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(54) **Title:** INFUSION PUMP ERROR DISPLAY

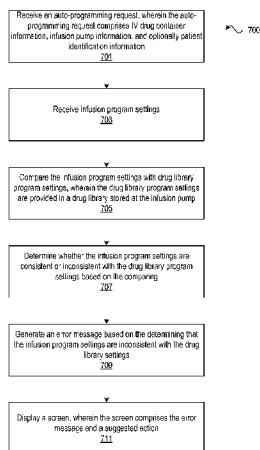


FIG. 7

(57) **Abstract:** Systems and methods are disclosed for receiving auto-programming requests to deliver medication at an infusion pump. The pump may receive the request and analyze the auto-programming settings. The infusion pump may also compare the auto-programming settings with program settings stored in a drug library. When the pump detects an error in the auto-programming request, the pump may generate and display an error message that specifically identifies the cause of the error. The pump may also display a suggested action that may be taken to eliminate the error message.



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INFUSION PUMP ERROR DISPLAY

Technical Field

- [01] The present disclosure relates to infusion pump error display. Specifically, disclosed is a system and method for analyzing an auto-programming request at an infusion pump and displaying an error message at the infusion pump if the auto-program request is inconsistent with a drug library.

Background

- [02] Infusion pumps are commonplace among medical devices in modern hospitals. The pumps serve as a useful tool for delivering medication to patients, and are particularly beneficial for their great accuracy in delivering medication at a specific rate and dose. Moreover, medical facilities have enabled hospital caregivers, such as nurses, to deliver medication to patients using auto-programming features available for the infusion pump. Although auto-programming features may reduce errors made manually by hospital caregivers, medical facilities still struggle with identifying and responding to errors made when using an infusion pump. In a conventional auto-programmable pump, error codes and messages may be sent surreptitiously from the pump to other areas of the medical network, but are not immediately accessible to a hospital caregiver submitting an auto-program request at the infusion pump. Furthermore, these error codes often do not specifically describe the error to the caregiver at the pump so that the caregiver may immediately respond to the error. Thus, there is a need for system and method for displaying detailed auto-programming error messages directly at an infusion pump so that the operator of the pump may quickly respond to the error and take appropriate action for delivery of appropriate medication.

Summary

- [03] The following presents a simplified summary of the present disclosure in order to provide a basic understanding of some aspects of the disclosure. This summary is not an extensive overview of the disclosure. It is not intended to identify key or critical

elements of the disclosure or to delineate the scope of the disclosure. The following summary merely presents some concepts of the disclosure in a simplified form as a prelude to the more detailed description provided below.

- [04] Certain aspects disclose a method, comprising: receiving, at an infusion pump, an auto-programming request, wherein the auto-programming request comprises IV drug container information, infusion pump information, and optionally patient wristband information; receiving, at the infusion pump, infusion program settings; comparing, at the infusion pump, the infusion program settings with drug library program settings, wherein the drug library program settings are provided in a drug library stored at the infusion pump; determining, at the infusion pump, that the infusion program settings are inconsistent with the drug library program settings based on the comparing; generating, at the infusion pump, an error message based on the determining; and displaying, at the infusion pump, a screen, wherein the screen comprises the error message and a recommended action.
- [05] Certain other aspects disclose a non-transitory computer-readable storage medium having computer-executable program instructions stored thereon that, when executed by a processor, cause the processor to: receive an auto-programming request, wherein the auto-programming request comprises patient wristband information, IV drug container information, infusion pump information, and optionally patient wristband information; receive infusion program settings; compare the infusion program settings with drug library program settings, wherein the drug library program settings are provided in a drug library stored at the infusion pump; determine that the infusion program settings are inconsistent with the drug library program settings based on the comparing; generate an error message based on the determining; and display a screen on the infusion pump, wherein the screen comprises the error message and a recommended action; and receive a command in response to the error message and the suggested action.
- [06] Certain other aspects disclose an apparatus comprising: a memory; a processor, wherein the processor executes computer-executable program instructions which cause the processor to: receive an auto-programming request, wherein the auto-programming

request comprises patient wristband information, IV bag information, infusion pump information, and optionally patient wristband information; receive infusion program settings; compare the infusion program settings with drug library program settings, wherein the drug library program settings are provided in a drug library stored at the infusion pump; determine that the infusion program settings are inconsistent with the drug library program settings based on the comparing; generate an error message based on the determining; and display a screen at the infusion pump, wherein the screen comprises the error message and a recommended action.

- [07] The details of these and other embodiments of the disclosure are set forth in the accompanying drawings and description below. Other features and advantages of aspects of the disclosure will be apparent from the description, drawings, and claims.

Brief Description of the Drawings

- [08] All descriptions are exemplary and explanatory only and are not intended to restrict the disclosure, as claimed. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and, together with the description, serve to explain principles of the disclosure. In the drawings:
- [09] Figure 1 shows an illustrative schematic diagram of a network for communication with an infusion pump.
- [010] Figure 2 shows an illustrative flowchart for auto-programming an infusion pump without an error being encountered.
- [011] Figure 3 shows an illustrative flowchart for auto-programming an infusion pump with an error being encountered and handled according to the present invention.
- [012] Figure 4 shows an illustrative infusion pump.
- [013] Figures 5 and 6 show illustrative flow diagrams for displaying error messages at an infusion pump.

[014] Figure 7 shows an illustrative flowchart for displaying error messages.

Detailed Description

[015] FIG. 1 illustrates an exemplary schematic diagram of a system for administering medication via an infusion pump. The medication management system (MMS) shown in FIG. 1 comprises a medical management unit (MMU) 3108 and a medical device, such as infusion pump 3130, typically operating in conjunction with one or more information systems or components of a hospital environment.

[016] Intravenous (IV) fluid(s) and/or medication(s) 3100 in containers 3102 may be administered to a patient 3104 using the system shown in FIG. 1. Although the system shown in exemplary FIG. 1 utilizes barcodes and a barcode reader as a means for inputting and reading machine readable information, those skilled in the art will appreciate that other means for inputting and reading information may be utilized. Machine readable indicia or identifying information may be provided by a transmitter, radio frequency identification (RFID) tag, or transponder and read by a radio frequency receiver or transceiver. The system may also utilize digital photography or imaging and scanning technology. Human biometric data, including retina patterns, voice, skin, fingerprints, and the like may also be recognized by an appropriate scanner or receiver. Moreover, POC client 3126 may comprise an identification receiver 32 adapted to recognize such indicia may be provided in the MMS.

[017] In certain aspects, the IV fluids and/or medications 3100 in container 3102 may be provided with new or supplemental labels with a unique infusion order identifying barcode by a pharmacist according to certain hospital practices. Specifically, drug container specific identification information, such as barcoded information on the container 3102 may include patient identification information, including a patient name, patient number, medical record number for which the medication has been prescribed, medication identification information such as a medication name or solution within the IV container 3102, universal identification information which may be created or assigned at the hospital, medical device delivery information, such as the operating parameters to

use in programming an infusion pump to deliver fluids and/or medication 3100 to the patient 3104, and/or medication order information, such as one or more of above information items and/or other medication order information specific to a particular patient 3104, and which may be a part of a medication order for a particular patient. The IV fluids and/or medications 3100 in barcode-identified containers 3102 may be supplied to hospitals by various vendors, with preexisting unique barcode identifiers which include medication information and other information, such as a National Disease Center (NDC) code, expiration information, drug interaction information, and the like.

- [018] In some aspects of the disclosure, the universal identification information on the container 3102 may be a unique medication order identifier that, by itself, identifies the order associated with the container. In other aspects, the identification information on the container 3102 may be a composite patient/order code that contains both a patient ID (such as a medical record number) and an order ID unique only within the context of the patient. In certain aspects, the identification information on the container 3102 may comprise a medication ID. Within a particular hospital, all medication prepared or packaged for patients by the pharmacy may contain either a composite patient/order ID or a universally unique order ID, but generally not within the same hospital. The medication ID alone option may be used only for medication that are pulled by a nurse directly from floor stock at the point of care.
- [019] The system identified in FIG. 1 may comprise a drug library editor (DLE) or DLE computer 3106, such as a notebook, desktop or server computer. The DLE computer 3106 may comprise DLE software that runs on the DLE terminal, computer or workstation 3106, shown as DLE Client in FIG. 1. As described above, a medication management unit (MMU) or computer 3108, such as a server, may have MMU software that is installed and runs on the MMU server 3108. The drug library and other databases may be stored on the MMU server 3108, a separate server, and/or in remote locations.
- [020] Hospital information systems (HIS) 3110 may include one or more computers connected by cabling, interfaces and/or Ethernet connections. Alternatively wireless connections and communications may be used in whole or in part. Servers provide processing

capability and memory for storage of data and various application programs or modules, including but not limited to a module for admissions-discharge-and-transfer (ADT) 3112, a computerized physician order entry (CPOE) module 3114, and a pharmacy information system (PIS) module 3116. Hospital personnel, such as admission clerks 3118, physicians 3120, and pharmacists 3122, respectively, may be authorized to access these modules through client workstations connected to the servers in order to enter data, access information, run reports, and complete other tasks.

[021] In the embodiment shown in FIG. 1, the HIS 3110 may also include a point of care (POC) system 3125 including a server or POC computer 3124 (sometimes referred to as a barcode point of care server or computer), or the POC computer 3124 may be separate from the HIS 3110. The POC computer 3124 may act as a part of a point of care (POC) system 3125 (sometimes referred to as the barcode point of care system or BPOC) and may be able to wirelessly communicate through a plurality of wireless communication nodes located throughout the hospital, utilizing a wireless communications protocol, such as IEEE 801.11, IEEE 802.11, or Bluetooth. The POC computer 3124 may communicate wirelessly with a portable thick client POC or input device 3126 carried by a caregiver. The POC client device 3126 may be a personal digital assistant (PDA) that comprises significant memory, display and processing capabilities. The POC client device may execute a variety of programs stored in its memory in some degree independently of the POC computer 3124.

[022] In one embodiment of FIG. 1, the MMU server 3108 may be hard-wired to the DLE client desktop computer/workstation 3106 and to a MMU client computer/workstation 3128. Alternatively, the MMU and DLE client functions may be combined onto a single client computer/workstation or may reside together with the MMU server 3108 on a single combined MMU/DLE server. The MMU server 3108 may reside in a location remote from the patient's room or treatment area. For instance, the MMU server 3108 may reside in a secure, climate controlled information technology room with other hospital servers and computer equipment and its client terminals may be located in the pharmacy, biomedical engineering area, nurse station, or ward monitoring area. One MMU server 3108 may monitor, coordinate and communicate with many

infusion pumps 3130. For example, in one embodiment, the MMU software running on the MMU server 3108 may support up to one thousand infusion pumps concurrently.

- [023] In embodiment of FIG. 1, the client PDA 3126 in the POC computer system 3125 may communicate through the POC server 3124 with the MMU server 3108. The MMU server 3108 may interface or communicate wirelessly with the infusion pump 3130 through the same wireless nodes 84 utilized by the POC system 3125 and a connectivity engine and antenna on or in the infusion pump 3130. Communication between the infusion pump 3130 and the POC client 3126 may take place through the MMU server 3108 and POC server 3124. The MMU computer 3108 may store in an associated memory both the logical ID and the network ID or Internet Protocol (IP) address of the infusion pump(s) 3130, such that only the MMU computer 3108 may communicate in a direct wireless manner with the infusion pump 3130. Alternatively the MMU 3108 may provide the IP address and other information about the pump 3130 to the POC system 3125 to facilitate direct communication between the POC system 3125 and the pump 3130.
- [024] Upon admission to the hospital, the admission clerk 3118 or similar personnel may enter demographic information about each patient 3104 into an associated memory of the ADT computer or module 3112 of an HIS database stored in an associated memory of the HIS system 3110. Each patient 3104 may be issued a patient identification wristband, bracelet or tag 112 (or other patient identification device) that may include an identifier 3103, such as a barcode or RFID tag for example, representing a unique set of characters, typically a patient ID or medical record number, identifying the patient, sometimes referred to as patient specific identification information. The wristband, bracelet or tag 112 may also include other information, in machine readable or human-readable form, such as the name of the patient's doctor, blood type, allergies, and the like as part of the patient specific identification information.
- [025] The patient's doctor 3120 may prescribe medical treatment by entering an order into the CPOE computer terminal or module 3120 within the HIS system 3110. The order, as prescribed, may specify a start time, stop time, a range of allowable doses, physiological

targets, route, and site of administration. In the case of an order for infusion of fluids or medication, the order may be written in various formats, but typically includes the patient's name, patient ID number, a unique medication order or prescription number, a medication name, medication concentration, a dose or dosage, frequency, and a time of desired delivery. This information may be entered into the memory of the CPOE computer 3124, and may be stored in a memory associated with at least the POC server or computer 3124.

- [026] The medication order may also be delivered electronically to the PIS computer 3116 in the pharmacy and may be stored in an associated memory. The pharmacist 3122 may screen the prescribed order, translate it into an order for dispensing medication, and prepare the medication or fluids with the proper additives and/or necessary diluents. The pharmacist 3122 may prepare and affix a label 102 with drug container specific identifying information 3101 to the medication or drug container 3102. In one embodiment, the label only includes in machine-readable (barcode, RFID, etc.) form a unique sequentially assigned “dispense ID number” that may be tied to or associated with the particular patient ID number and medication order number in the HIS 3110, PIS 3116 and/or POC computer 3125. In another embodiment, the label may include in machine readable form a composite identifier that includes an order ID and a patient ID, which may be a medical record number. In another embodiment, the label does not include a patient ID at all in barcode or machine readable format but includes in machine readable form only a medication ID. Another embodiment may be useful for “floor stock” items that are commonly stocked in operating rooms, emergency rooms, or on a ward for administration on short notice with ad hoc or post hoc orders. In another embodiment, the label may include in machine readable and/or human-readable form medical device specific delivery information including but not limited to the dispense ID number, patient ID, drug name, drug concentration, container volume, volume-to-be-infused (“VTBI”), rate or duration, and the like. Only two of the three variables VTBI, rate and duration may be required to be defined as the third may be calculated when the other two are known. The labeled medication may be delivered to a secure, designated staging location or mobile drug cart on the ward or floor near the patient's room or treatment area. The medication order pending dispensing or administration may be posted

to a task list in the HIS system 3110 and POC system 3125 and stored in an associated memory.

- [027] The caregiver 3132 (e.g., a nurse) may use the identification receiver 32 associated with the POC client 3126 to scan the caregiver specific identification information 3133 or barcode on his/her caregiver identification badge 116 (or other caregiver identification device) and enter a password, which logs the caregiver into the system and authorizes the caregiver to access a nurse's task list from the POC system 3125 through the POC client 3126. The information within the nurse's badge 116 is sometimes referred to as the caregiver specific identification information herein. The caregiver 3132 may view from the task list that IV drugs are to be administered to certain patients 3104 in certain rooms. The caregiver 3132 obtains the necessary supplies, including medications, from the pharmacy and/or a staging area in the vicinity of the patient's room.
- [028] The caregiver 3132 may take the supplies to a patient's bedside, turn on the infusion pump 3130, verify that the network connection icon on the pump 3130 indicates a network connection (for example, a wireless connection such as Wi-Fi or the like) is present, select the appropriate clinical care area (CCA) on the pump, and mount the IV bag, container, or vial 3102 and any associated tube set as required in position relative to the patient 3104 and infusion pump 3130 for infusion. Another connection icon on the pump 3130 or pump user interface screen can indicate that a wired or wireless connection to the MMU server 3108 is present. Using the identification receiver/reader integral to the POC client PDA 3126, the caregiver 3132 may scan the barcode on the patient's identification wristband, bracelet or tag 112 or other patient identification device. A task list associated with that particular patient may appear on the PDA 3126 screen. The task list, which may also include orders to give other forms of treatment or medication by other routes (oral, topical, etc.), may be obtained from the HIS via the POC server 3124 and communicated wirelessly to the POC client PDA 3126. In one embodiment, the list is generated by matching the scanned patient ID with the patient ID for orders in memory within the POC server 3124. In another embodiment, as will be described below, the order information may be obtained by scanning the drug

container specific identification information for associated orders in memory within the POC server 3124, through the following step(s).

- [029] The caregiver 3132 may scan the medication barcode label 102 containing medication container specific identification information 3101 on the medication container 3102 with the PDA 3126. The PDA 3126 may highlight the IV administration task on the task list and send the scanned medication container specific identification information, such as dispense ID information, from the medication container 3102, to the POC server 3124, which uses the medication container specific identification information, such as the dispense ID, to pull together the rest of the order details and send them back to the PDA 3126. The PDA 3126 may then display an IV Documentation Form on its screen. One side of the IV Documentation Form screen may show the order details as “ordered” and the other side may be reserved for a status report from the infusion pump 3130. The status report from the infusion pump 3130 may be transmitted to the PDA 3126 through the POC server 3124 and MMU server 3108, as will be described below. The lower portion of the IV Documentation Form screen may provide the caregiver 3132 with instructions (like to scan the infusion pump 3130 barcode) or identify whether the pump is running or stopped.
- [030] The caregiver 3132 may then scan the barcode label 92 associated with the infusion pump 3130 (or pump channel if the pump is a multi-channel pump). The barcode label 92 may contain medical device specific identification information 3131, such as the logical name and/or logical address of the device or channel. The POC system 3125 then automatically bundles the information into a program pump request containing the “order details” and in one embodiment, without further interaction with the caregiver 3132, transmits this information to the MMU server 3108.
- [031] The program pump request may include at least some of the following information (in HIS/POC system format): a Transaction ID, which may include a Logical Pump ID, a Pump Compartment, a Pump Channel ID, a Reference Device Address, a Caregiver ID, a Caregiver Name, a Patient/Person ID (HIS identifier), a Patient Name, a Patient Birth Date & Time, a Patient Gender, a Patient Weight, a Patient Height, and an Encounter ID

which may include a Room, a Bed, and a Building (including Clinical Care Area or CCA). The program pump request may also include Order Information or “order details”, including an Order ID, a Start Date/Time, a Stop Date/Time, a Route of Administration, a Rate, a Duration of Infusion (Infuse Over), a Total Volume to be Infused (VTBI), an Ad Hoc Order Indicator, and Ingredients including HIS Drug Name or HIS Generic Drug Name, HIS Drug Identifier or HIS Generic Drug ID, Rx Type (Additive or Base), Strength w/units, and Volume w/units. The program pump request may further include Patient Controlled Analgesia (PCA) Orders Only information, such a PCA Mode-PCA only, Continuous only, or PCA and Continuous, a Lockout Interval (in minutes), a PCA Continuous Rate, a PCA Dose, a Loading Dose, a Dose Limit, a Dose Limit Time w/units, a Total Volume in vial or syringe, and Order Comments.

- [032] The MMU 3108 may map or convert the wide range of expressions of units allowed by the HIS system 3110 or POC system 3125 for PDA 3126 requests into the much more limited set of units allowed in the MMU 3108 and infusion pump 3130. For example, the PDA 3126 request may express “g, gm, gram, or grams” whereas the MMU 3108 and/or infusion pump 3130 may accept “grams” only. Infusion pump 3130 delivery parameters or infusion pump 3130 settings are mapped or converted from corresponding order information or “order details” of the program pump request.
- [033] The MMU 3108 may store in an associated memory a mapping or translation table that keep track of the logical ID, serial number or other identifier of an infusion pump 3130 and the corresponding current network (static or dynamic) address (Internet Protocol (IP) address) or ID of the infusion pump 3130 on the network, which in this example is a wireless network. The MMU 3108 may be able to translate or associate a given identifier of the infusion pump 3130 with its network address in the translation table and provide the network IP address to the requesting POC system 3125 or device. The MMU 3108 may also store in an associated memory and/or may look up the drug library applicable to the scanned infusion pump 3130 and may also convert the Drug ID and Strength from the pump program request into an index number of the medication at the desired strength or concentration from the drug library. The duration of the infusion may come from the POC system 3125 in hours and minutes and may be converted to just

minutes for the infuser to recognize it. Volume or VTBI may be rounded to provide a value-specific and infuser-specific number of digits to the right of the decimal point. Units (of drug) may be converted to million units where appropriate. Patient weight may be converted and either rounded according to infuser-specific rules or not sent to the infuser.

- [034] Once the MMU 3108 transforms the information from the program pump request into infusion pump settings or delivery parameters and other information in a format acceptable to the infusion pump 3130, the MMU 3108 may wirelessly download a command message to the infusion pump 3130. If the infusion pump 3130 is not already equipped with the latest appropriate version of the hospital-established drug library, the MMU 3108 may also automatically download a drug library to the infusion pump 3130. The hospital-established drug library may be maintained in a separate process undertaken by the biomedical engineer or pharmacist 3122 to place limits on the programming of the infusion pump 3130, as well as other infusion pump operating parameters such as default alarm settings for air in the line, occlusion pressure, and the like. The drug library may set up acceptable ranges or hard and/or soft limits for various drug delivery parameters in the infusion pump 3130.
- [035] The MMU 3108 may also download to the infusion pump new versions, patches, or software updates of the infusion pump's internal operating system software. The infusion settings or delivery parameters and other information from the MMU 3108 may be entered into the memory of the infusion pump 3130 and the infusion pump 3130 settings may automatically populate the programming screen(s) of the infuser, just as if the caregiver 3132 had entered the information and settings manually. The infusion pump 3130 screen may populate with the name of the drug and drug concentration based on the drug library index number, patient weight (if applicable), rate, VTBI, and duration (only two of the last three variable are sent by the MMU 3108 because the pump 3130 may calculate the third from the other two). A return message of confirmation signal may be sent to the MMU 3108 by the infusion pump 3130 to indicate that the command message has been received. At this point, if necessary, the caregiver 3104 may

manually enter any additional infusion settings or optional information that was not included in the command message.

- [036] The infusion pump 3130 may then prompt the caregiver 3132 to start the infusion pump 3130 by pressing the start button. When the caregiver 3132 presses the start button, a confirmation screen with the infusion settings programmed may be presented for confirmation and an auto-program acknowledgment message can be sent to the MMU server 3108 to forward without request (i.e., pushed in a near real-time manner) or provide to the POC system 3125 when requested or polled. When the caregiver 3132 presses the button to confirm, the infusion pump 3130 may begin delivering fluid according to the programmed settings. The infusion pump 3130 may send a status message to the MMU 3108 indicating that the infusion pump 3130 was successfully auto-programmed, confirmed and started by the caregiver 3132, and is now delivering fluid. This information may also be displayed at the infusion pump. The MMU 3108 may continue to receive logs and status messages wirelessly from the infusion pump 3130 periodically as the infusion progresses or when alarms occur.
- [037] The MMU 3108 may report a portion of the initial status message to the PDA 3126 through the POC server 3124 (in MMU format) to indicate that the infusion pump 3130 has been auto-programmed and the caregiver 3132 has confirmed the settings. The MMU 3108 may communicate to the POC system 3125 and/or at the infusion pump 3130 the actual Rate, VTBI and Duration. A notation at the bottom of the PDA screen and/or the infusion pump may indicate that the infusion pump 3130 is running. The infusion pump 3130 may compare and give a visual, audio or other type of affirmative signal if the pump information matches or acceptably corresponds with the ordered information. An initial determination of whether the pump information matches the order may be done in the MMU 3108 and communicated to the PDA 3126 through the POC server 3124. Alternatively, the POC server 3124 or the infusion pump 3130 may make the necessary comparisons. If the pump information does not match the order, the infusion pump 3130 at the display 88 may output a visual, audio or other type of negative signal, which may include an error message.

- [038] The caregiver 3132 may be prompted to review and press a save button on the infusion pump 3130 if the order has been begun as desired or any variations are acceptable. In a separate subsequent step, the nurse may electronically sign the record and presses a send button on the POC client PDA 3126 to send the information to the patient's electronic medication record (EMR) or medication administration record (MAR).
- [039] Referring now to FIGS. 2 and 3, flowcharts further illustrate a system and method for notifying a caregiver (e.g., caregiver 3132, such as a nurse) at an infusion pump 3130 of the status of administration of fluid and/or medication 3100 to a patient 3104 according to aspects of the disclosure. In one embodiment, the POC system 3125 sends a program pump message containing infusion pump settings to the MMU computer 3108, which looks up the targeted infusion pump 3130 according to its identifier and relays the infusion pump settings to the pump 3130. In another embodiment, when the POC system 3125 is auto-programming the infusion pump 3130, the POC system 3125, including the POC computer 3124 and/or the POC client 3126 may request the MMU 3108 for permission to program the infusion pump 3130. The MMU computer 3108 may grant this permission and then the POC system 3125 may communicate directly with the infusion pump 3130, without intervention by the MMU computer 3108. The MMU computer 3108 may continually receive asynchronous or synchronous near real-time status messages and event logs from the infusion pump 3130 and store this information in an associated memory for purposes of at least displaying infusion pump 3130 status and generating reports.
- [040] In certain aspects of the disclosure, prior to beginning the workflow illustrated in FIGS. 2 and 3, a caregiver 3132 may first be required to use POC system 3125 to scan an identifier of the caregiver's ID badge 116. The POC system 3125 may then determine if the caregiver 3132 is a valid POC system 3125 user. The POC system 3125 may also require the caregiver 3132 to enter a password, user name, and/or other information.
- [041] As shown in FIGS. 2 and 3, the caregiver 3132 may initiate the workflow for automatically programming the infusion pump 3130 by scanning the patient's wristband (step 201), scanning the IV bag (step 203), and scanning the infusion pump (step 205).

At step 201, the caregiver 3132 may use a scanner, such as identification receiver 32 at POC client 3126, to scan the identifier on the patient's wristband, bracelet, or tag 112. The patient ID, which may be a medical record number, an account number or some other identifier that the care facility uses to positively identify the patient, may be retained in a memory in the POC client 3126.

- [042] At step 203, the caregiver 3132 may use the POC client 3126 to scan the identifier 3101 on the identification label 102 on the IV bag 3102. The container ID 3101 may comprise machine-readable indicia such as a bar code, RFID tag, or the like. The container ID 3101 may be a universally unique order ID so that the HIS 3110 or POC system 3125 may retrieve information about the association medication order without having to scan the patient ID on the patient wristband, bracelet, or tag 112 (or other patient identification device) or rely on such patient ID information for comparison purposes. Alternatively, the container ID may be a composite ID that includes patient ID or some portion thereof and an order ID related to that particular patient. Alternatively, the container ID may be an absolute or unique pharmacy order identifier that may be generated by the order entry or pharmacy information systems. Alternatively, for commonly used containers that are stocked on the ward or patient care floor, like dextrose, saline or other solutions, the container ID may be a medication ID that includes only medication-specific information, including but not limited to medication name, concentration (if applicable) and volume.
- [043] At step 205, the caregiver 3132 may use the POC client 3126 to scan the barcode label 92 or RFID tag on the infusion pump 3130 or a channel of the pump to obtain medical device specific identification information 3131 on the identifier. Thus, the POC client 3126 may receive or capture the pump ID or identifier information. Steps 201, 203, and 205 may be performed in any order. For instance, the caregiver 3132 may perform step 203 first, followed by steps 201 and 205, or may perform step 205 first, followed by steps 203 and 201, and the like.
- [044] As shown in FIGS. 2 and 3, the information scanned by the caregiver 3132 at steps 201, 203, and 205 may be transmitted to the patient's electronic medical records (EMR) and/or the barcode medication administration (BCMA). In certain aspects, the caregiver 3132,

after performing the scans with the POC client 3126, may select a button (such as a “start” or “done” button) on the POC client 3126. Selection of the button may cause the POC client 3126 to transmit the scanned information to the EMR/BCMA. The BCMA may comprise, for example, POC system 3125.

- [045] Based on the received scanned information, the EMR/BCMA within the HIS 3110 may look up patient demographic information it received from the Admission, Discharge and Transfer (ADT) system 3112 and an infusion order for the patient or medication it received from the Pharmacy Information System (PIS) 3116. Software in POC system 3125 may then perform a variety of safety checks, comparisons or matching functions to ensure that the right drug is administered to the right patient, at the right rate, in the right dose, at the right time, via the right route, and by an authorized or right caregiver, etc. as is conventional in the BCMA art. The BCMA/POC system 3125 then transmits an auto-programming message containing infusion pump settings to the MMU 3108.
- [046] At step 209, based upon the pump identification information contained in the auto-programming message, the MMU 3108 may then look up the infusion pump network location to determine the pump that is targeted to receive the infusion pump settings contained in the auto-programming message.
- [047] At step 211, the MMU 3108 may send the infusion pump settings to the infusion pump 3130 using the pump’s IP address. At step 213, the infusion pump 3130 may receive the infusion pump setting and then verify the infusion program settings against the installed drug library. In other words, the infusion pump 3130 may ensure that the received program settings for the patient 3104 are consistent with the information provided in the drug library. Steps 215, 217, and 219 shown in FIG. 2 illustrate exemplary steps that may be performed after the infusion pump has determined that the program settings are consistent with the permissible settings specified in the drug library of the pump 3130. As discussed further below, steps 315, 317, and 319 shown in FIG. 3 illustrate exemplary steps that may be performed after the infusion pump has determined that the program settings are inconsistent with the permissible settings specified in the drug library of the pump 3130.

- [048] As shown in FIG. 2, at step 215, after the infusion pump 3130 has verified that the program settings are consistent with the drug library, the infusion pump may populate the program settings, for example at display screen 88. The infusion pump 3130 may display one or more program settings at display screen 88, such as drug name, drug concentration, container volume, VTBI, rate or duration, and the like. The infusion pump 3130 may also display a request for a nurse to confirm the displayed program settings.
- [049] At step 217, the caregiver 3132 may review and verify that the displayed infusion program settings were correctly populated. The caregiver 3132, in some aspects, may be required to select a button at the infusion pump 3130 in order to indicate confirmation that the infusion program settings were correctly populated. In response, the infusion pump 3130 may display a start button on screen 88 that enables the caregiver 3132 to start the infusion in accordance with the final confirmed programmed pump settings. The caregiver 3132 may select the start button to start the infusion program at step 219.
- [050] Referring now to FIG. 3, workflow steps illustrate an exemplary process in which the infusion pump settings are inconsistent with the settings stored in the drug library. The process illustrated in FIG. 3 comprises the same steps 201, 203, 205, 207, 209, 211, and 213 as FIG. 2. However, the auto-programming workflow illustrated in FIG. 3 comprises exemplary steps 315, 317, and 319, not performed at FIG. 2, and which may be performed after infusion pump 3130 determines that the infusion program settings are inconsistent with the drug library at step 213.
- [051] At step 315, infusion pump 3130 may display an error message. The error message may be reported to the MMU 3108 at step 315a. The error message may be relayed and reported to the EMR/POC system 3125 via the MMU server 3108 at step 315b. Alternative, the error message can be reported directly from the pump 3130 to the EMR/POC system 3125 through any wired or wireless networks available in the hospital. Most importantly, the error message may be displayed at or on the display screen 88 of infusion pump 3130. Thus, even if the caregiver has limited or no access to the POC client or other computer systems within the hospital at the time, they will be advised of auto-programming errors at the pump 3130. As will be discussed in greater detail below,

the error message may notify the caregiver 3132 of the rejection of the auto-programming request. The error message may comprise an error code and a brief description of the error cause. The error message may further comprise suggested actions for the caregiver 3132 to perform in response to the error message. For example, if the keypad is locked, the infusion pump 3130 may output an error message KLO00017 stating “The auto-program is not valid because the keypad is locked.” The infusion pump 3130 may also display, on the same screen, a suggested or recommended action, e.g., “Unlock the keypad”. A table of errors, including exemplary code numbers, descriptions and recommended actions are included below in Table 1.

[052] Table 1 – Messages and Suggested Actions Relating to Auto-Programs

Error Code	Message	Action
EPC00001	Order rejected. Physician’s order for an automatically programmed therapy exceeds the capabilities of the pump.	Recheck the order with pharmacy or physician.
HLV00002	Order rejected. Physician’s order for an automatically programmed therapy exceeds a hospital-defined drug library hard limit.	Recheck the order with pharmacy or physician.
NTA00003	The auto-program received contains duration information, and you cannot titrate the duration of a delivery with this dosing unit(s).	Press [OK] now, or wait for this screen to automatically dismiss.
MRI00004	The auto-program received did not contain all required information.	Press [OK] now, or wait for this screen to automatically dismiss.
SLV00005	The auto-program received contains a value that exceeds a system limit. Or the values cause a calculated parameter to exceed a system limit.	Press [OK] now, or wait for this screen to automatically dismiss.
MCD00006	The auto-program received contained a medication which is different from what is delivering on the programmed line.	Press [OK] now, or wait for this screen to automatically dismiss.

UPD00007	The auto-program is for a line that contains unconfirmed programming data.	Resubmit the auto-program. All unconfirmed data will be cleared.
LIS00008	The auto-program is for a line which is in Standby.	Clear this line and resubmit the auto-program.
LDS00009	The auto-program is for a line which is in Delay Start.	Clear this line and resubmit the auto-program.
ACP00010	The auto-program is for a line that has an active alarm that stops or prevents delivery, thus the auto-program is not valid in this alarm condition.	Clear alarm condition and resubmit the auto-program.
COV00011	The auto-program is not valid due to concurrency violation. Delivery A+B greater than 500 mL/hr or less than 0.5 mL/hr for each line.	Press [OK] now, or wait for this screen to automatically dismiss.
NIB00012	The auto-program is not valid for line B. The medication delivering on line A cannot be interrupted.	Press [OK] now, or wait for this screen to automatically dismiss.
NMW00013	The auto-program is not valid because the weight in the auto-program does not match the weight on the program delivering on the other line.	Press [OK] now, or wait for this screen to automatically dismiss.
NMH00014	The auto-program is not valid because the height in the auto-program does not match the height on the program delivering on the other line.	Press [OK] now, or wait for this screen to automatically dismiss.
NMB00027	The auto-program is not valid because the BSA in the auto-program does not match the BSA on the program delivering on the other line.	Press [OK] now, or wait for this screen to automatically dismiss.
NCS00015	The auto-program is not valid because a CCA has not been selected on the infuser.	Select a CCA and resubmit the auto-program.
NVD00018	The auto-program is not valid because the received parameters will not result in a valid dose.	Press [OK] now, or wait for this screen to automatically dismiss.
NDT00016	The auto-program is not valid	Press [OK] now, or wait for

	because the drug in the confirmed program was a “No Drug Selected” auto-program and titration is not allowed.	this screen to automatically dismiss.
ZVV00019	The auto-program is not valid because the Rate cannot be titrated when VTBI is 0.	Press [OK] now, or wait for this screen to automatically dismiss.
NCP00020	The auto-program is not valid because it is a titration for a line that has no confirmed program.	Press [OK] now, or wait for this screen to automatically dismiss.
KLO00017	The auto-program is not valid because the keypad is locked.	Unlock the keypad.
MLV00021	The auto-program is not valid for a line with a Multistep or Loading dose program.	Press [OK] now, or wait for this screen to automatically dismiss.
NIA00022	The auto-program is not valid for line A. The medication in the auto-program is not interruptible and Line B is delivering a Piggyback infusion.	Press [OK] now, or wait for this screen to automatically dismiss.
ICD00023	The auto-program for this infuser was rejected by Hospira MedNet due to incomplete or corrupt data.	Press [OK] now, or wait for this screen to automatically dismiss.
DLI00024	The auto-program for this infuser was rejected by Hospira MedNet due to drug library incompatibility.	Press [OK] now, or wait for this screen to automatically dismiss.
PPL00025	The auto-program is rejected because of a partially programmed line.	Press [Clear] and resubmit the auto-program. All unconfirmed data will be cleared.
ITP00026	<p>The auto-program is rejected because auto-programming is performed on a line in the PENDING or PUMPING state and the Post Infusion Rate (KVO or RATE) is interpreted as not being a titration.</p> <p>A pump with an installed cassette was started. The CCA was selected. Line A</p>	Press [OK] now, or wait for this screen to automatically dismiss.

	<p>was programmed and delivery was started. A barcode was scanned and an order on line A was placed. The auto-program for line A was sent to the infuser.</p> <p>The infuser determines that the auto-program is a new delivery based on titration rules and rejects the auto-program.</p>	
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[053] At step 317, the caregiver 3132 may review and respond to the error message displayed at the infusion pump 3130. The caregiver 3132 may provide a response that comprises at least one of a modification to the auto-programming request, performing the actions suggested at the pump 3130, and/or rejecting or clearing the error message and suggested action. Based on the response to the error message received at step 317, pump 3130 may perform an operation at step 319. For example, after displaying the error message provided above and suggested action “Unlock the keypad”, infusion pump 3130 may receive a response from the caregiver 3132 that the keypad has been unlocked. The caregiver’s action of unlocking the keypad may itself serve as the response to the error message at step 317. Thereafter, the operation performed at step 319 may comprise the infusion pump starting the infusion program similar to or the same as step 219 illustrated in FIG. 2. Thus, if the caregiver 3132 responds to the error message at step 317 by performing the suggested action, the infusion pump 3130 may, at step 319, automatically start the requested infusion auto-program. The caregiver 3132 may respond to the error message by adjusting program settings such as dose, rate, VTBI, duration, and the like on the infusion pump 3130.

[054] In some aspects, the caregiver 3132 may reject or override the error message displayed at step 315. The caregiver 3132 may override the error message at step 317 in cases of soft limit violations. Some limit violations may require entry of a special override code or input of a code from a second caregiver or supervisory personnel. In another aspect of

the invention, the infusion pump 3130 may display an error message that a pump channel is “Already in Use”. The caregiver 3132 may investigate and determine that the pump is not in use. The caregiver 3132 may send a response rejecting the error message and indicating that the pump channel is not currently in use. The pump 3130 may then return to step 213 to verify infusion program settings against the installed drug library or may automatically start the infusion program at step 219.

[055] In certain aspects, the caregiver 3132 may not input a response into infusion pump 3130 within a predetermined time. The lack of a response within this predetermined time may itself server as a response to error message 317. Specifically, the infusion pump 3130 may be configured (for example, by the manufacturer or the hospital via the user customized drug library configuration settings downloaded to the pump by the MMU) to timeout after a predetermined time. The predetermined time may be about 15 seconds, 30 seconds, 35 seconds or any other amount of time. If the infusion pump 3130 does not receive a response within the timeout period (or predetermined time), the infusion pump 3130 may reject the auto-program and display a previous or home screen at display screen 88. In this case, the operation performed at step 319 may comprise clearing the error message and displaying a previous or home screen at the pump 3130.

[056] FIG. 4 illustrates an enhanced view of the exemplary infusion pump 3130 comprising display screen 88. The exemplary screens provided in FIGS. 5 and 6 may be displayed at display screen 88. The infusion pump 3130 may display error messages, error codes, and suggested actions at display screen 88. The display screen 88 includes a plurality of areas or regions such as a status region 88A, a working region 88B, and a message region 88C. The pump may comprise a memory, a processor, a clock (real time or otherwise) and other components. The memory may store computer-executable program instruction. Moreover, the processor may execute the computer-executable program instructions, which may cause the processor to perform one or more steps recited in the present disclosure.

[057] FIGS. 5 and 6 illustrate exemplary flow diagrams for displaying error messages at display screen 88. Prior to turning on the multi-channel infusion pump 3130, a cassette may or

may not first be required to be installed in the infuser. A caregiver 3132 may install the cassette into the door of pump 3130 and then close the door. Next, the nurse may turn on the infusion pump 3130 by pressing an ON/OFF button, such as the ON/OFF button 405 shown in FIG. 4. After the ON/OFF button 405 is pressed, infusion pump 3130 may begin its startup process. After the startup process, which may take up to a few minutes, the infusion pump 3130 may be prepared to accept an auto-programming request.

[058] At this point, infusion pump 3130 may display screen 501. Display screen 501 may be referred herein as the A/B screen or home screen. As shown in FIG. 5, screen 501 may display (in the working region 88B or elsewhere) delivery information for channel A and channel B, such as the rate and volume infused or volume to be infused (VTBI). Because an auto-programming request has not yet been received, the initial values for the delivery information may be set at 0 as shown in screen 501. The home screen 501 may also display a selected CCA (here shown directly below the Volume Infused or Volume To Be Infused (VTBI) as “ICU,” which represents an intensive care unit). Home screen 501 may also display instructions or suggested actions that could be taken by a caregiver 3132. For example, screen 501 may initially display suggested action “Select Line A/B to program” as shown in FIG. 5. The suggested action may alert the caregiver 3132 of the next steps to be taken in order to submit a manual or an auto-program request. In certain aspects, infusion pump 3130 may display the suggested actions at screen 88 in a different color and/or with different shading than other information displayed on the screen. Exemplary screens shown in FIGS. 5 and 6, for example, display the suggested actions in white text with black shading in contrast to other information displayed in black text and white shading. Moreover, the suggested actions may be displayed in a particular section, region or area of each screen, such as in the message region near the bottom of each screen shown in FIGS. 5 and 6.

[059] The screens displayed at the infusion pump 3130 may include other indicators, such as a battery life indicator 563 (which may indicate the amount of battery life remaining for the pump 3130), a wireless signal indicator 565 (which may indicate the strength of the wireless signal connection at pump 3130), and a two-way arrow 561 (which may indicate

connection between the MMU and the pump and thus the capability of pump 3130 to upload and download information to and from the MMU server 3108).

- [060] Screens, as shown in FIGS. 5 and 6, may further comprise various input options. The input options may be presented in a row at the bottom of the screen (such as directly below the suggested actions as shown in FIGS. 5 and 6). Each input option may be an option that may be selected by a caregiver 3132. In some aspects, the caregiver 3132 may touch the screen itself to select an input option, and in other aspects, the caregiver 3132 may select a corresponding soft key or button directly below the input option. See the triangles below the screen 88 and the input options in FIG. 4. Other options and text, such as “OK”, “Continue”, “Reject”, “Yes”, “No”, “Standby”, “Standby Confirmation”, “Delay Start”, “Return to A/B”, etc. may be displayed in the message region 88C and selected by caregiver using a touchable screen or the corresponding soft key below the displayed option or text. In response to the display at screen 501 and the suggested action “Select Line A/B to program”, caregiver 3132 may select either input option “A”, input option “B”, or input option “Settings/Vols/CCA”. Selecting option “Settings/Vols/CCA” may cause infusion pump 3130 to display a screen in which caregiver 3132 may edit settings, the way volume is displayed (volume infused versus volume to be infused or VTBI), or a CCA for the infusion pump 3130. Selecting either option “A” or “B” may initiate the auto-program sequence for that selected channel.
- [061] At step 551, infusion pump 3130 may determine whether an auto-programming request has been received. In other words, infusion pump 3130 may determine whether the steps described with respect to FIGS. 1-3 have been performed, particularly steps 201, 203, 205, 207, 209, and 211.
- [062] At step 553, the infusion pump 3130 may determine whether it needs to change the auto-program drug order to “No Drug Selected”. The analysis performed at step 553 is an example of the various analyses that may be performed when the infusion pump 3130 verifies the infusion program settings against the installed drug library at step 213. Thus, as the pump 3130 performs its verification step 213, one of the plurality of verification actions it may perform may include determining whether the medication selected by

caregiver 3132 is stored in the drug library for the selected CCA. For example, caregiver 3132 may select the CCA “ICU” prior to auto-programming. Then the caregiver 3132 may select or scan medication using POC client 3126 at step 203. After pump 3130 receives the auto-programming request for the ICU CCA, pump 3130 may verify the program settings against installed settings stored in its drug library at step 213. One of the verification steps may include determining whether the selected or scanned medication is included among the medications stored in the drug library for the ICU CCA. In other words, a processor of the pump 3130 makes a comparison between the drug name, concentration and dosing units provided in the auto-programming request to the same parameters in the drug library for the particular clinical care area selected or active on the pump. If, in the drug library, the selected medication is not among the listed medications available for the ICU CCA, pump 3130 may be programmed to output “No Drug Selected” as a substitution alert error message. At step 553, if the pump 3130 determines that it must change the order to “No Drug Selected”, it may display an error message such as screen 503.

- [063] The error message may comprise a brief description of the error so that the caregiver 3132 may be able to quickly determine the cause of the error at the pump 3130 and perform subsequent actions in response to the error. In the example provided at screen 503, processor of the pump 3130 may perform a drug name, concentration, dosing units, or drug ID comparison against the drug list in the drug library on the pump for the selected clinical care area or CCA and display at display screen 88 the error message “The Auto-Program contains a medication which is not available in the CCA (ICU)” and “For this order the medication ‘No Drug Selected’ has been substituted”. The pump 3130 may display a “Substitution Alert” in the status region or elsewhere on screen 503 to notify caregiver 3132 that an error has occurred. The error message may then notify the caregiver 3132 of the precise cause of the error (here, the selected CCA and the fact that the auto-program contained a medication that, pursuant to the hospital’s best practices as set forth in the customizable drug library, is not planned to be available in the CCA). The error message may also, in some aspects display the actions taken by the pump 3130 in response to the error (here, “No Drug Selected” has been substituted for the medication

by the processor of the pump because it found no match for the medication in the drug library entries for the selected CCA).

[064] Also shown in the message region or elsewhere on the screen 503 is the suggested action “Continue with no drug selected or Reject program”. The suggested action may notify caregiver 3132 that s/he should either select the input option “Continue” in order to continue the auto-program request with no drug selected substituted for the medication, or select the input option “Reject” to cancel the auto-program request. The input options may be displayed immediately below the suggested action, as shown in screen 503. If the caregiver 3132 selects the “Reject” option, pump 3130 may deny the auto-program request and display a previous screen such as home screen 501. A message concerning the rejection of the auto-program request may be sent to the MMU server 3108, which then relays the message to the POC system 3125. In certain aspects, screen 503 may be displayed for a predetermined amount of time, such as about 30 seconds. If no response or input option is selected within that predetermined amount of time, pump 3130 may automatically reject the auto-programming request and display screen 501. If, instead, the caregiver 3132 selects the “Continue” input option, pump 3130 may display screen 505 where the rest of the auto-programmed delivery information is pre-populated on the pump screen 88 in the working region 88B or elsewhere as shown on screen 505. At screen 505, caregiver 3132 may edit the delivery information, such as rate, VTBI, and duration. Screen 505 may continue to display “No Drug Selected” in or near the status region 88A at the top of the screen and a suggested action “Enter value using keypad” in the message region 88C at the lower portion of the screen 88. Pump 3130 may also highlight the field that may have its value edited (here, e.g., “500” for VTBI in mL) or do so when activated by touch or other keys. The caregiver 3132 may enter these values on the keypad 401 provided at the pump 3130, as shown in FIG. 4.

[065] At step 555, pump 3130 may determine if the start button 403 (FIG. 4) has been selected or pressed by the user. If so, pump 3130 may display a screen such as screen 507. The screen 507 may correlate with step 217 in which the caregiver 3132 verifies the infusion program settings were correctly populated. Caregiver 3132 may select input option “No” to return to screen 505 and edit one or more of the displayed delivery information values.

Alternatively, caregiver 3132 may select the “Standby” input option to standby for a predetermined or configurable period of time to await confirmation of the medication delivery. If the “Yes” input option is selected, pump 3130 may start the infusion program at step 219 and may display screen 509. Screen 509 may notify the caregiver 3132 that medication is pumping on the selected channel (here, channel A) at the selected rate (here, 250 mL/hr) and display a current Volume Infused (here, 0.1 mL). Screen 509 may also display the suggested action “Select Line A/B to program”, which may enable the caregiver 3132 to edit or submit another auto-program request for channel A or B. In certain aspects, channel A may be a primary channel for administering medication and channel B may be a secondary line for administering medication.

[066] FIG. 6 illustrates another example of a flow diagram of screens displayed at pump 3130. The series of screens shown in FIG. 6 begins at screen 601, which may be similar to screen 509 shown in FIG. 5. In the example provided in FIG. 6, a caregiver 3132 may request an auto-program at pump 3130 even as channel A is pumping. Here the pump 3130 is pumping Dopamine, a commonly prescribed vasoactive medication for controlling blood pressure. Dopamine is prescribed based on the patient’s weight, which in this example is 70 kg. The Dopamine is supplied at a concentration of 400 mg in a 250 mL container. The prescribe dose is 5.0 mcg/kg/min, which the pump converts to a rate of 13.1 mL/hr. The pump 3130 has pumped 240 mL so far. Similar to step 551 of FIG. 5, the pump 3130 may determine in step 651 whether an auto-programming (AP) request has been received for channel A. The request may be received after steps 201, 203, 205, 207, 209, and 211 have been performed. At step 213, pump 3130 may verify infusion program settings against program settings stored in the drug library. In some aspects, pump 3130 may further verify the infusion program settings against settings hard-coded into the pump. The verification step 213 of FIG. 2 or FIG. 3 may comprise step 653 of FIG. 6, in which pump 3130 may determine whether the auto-program request for channel A is for the same medication currently being delivered at channel A. In one aspect, the concept of the “same medication” can comprise the same medication by name (generic or brand), and one or more of concentration and dosing units. If the medication in the auto-program request for channel A is Dopamine, it might be okay and not trigger a mismatched medication/concentration error (code MCD00006 in Table 1 above).

However, if the pump determines in step 653 that a different medication is specified in the auto-program request received in step 651, such as Morphine for example, the pump 3130 displays the error message shown on screen 603.

[067] Screen 603 may display “Rejection Alert” in the status region or another region of the screen to notify caregiver 3132 of an error. Screen 603 may also display the error message, such as “The Auto-Program received contained a medication which is different from what is delivering on the programmed line” in the working region or another region. Thus, the caregiver 3132 may be notified at the pump 3130 that there has been an error and the cause of the error. In some aspects, this error message may also display the medication that is being delivered on the channel, and/or other information such as the concentration and or dosing units of the medication order. For example, the error message at screen 603 may display “The Auto-Program received contained a medication [Morphine] which is different from [Dopamine] that is delivering on the programmed line” or “The Auto-Program received contained a medication which is different from the [Dopamine 400 mg/250 mL] that is delivering on the programmed line”. Screen 603 may also display the suggested action for this error message in the message region or another region, in this case “Reject this order now, or wait for automatic rejection?” Pump 3130 may provide one or more one input options at screen 603, e.g., an option to reject the auto-program order. Caregiver 3132 may select the “Reject” option to return to screen 509. Alternatively, caregiver 3132 may not select an input option at all, in which case pump 3130 may automatically reject the auto-program order after the timeout period, such as about 30 seconds.

[068] If, at step 653, pump 3130 determines that the medication in the auto-programming request is the same as the medication currently pumping on channel A, pump 3130 may display screen 605. Similar to screen 505, discussed above, screen 605 may enable a caregiver 3132 to modify the settings of the delivery information values, such as concentration, rate, VTBI, and duration. Also shown at screen 605 is an input option “Delay Start”. A caregiver 3132 may select the “Delay Start” input option in order to select a later time in which to begin pumping of the auto-program medication.

Alternatively, caregiver 3132 may select the “Return to A/B” input option to return to screen 509.

- [069] At step 655, pump 3130 determines if the start button 403 (as shown in FIG. 4) has been selected. If so, pump 3130 may display screen 607. Caregiver 3132 may be able to review the information displayed at screen 607, similar to screen 507 as discussed above. Caregiver 3132 may then select the “Yes” input option to verify that the infusion program settings were correctly populated at step 217. In response, pump 3130 may start the infusion program at step 219 and the infusion pump 3130 may display screen 609.
- [070] Some other examples of error messages that may be displayed by the pump 3130, for example at screens such as screens 503 and 603, will now be discussed in further detail. In certain aspects, pump 3130 may determine an error at step 213 without any outside intervention from, for example, MMU, HIS, BCMA, EMR, and the POC system. In some cases, pump 3130 may allow an auto-programming order to continue after displaying an error message. Pump 3130 may also notify parties, such as MMU, HIS, BCMA, EMR, and the POC system of an error and the error message that was displayed. Those of ordinary skill in the art will appreciate that the error messages disclosed herein are exemplary, and may be modified without veering from the scope of this disclosure.
- [071] Pump 3130 may display an error message such as associated with error code NTA00003 in Table 1 above, “The auto-program received contains duration information, and you cannot titrate the duration of a delivery with this dosing unit”. This error message will be displayed when the infuser receives an auto-program message with a titrated duration value and is for a medication that normally has time-based alternative dosing units. For example, if the drug involved in the program has time-based alternative dosing units the caregiver is not allowed to change the duration because such an action would change the associated dose. Examples include but are not limited to vasoactive drugs like nitroglycerin or Dopamine dosed in mcg/kg/min, anti-coagulants like Heparin dosed in units/kg/hour, diabetes control drugs like Insulin dosed in Units/kg/day, and oncolytic drugs like Taxol dosed in mg/m²/day. The particular drugs or categories of drugs for which this type error is generated can be established by the hospital according to their

preferences in their user customizable drug library. On the same screen, pump 3130 may display the suggested action, e.g., “Press OK now, or wait for this screen to automatically dismiss”. After selection of the “OK” input option or waiting for the screen to automatically dismiss after the timeout period, pump 3130 may display the home A/B screen.

- [072] In some aspects of the disclosure, pump 3130 may display an error message such as “The auto-program received did not contain all required information”. Generally, the auto-programming message should include at a minimum the following information: pump channel, drug name and concentration. If one or more of these elements, parameters or settings is missing, the above-mentioned error message is displayed. On the same screen, pump 3130 may display the suggested action, e.g., “Press OK now, or wait for this screen to automatically dismiss”. As discussed above, after selection of the “OK” input option or waiting for the screen to automatically dismiss after the timeout period, pump 3130 may display the home A/B screen.
- [073] Pump 3130 may be programmed to generate and display an error message such as “The auto-program received contains a value that exceeds a system limit. Or the values cause a calculated parameter to exceed a system limit.” One or more system limits may be hard-coded into pump 3130 and/or included in the drug library. The system limits may pertain to a rate. For example, the pump 3130 may be able to pump at a maximum rate of 999 mL/hr. If an auto-program request is received at a rate greater than 999 mL/hr., for example say 2000 mL/hr., pump 3130 may display the error message. Similar system limits may exist for other information such as duration, VTBI, and the like. Along with the error message, pump 3130 may display the suggested action, e.g., “Press OK now, or wait for this screen to automatically dismiss”.
- [074] In some instances, pump 3130 may display an error message such as “The auto-program is for a line that contains unconfirmed programming data”. This might happen if the caregiver got called away on an emergency to help another patient or co-worker before confirming the programming data. Pump 3130 may also display the corresponding suggested action “Resubmit the auto-program. All unconfirmed data will be cleared.”

Thus, in response to the error message, caregiver 3132 may either resubmit the auto-program or reject the auto-program. If the user elects to resubmit the auto-program, all of the unconfirmed data previously entered will be cleared and thereafter replaced with the data from the resubmitted auto-program. If the caregiver rejects the auto-program, the unconfirmed data will be maintained and the user is taken to the last input screen used or the home A/B screen.

- [075] Pump 3130 may generate an error message at screen 603 stating “The auto-program is rejected because of a partially programmed line.” A line is partially programmed when a drug is selected for the line and the line program has not been cleared or confirmed. A pump with an installed cassette was started. The CCA was selected. A new IV bag containing the same or different drug was hung. The user manually selects one of the lines and a medication on the pump. The user then switches part way through the programming sequence to the auto-program process, wherein the barcode on the drug container is scanned and the order sent. The standard auto-program for line A is sent to the infuser, which rejects the auto-program because a manual program was already partially input. On the same screen, the suggested course of action is displayed: “Press [Clear] and resubmit the auto-program. All unconfirmed data will be cleared.”
- [076] Caregiver 3132 may select a “Standby” input option at pump 3130 for a particular channel. The standby input option is selected to suspend for an indefinite time, up to 72 hours, an infusion that has already been programmed on a particular channel or infusion line. The standby option can be used prior to an infusion being started if the caregiver is unsure of the time the infusion should be started. For example, the caregiver can set up the pump and it can be programmed, but the patient may not yet be present at their bed. However, unlike the delayed start option which inserts a predetermined delay prior to the start of a programmed infusion, the standby option also can be selected during the execution of a programmed infusion. It would be undesirable in most cases for a previously programmed and started infusion program to be automatically supplanted by a new set of infusion pump settings through an auto-programming message or request. Thus, the pump 3130 may not accept an auto-program request for a channel or line that is already in standby mode. When a request is received for a line in standby, pump 3130

may display an error message such as “The auto-program is for a line which is in Standby”. Similarly, pump 3130 may not accept an auto-program request for a channel or line that is “Delay Start” mode. As discussed above, “Delay Start” may enable a caregiver 3132 to input auto-program settings to be started automatically at a later time (X number of minutes or hours later), wherein the later time may be predetermined, known and selected by the caregiver 3132. If pump 3130 receives a request for auto-program on a line which is in “Delay Start” mode, pump 3130 may display an error message such as “The auto program is for a line which is in Delay Start”. For both the Standby and Delay Start error messages, pump 3130 may display a suggested action, e.g., “Clear this line and resubmit the auto-program”. This suggested action may advise the caregiver 3132 to clear the line that is in either “Standby” or “Delay Start” mode and then resubmit the auto-program request.

[077] Pump 3130 may display the error message “The auto-program is for a line that has an active alarm that stops or prevents delivery, thus the auto-program is not valid in this alarm condition.” Pump 3130 may be capable of outputting alarms for various situations or conditions. For example, the pump 3130 battery may be almost dead and not plugged in to a power source. In another example, a high priority alarm may be in progress. During these situations, pump 3130 may not accept an auto-program request and, along with the error message, may display the suggested action “Clear the alarm condition and resubmit the auto-program”. Clearing the alarm may comprise eliminating the condition causing the alarm (such as replacing or charging the pump battery).

[078] Because of the unique concurrent delivery capabilities of the PLUM™ infusion pump, two different medications can be delivered from two different source containers upstream of the pump, effectively at the same time through a single line to the patient downstream of the pump. The pump can also switch back and forth from delivering medication from lines A and B respectively, and vice versa, making separate but coordinated “piggyback” delivery possible and convenient. However, this can lead to some rather complex scenarios from an auto-programming perspective. Many things can go wrong and lead to errors, including failures, unintended consequences or problems. Previously many of these errors would not have been communicated to the caregiver at the pump or on its

display screen. Recall from above that the pump may have a rate limit of 999 mL/hr. The pump may have certain low flow limitations too. Thus, in certain aspects, pump 3130 may display an error message such as “The auto-program is not valid due to concurrency violation. Delivery A+B greater than 500 mL/hr or less than 0.5 mL/hr for each line.” Although the pump is physically capable of 999 mL/hr. through a single line, when concurrent delivery is taking place through two lines (A and B) only 500 mL/hr. is permitted for each of the lines A and B. Otherwise, if each line were to be programmed to deliver 500 mL/hr. or more, the pump system rate limit of 999 mL/hr. would be exceeded. Also, each line must also be programmed to deliver at least 0.5 mL/hr. or more for proper pump operation. As discussed above, on the same screen, pump 3130 may display the suggested action, e.g., “Press OK now, or wait for this screen to automatically dismiss”. For greater clarity to the pump user, the specific cause for the concurrency violation could be specified. For example, the error message could read “Delivery of A+B greater than 500 mL/hr” or “Delivery A+B less than 0.5 mL/hr” depending upon the specific cause. Concurrency errors can result from various situations as well. For example, an auto-program can be rejected for a concurrency violation when a new IV bag or container or rate change is requested for Line A or Line B when B is running in concurrent, which would result in a concurrency violation, i.e., delivery greater than 500 mL/hr. for the sum of the two lines or less than 0.5 mL/hr. on each line. Alternatively a concurrency violation can happen on the first attempt to program an initial concurrent delivery on Line B. The error messages can be tailored to more clearly indicate the specific situation that caused the rejection of the auto-program.

- [079] In some aspects, infusion pump 3130 may be configured to pump primary medications through line A and secondary medication through line B in a separate but coordinated piggyback delivery in series. In some cases, an auto-program request for line B may cause an interruption to the pumping medication in line A. This may be undesirable, particularly when the medication pumping in line A is vital such as critical medications including but not limited to Dopamine, Heparin or Insulin. Thus, when the infusion pump 3130 receives an auto-program for line B in step 651, the infusion pump 3130 may at step 653 make a determination whether a medication on that or another line is interruptible. If the answer is affirmative, then the process can continue to screen 605,

step 655, etc. If the answer is negative, the pump 3130 can display an error message at screen 603 such as “The auto-program is not valid for line B. The medication delivering for line A cannot be interrupted.” Similarly, infusion pump 3130 may display an error message such as “The auto-program is not valid for line A. The medication in the Auto-Program is not interruptible and Line B is delivering a Piggyback infusion.” Correspondingly, pump 3130 may display the suggested action “Press OK now, or wait for this screen to automatically dismiss”.

[080] Pump 3130 may display the same suggested action on a screen with an error message such as “The auto-program is not valid because the weight of the patient in the Auto-Program does not match the weight of the patient on the program delivering on the other line.” The infusion pump 3130 may generate this or similar error message when the weight or expected weight range entered for a patient is inconsistent among the multiple lines. For instance, a nurse may enter a weight of 75kg for a patient on line A and then a weight of 7.5 kg for the same patient on line B. These inconsistent weights may cause infusion pump 3130 to display the error message. Similarly, pump 3130 may display an error message such as “The auto-program is not valid because the height of the patient in the auto-program does not match the height of the patient on the program delivering on the other line.” In this case, pump 3130 may ensure that the height or expected height range of the patient receiving medication is consistent on line A and line B. Similarly, pump 3130 may display an error message such as “The auto-program is not valid because the BSA in the auto-program does not match the BSA on the program delivering on the other line.” BSA means body surface area and is usually estimated or calculated based on a patient’s body mass and height. BSA is also sometimes expressed as BMI or body mass index and some drugs are dosed on this basis.

[081] As discussed previously, a caregiver 3132 may be required to enter a CCA prior to programming the pump 3130 manually or submitting an auto-program request. If no CCA is received or a CCA not stored in the drug library is received, infusion pump 3130 may display an error message such as “The Auto-Program is not valid because a CCA has not been selected on the infuser.” Pump 3130 may also suggest the action, e.g., “Select a CCA and resubmit the Auto-Program”.

- [082] Pump 3130 may comprise a lock to the keypad shown in FIG. 4. When the keypad is locked, pump 3130 may not receive commands submitted by selecting buttons on the keypad. Pump 3130 also may not receive auto-programming requests when the keypad is locked. In those cases, pump 3130 may display an error message such as “The auto-program is not valid because the keypad is locked.” The infusion pump 3130 may also display the suggested action, e.g., “Unlock the keypad.” After caregiver 3132 unlocks the keypad, pump 3130 may automatically accept the auto-programming request.
- [083] The remaining error messages discussed below may be displayed in conjunction with the suggested action, e.g., “Press OK now, or wait for this screen to automatically dismiss”. As discussed above, after selection of the “OK” input option or waiting for the screen to automatically dismiss after the timeout period, pump 3130 may display the home A/B screen.
- [084] Pump 3130 may, in some cases, generate and display an error message such as “The Auto-Program is not valid because the received parameters will not result in a valid dose.” When two out of the three parameters or variables volume, (flow) rate and duration are provided to the pump 3130, its processor can calculate a dose. Normally when a certain dosage is being targeted or ordered by the doctor, it is based upon the weight of the patient. The drug may be available as an amount or mass in a given volume of diluent such as 5 mg / 1000 mL IV container. When there is no combination of values of flow rate and duration that will result in a valid dose, this error message is generated.
- [085] Infusion pump 3130 may display an error message such as “The auto-program is not valid because the Rate cannot be titrated when VTBI is 0.” This error message may be displayed when a caregiver 3132 enters a rate for a medication to be pumped while also entering a total volume of the medication to be infused of 0 mL. Pump 3130 may therefore require a VTBI greater than 0. The auto-program might be a change to a currently running program – a “titration.” However, if there is no VTBI left to infuse in the program, the rate or other parameters cannot effectively be changed because there is no volume left to be infused. Similarly, infusion pump 3130 may display an error message such as “The auto-program is not valid because it is a titration for a line that has

no confirmed program.” A titration is by definition a change in rate, duration or VTBI in a currently running or already programmed infusion. Thus, you cannot auto-program a titration or change for a line or pump channel until after it has a prior program that has been confirmed.

- [086] In certain aspects, pump 3130 may display an error message such as “The auto-program is not valid for a line with a Multistep or Loading dose program.” If the line is busy with a multistep infusion or loading dose program, that program must be completed or cleared before any new auto-program request can be received and executed.
- [087] Infusion pump 3130 may display an error message such as “The Auto-Program was rejected by Hospira MedNet due to incomplete or corrupt data.” This might be highlighted by a checksum failure or handshake failure. Part of the auto-program message may have been lost or corrupted for one reason or another.
- [088] Pump 3130 may display an error message such as “The Auto-Program for this infuser was rejected by Hospira MedNet™ due to drug library incompatibility.” The drug library identified in the device manifest for the auto-program message is not recognized. In other words, the active drug library mentioned in the auto-program manifest does not match what the MMU server 3108 and/or the pump itself thinks is the appropriate drug library that is in the pump. For example, the drug library has an identifier (perhaps an alphanumeric string) that may include the pump type and version of the drug library. For some reason, the drug library version may get out of synch between the infusion pump and the MMU such that drug library identifier in the auto-program request does not match the drug library that is currently in the infusion pump.
- [089] FIG. 7 illustrates a flow chart of a process 700 in accordance with aspects of the disclosure. Process 700 may be carried out using infusion pump 3130 shown in FIG. 4. Step 701 may comprise receiving an auto-programming request, wherein the auto-programming request may comprise IV bag or drug container information such as drug name, concentration or other drug identifying information, and infusion pump information, and optionally patient identification information. Step 703 may comprise receiving infusion program settings, parameters or variables including but not limited to

dose, flow rate, duration and volume. Step 705 may comprise comparing the infusion program settings with drug library program settings, wherein the drug library program settings are included in rule sets that place soft (breachable) limits and hard (non-breachable) limits provided in a drug library stored at the infusion pump. Step 707 may comprise determining whether the infusion program settings are consistent or inconsistent with the drug library program settings based on the comparing. Step 709 may comprise generating an error message based on the determining that the infusion program settings are inconsistent with the drug library settings. Step 711 may comprise displaying a screen, wherein the screen comprises the error message and a suggested action. In some aspects, other steps may be performed as discussed above in connection with FIGS. 1-6.

[090] The foregoing descriptions of the disclosure have been presented for purposes of illustration and description. They are not exhaustive and do not limit the disclosure to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practicing of the disclosure. For example, barcodes or barcode scanning are not required in order to auto-program the infusion pump; the user of a EMR's medication administration functionality system can bypass the scanning functionality and simply select or manually type in the information required by the system to produce an auto-program request. While in the foregoing specification this disclosure has been described in relation to certain preferred embodiments thereof, and many details have been set forth for purpose of illustration, it will be apparent to those skilled in the art that the disclosure is susceptible to additional embodiments and that certain of the details described herein may be varied considerably without departing from the basic principles of the disclosure. It should be understood that the features of the disclosure are susceptible to modification, alteration, changes or substitution without departing from the scope of the disclosure or from the scope of the claims. For example, the dimensions, number, size and shape of the various components may be altered to fit specific applications. Accordingly, the specific embodiments illustrated and described herein are for illustrative purposes only.

What is claimed is:

1. A method, comprising:

receiving, at an infusion pump, an auto-programming request, wherein the auto-programming request comprises IV drug container information, infusion pump information, and infusion program settings;

comparing, at the infusion pump, the infusion program settings with drug library program settings, wherein the drug library program settings are provided in a drug library stored at the infusion pump;

determining, at the infusion pump, whether the infusion program settings are consistent or inconsistent with the drug library program settings based on the comparing;

generating, at the infusion pump, an error message based on the determining that the infusion program settings are inconsistent with the drug library settings; and

displaying, at the infusion pump, a screen, wherein the screen comprises the error message and a suggested action.

2. The method of claim 1, wherein the screen is displayed for a predetermined time.

3. The method of claim 2, further comprising automatically rejecting, at the infusion pump, the auto-programming request when no input is received at the infusion pump after the predetermined time.

4. The method of claim 1, wherein the screen further comprises one or more input options.

5. The method of claim 1, wherein the error message describes a cause of an error with the auto-programming request.
6. The method of claim 1, wherein the determining is performed solely at the infusion pump.
7. The method of claim 1, further comprising receiving a response to the error message, wherein the response comprises the suggested action.
8. The method of claim 1, wherein the predetermined time is about 15-35 seconds.
9. An apparatus comprising:
 - a memory;
 - a processor, wherein the processor executes computer-executable program instructions which cause the processor to:
 - receive an auto-programming request, wherein the auto-programming request comprises IV drug container information, infusion pump information, and infusion program settings;
 - compare the infusion program settings with drug library program settings, wherein the drug library program settings are provided in a drug library stored at an infusion pump;
 - determine whether the infusion program settings are consistent or inconsistent with the drug library program settings based on the comparing;
 - generate an error message based on the determining that the infusion program settings are inconsistent with the drug library settings; and

display a screen on the infusion pump, wherein the screen comprises the error message and a suggested action.

10. The apparatus of claim 9, wherein the screen is displayed for a predetermined time.
11. The apparatus of claim 10, wherein the computer-executable program instructions further cause the processor to automatically reject the auto-programming request when no input is received at the infusion pump after the predetermined time.
12. The apparatus of claim 9, wherein the screen further comprises one or more input options.
13. The apparatus of claim 9, wherein the error message describes a cause of an error with the auto-programming request.
14. The apparatus of claim 9, wherein the determining is performed solely at the infusion pump.
15. The apparatus of claim 9, wherein the computer-executable program instructions further cause the processor to receive a response to the error message, wherein the response comprises the suggested action.
16. The apparatus of claim 10, wherein the predetermined time is about 15-35 seconds.

17. A non-transitory computer-readable storage medium having computer-executable program instructions stored thereon that, when executed by a processor, cause the processor to:

receive an auto-programming request, wherein the auto-programming request comprises

IV drug container information, infusion pump information, and infusion program settings;

compare the infusion program settings with drug library program settings, wherein the drug library program settings are provided in a drug library stored at an infusion pump;

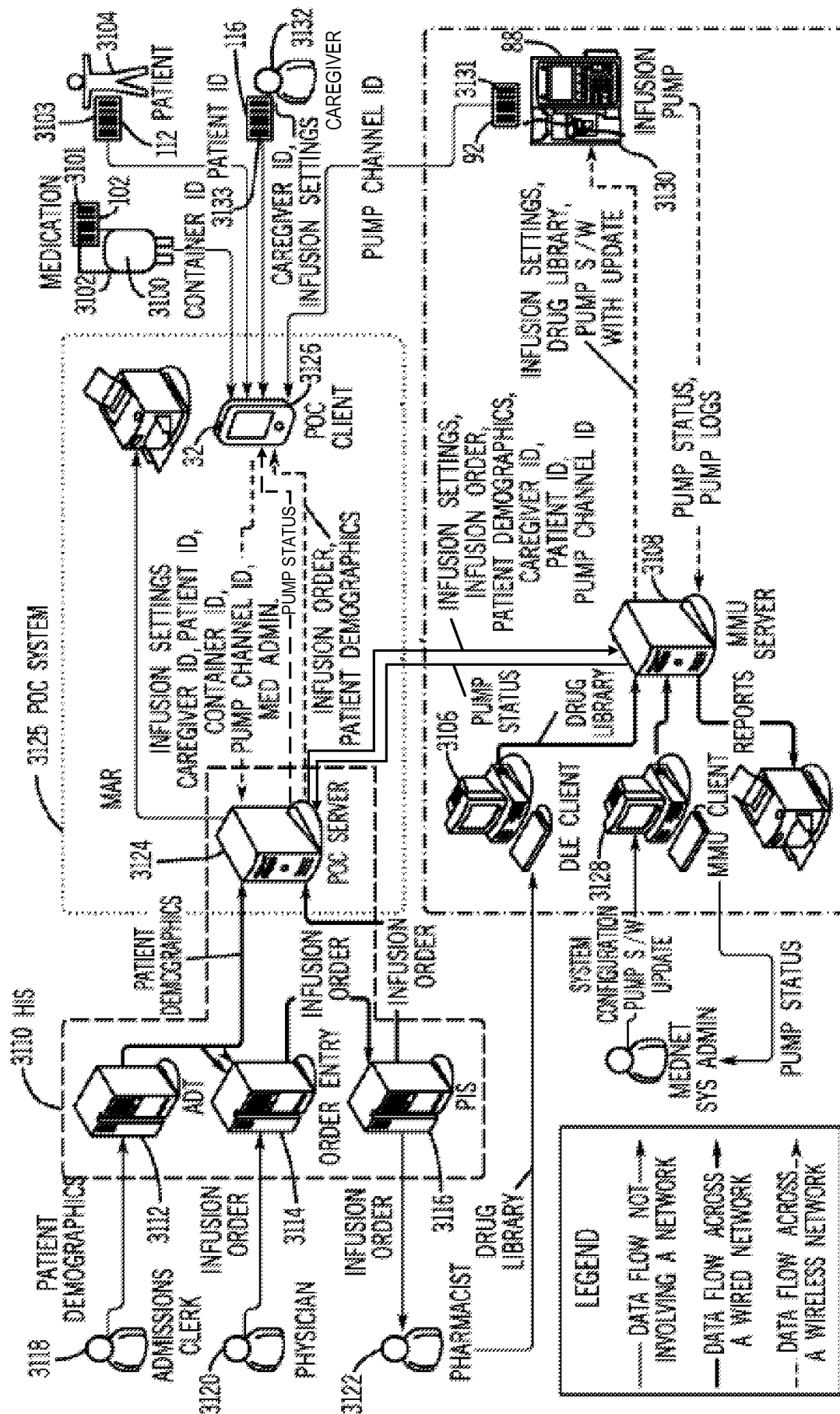
determine whether the infusion program settings are consistent or inconsistent with the drug library program settings based on the comparing;

generate an error message based on the determining that the infusion program settings are inconsistent with the drug library settings;

display a screen at the infusion pump, wherein the screen comprises the error message and a suggested action; and

receive a command in response to the error message and the suggested action.

18. The non-transitory computer-readable storage medium of claim 17, wherein the computer-executable program instructions further cause the processor to start an infusion program in response to the command.



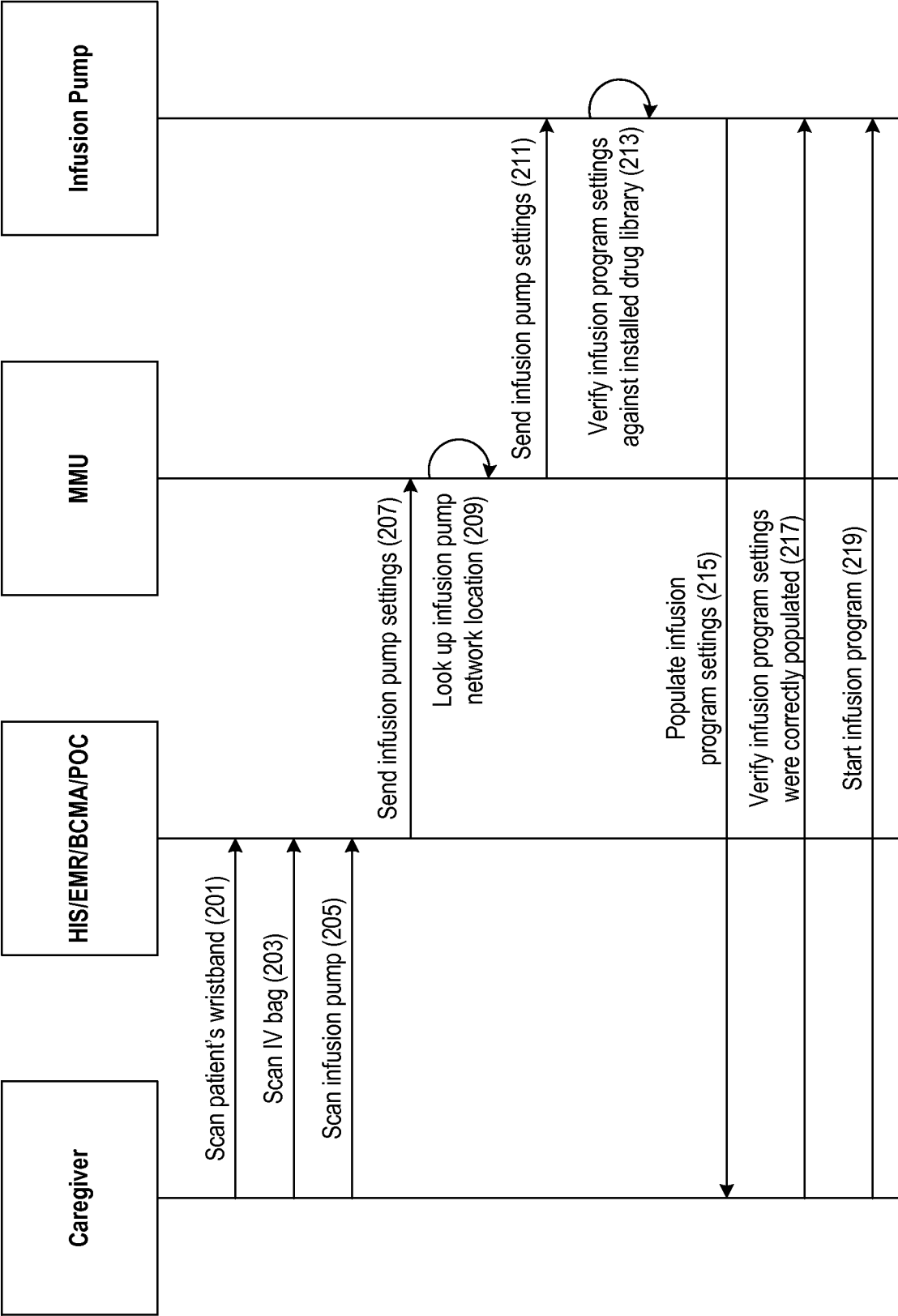


FIG. 2

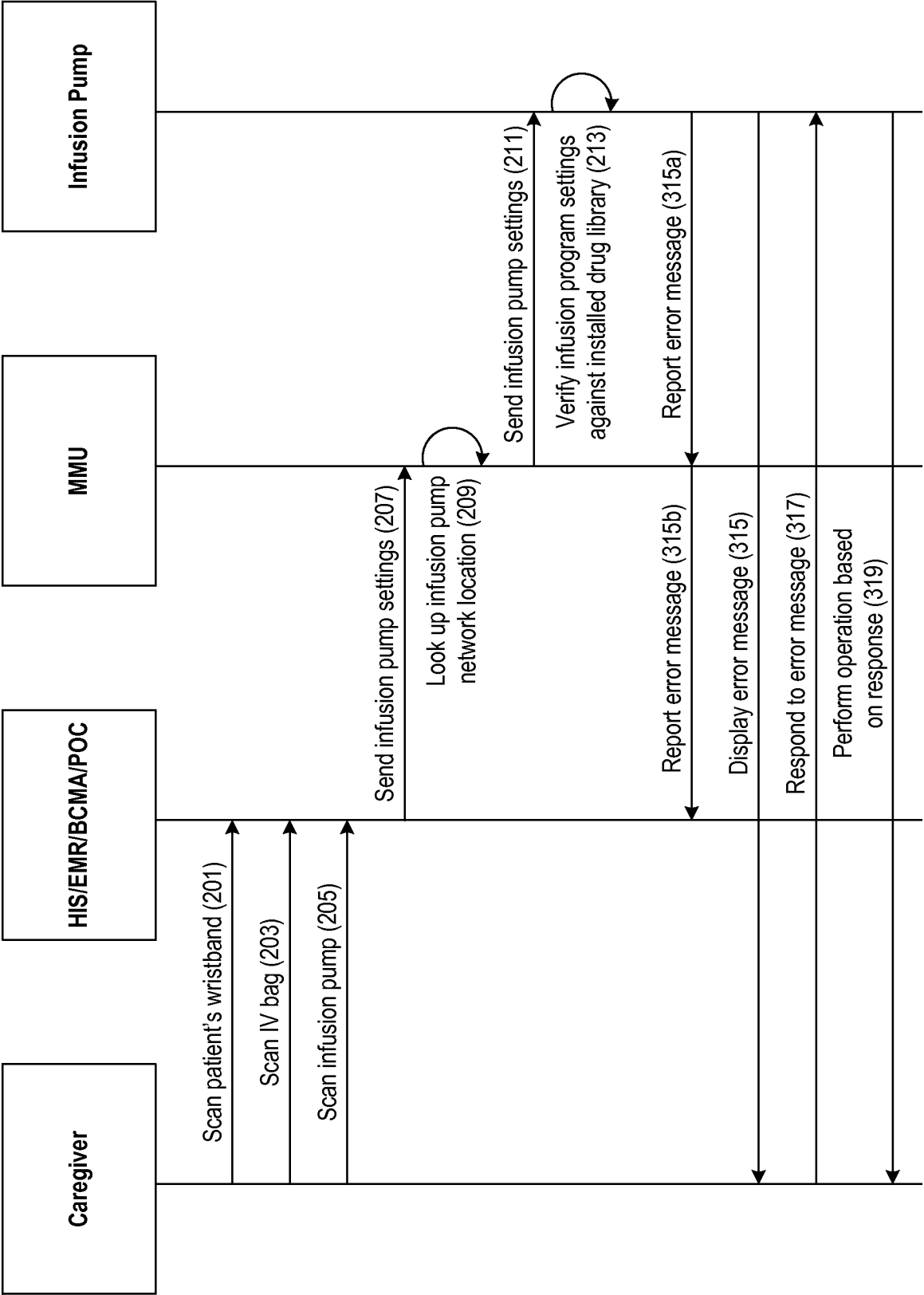


FIG. 3

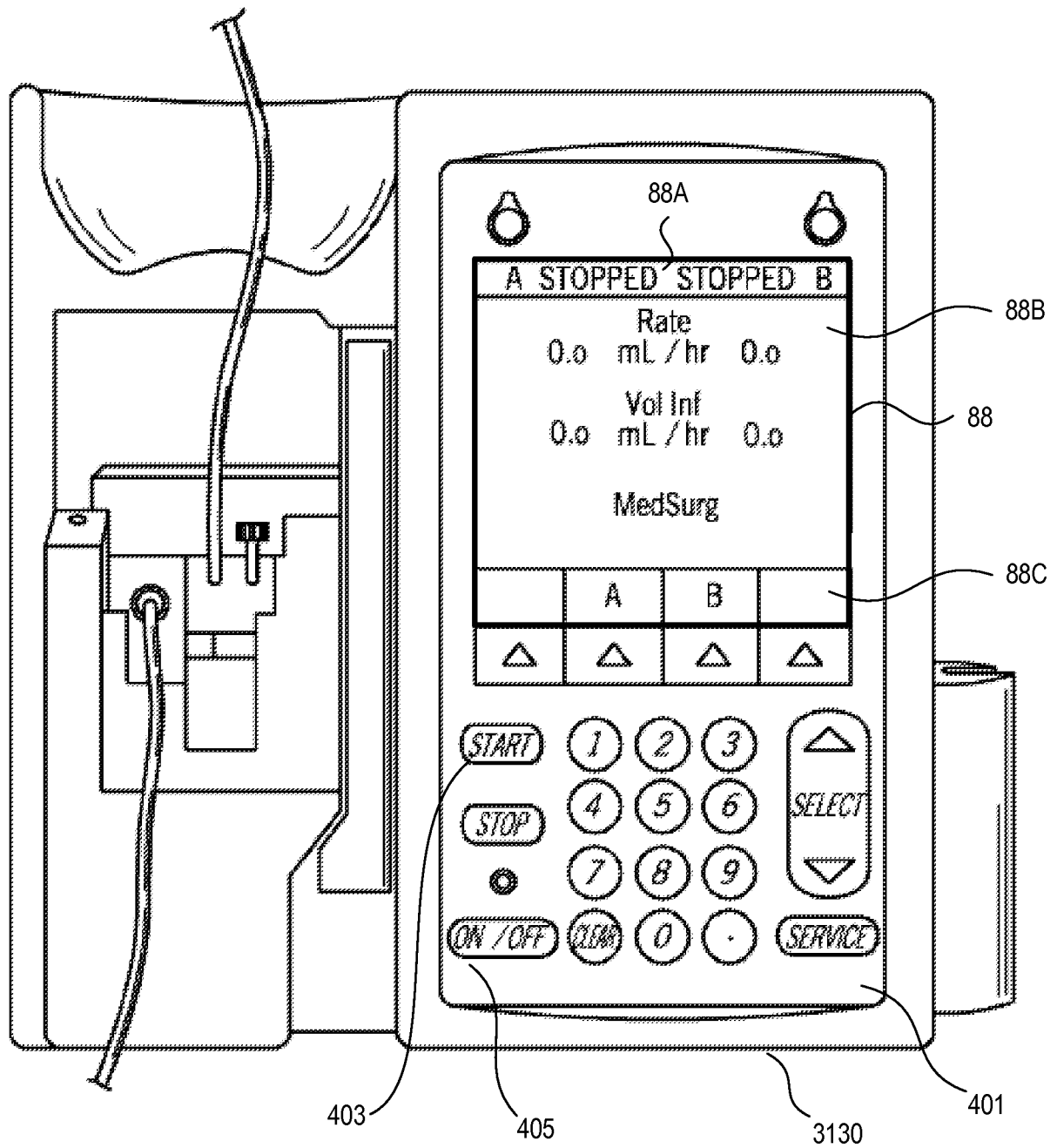


FIG. 4

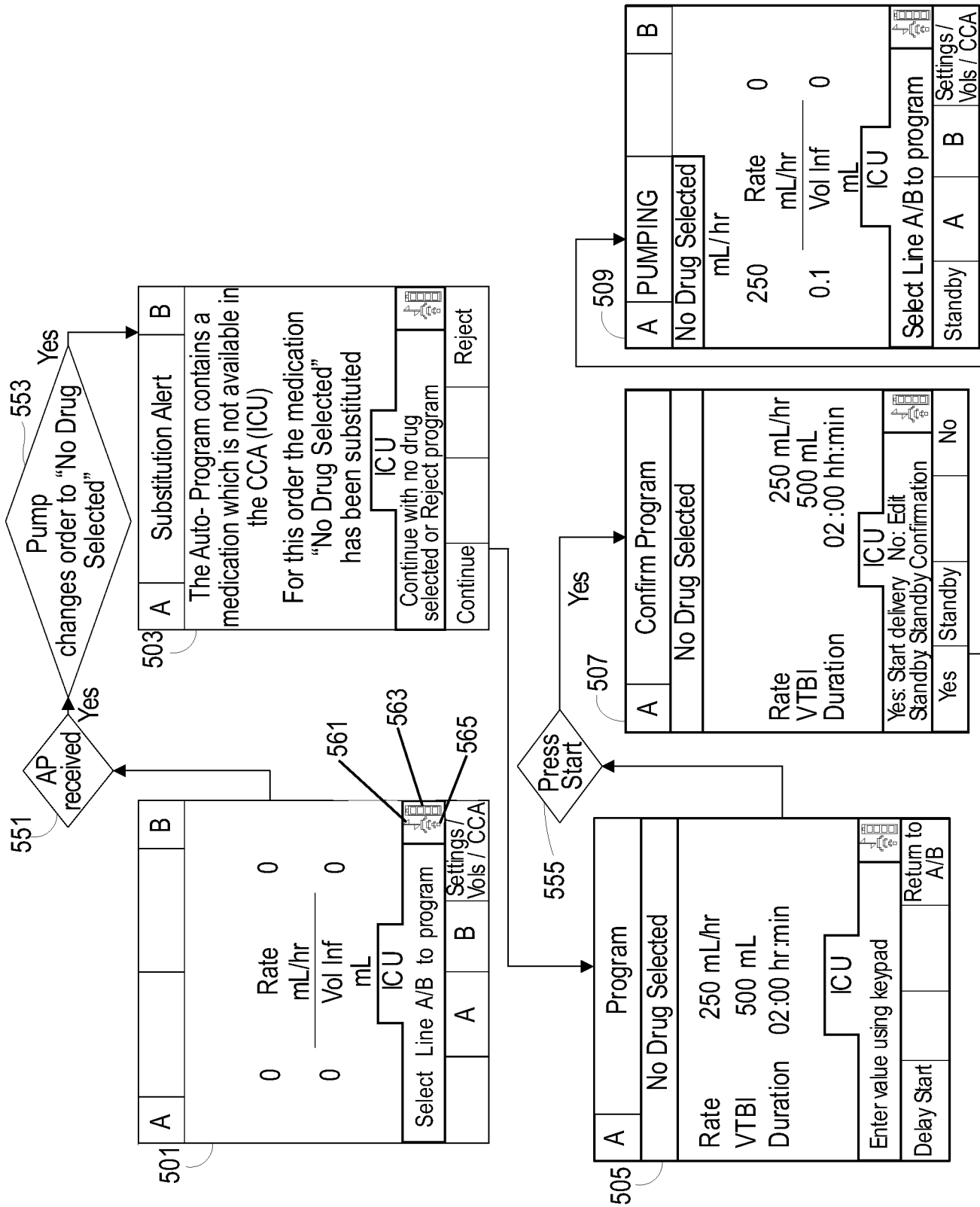


FIG. 5

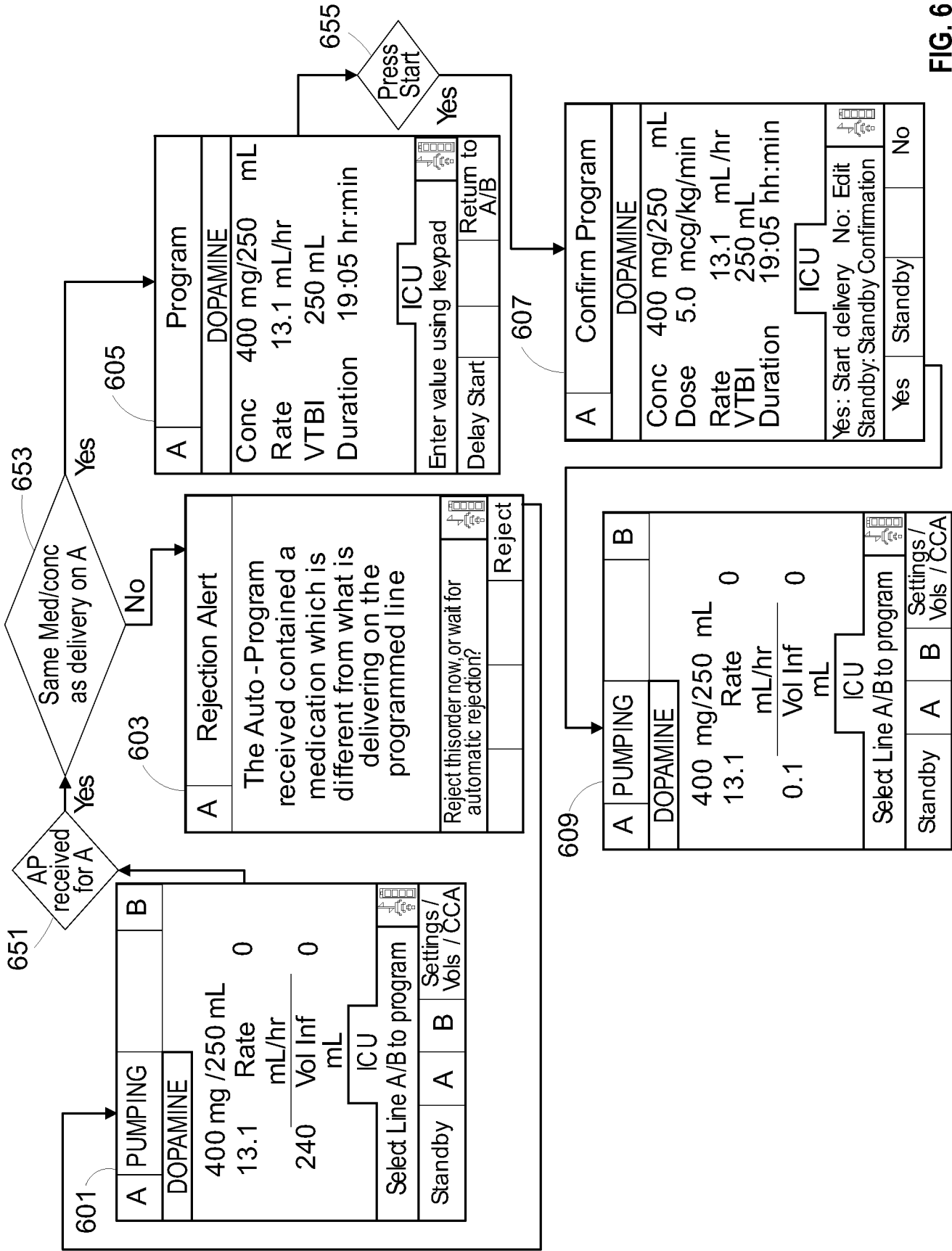


FIG. 6

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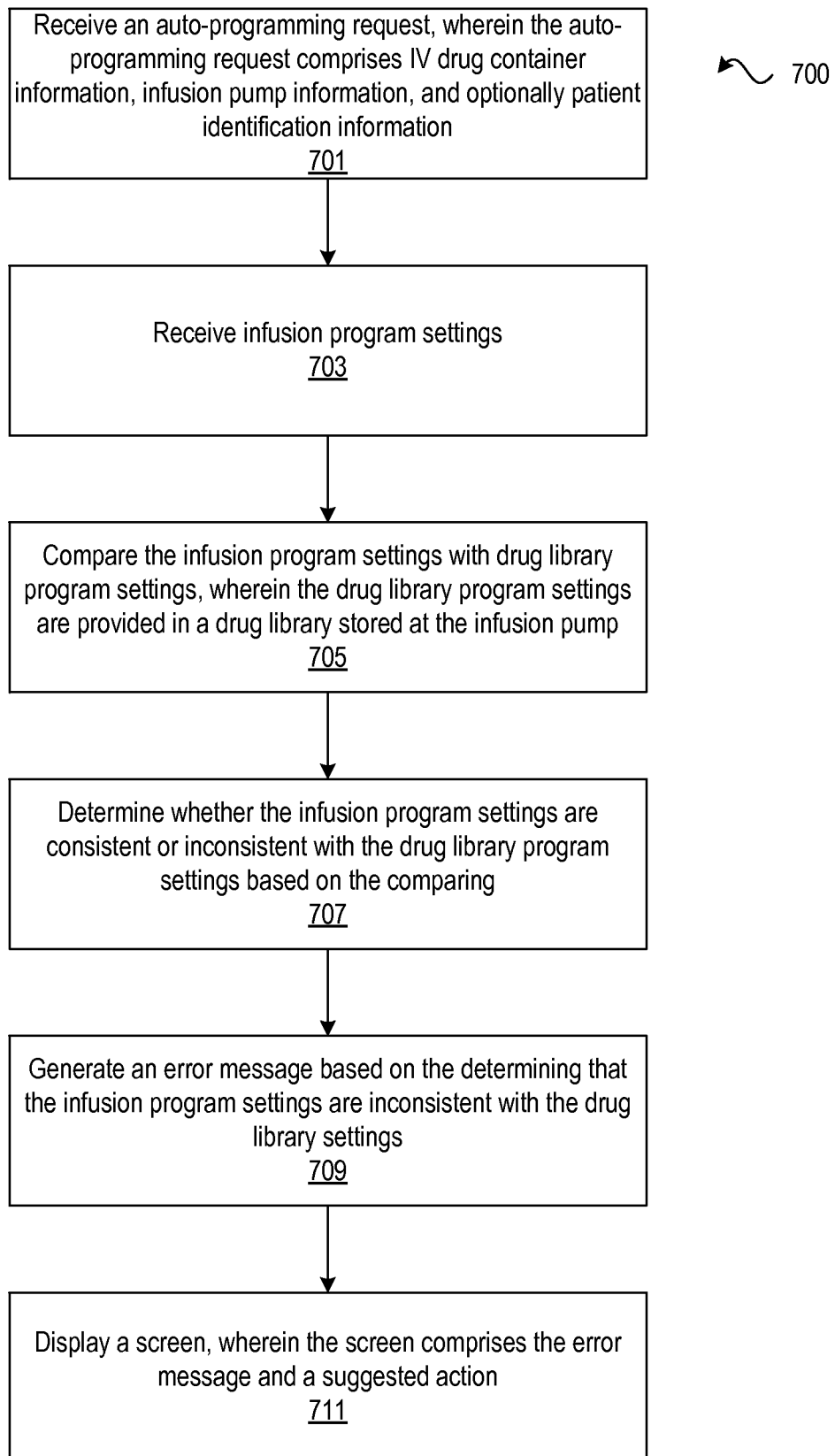


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US15/38633

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61M5/14, 5/142 (2015.01)

CPC - A61M5/14, 5/142, 2005/14208

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)

IPC(8) - A61M5/14, 5/142 (2015.01)

CPC - A61M5/14, 5/142, 2005/14208

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)

PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google Scholar; ProQuest; PubMed; Google Patents, EBSCO. Search terms: infusion, error, compar*, drug, library, mistake, pump, medium, detect*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/0213598 A1 (HOWARD GA et al.) 13 September 2007; figure 1; paragraphs [0004], [0008], [0044], [0094], [0095], [0129]; claims 132, 134, 135, 145, 146, 149	1-18

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

12 September 2015 (12.09.2015)

Date of mailing of the international search report

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