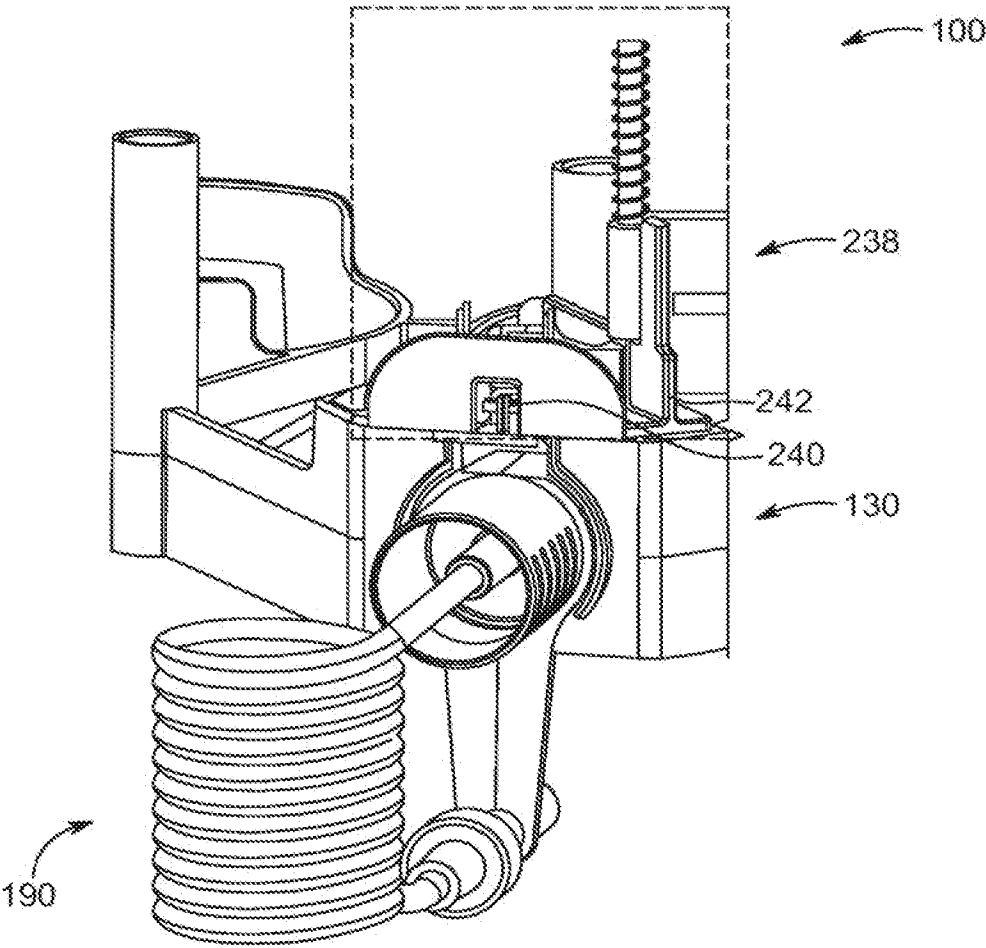


FIG. 5

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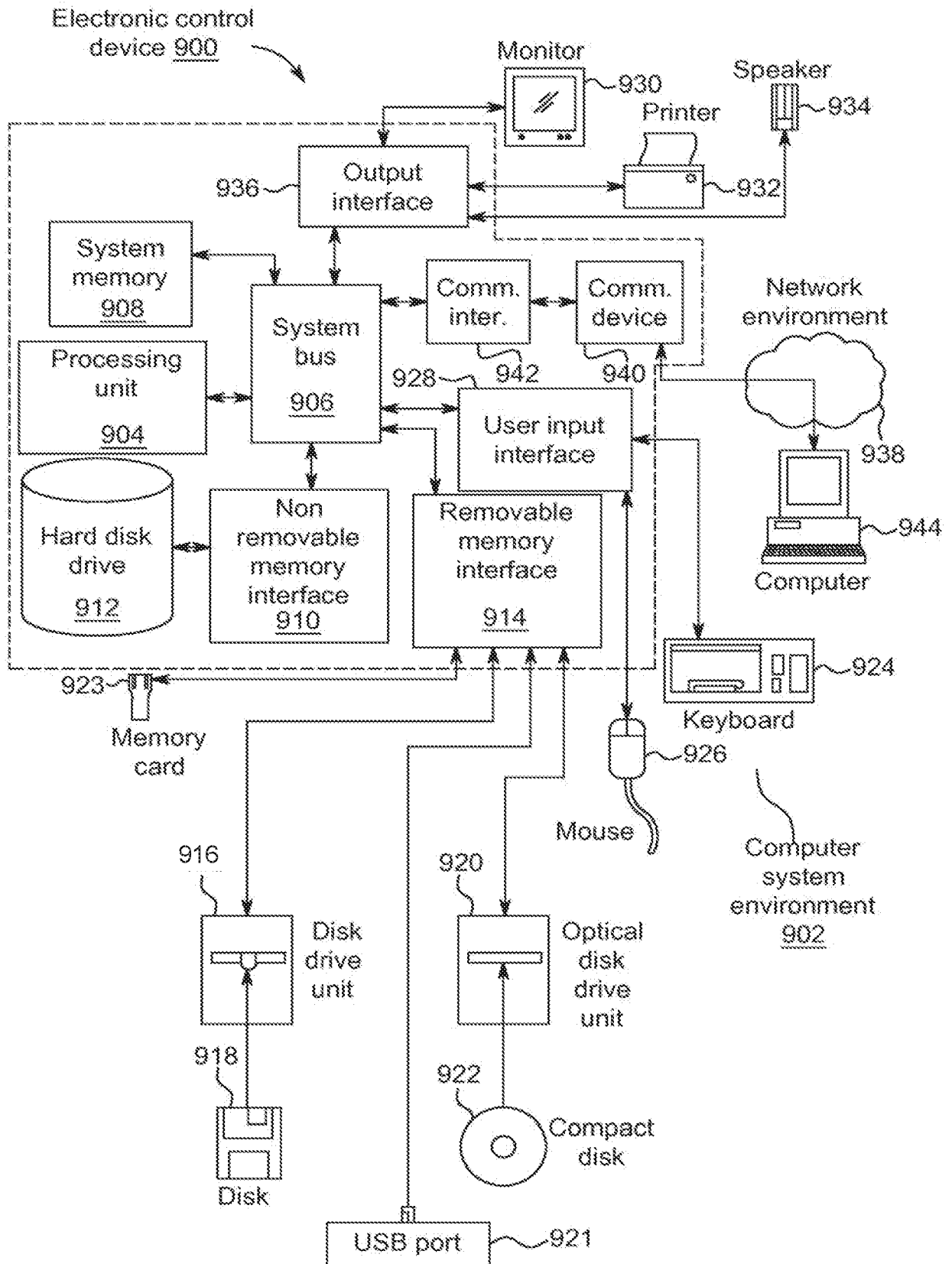


FIG. 6

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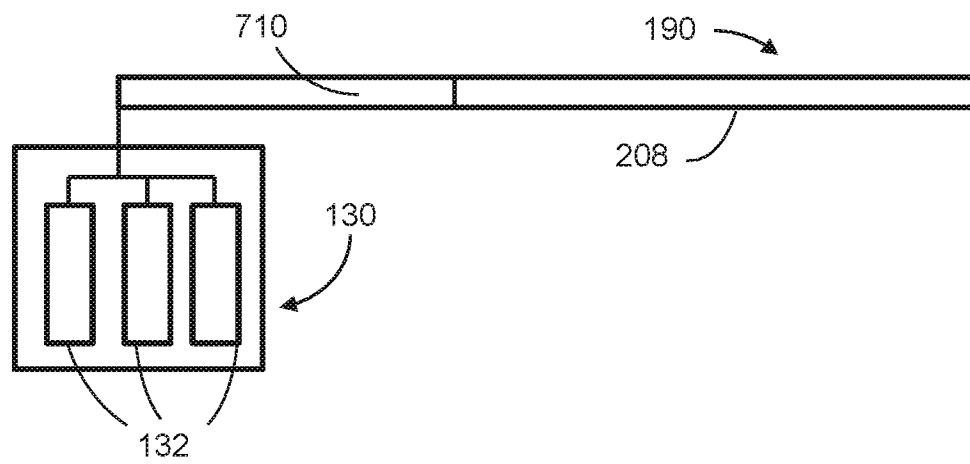


FIG. 7A

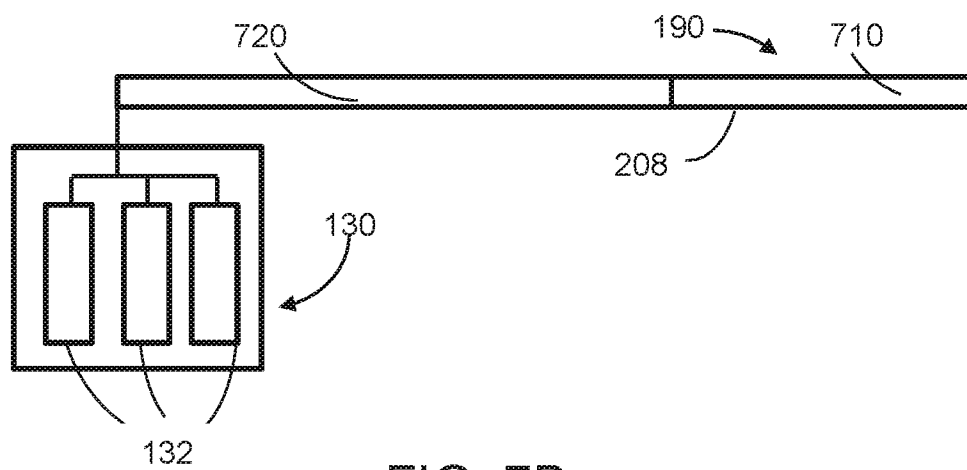


FIG. 7B

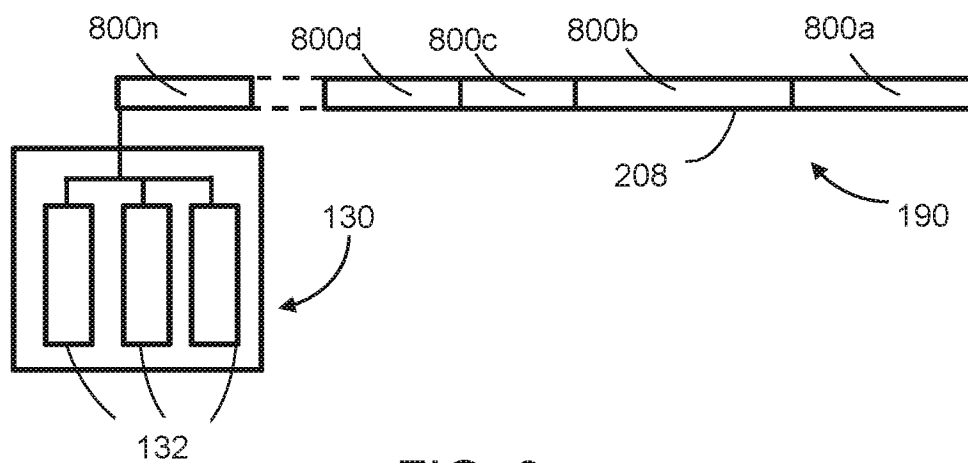


FIG. 8

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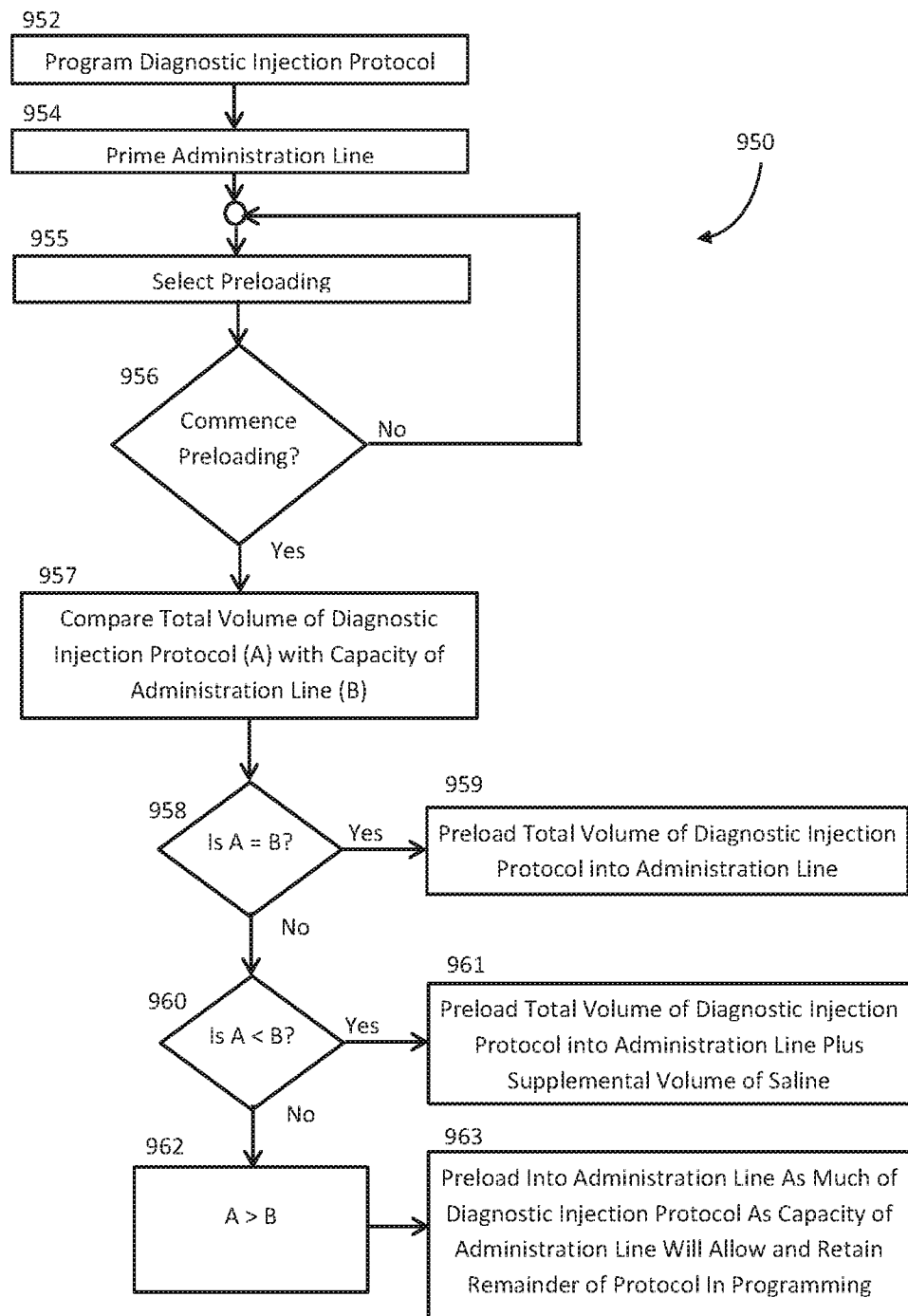


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/026481

A. CLASSIFICATION OF SUBJECT MATTER INV. G16H40/63 A61M5/14 A61M5/142 A61M5/20 ADD.														
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) G16H A61M Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, BIOSIS														
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>WO 2015/106107 A1 (BAYER MEDICAL CARE INC [US]) 16 July 2015 (2015-07-16) paragraphs [0003], [0004], [0006], [0057], [0064], [0071], [0085]; claims; figures -----</td> <td>1-21</td> </tr> <tr> <td>Y</td> <td>WO 2016/112163 A1 (BAYER HEALTHCARE LLC [US]) 14 July 2016 (2016-07-14) paragraphs [0003], [0004], [0165], [0184], [0191], [0206]; claims; figures -----</td> <td>1-21</td> </tr> <tr> <td>Y</td> <td>WO 02/096487 A1 (ACIST MEDICAL SYS INC [US]; TOEWS GLENN [US] ET AL.) 5 December 2002 (2002-12-05) claims; figures ----- -/-</td> <td>1-21</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	WO 2015/106107 A1 (BAYER MEDICAL CARE INC [US]) 16 July 2015 (2015-07-16) paragraphs [0003], [0004], [0006], [0057], [0064], [0071], [0085]; claims; figures -----	1-21	Y	WO 2016/112163 A1 (BAYER HEALTHCARE LLC [US]) 14 July 2016 (2016-07-14) paragraphs [0003], [0004], [0165], [0184], [0191], [0206]; claims; figures -----	1-21	Y	WO 02/096487 A1 (ACIST MEDICAL SYS INC [US]; TOEWS GLENN [US] ET AL.) 5 December 2002 (2002-12-05) claims; figures ----- -/-	1-21
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Date of the actual completion of the international search		Date of mailing of the international search report												
9 July 2019		22/07/2019												
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Vogt, Titus												

INTERNATIONAL SEARCH REPORT

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