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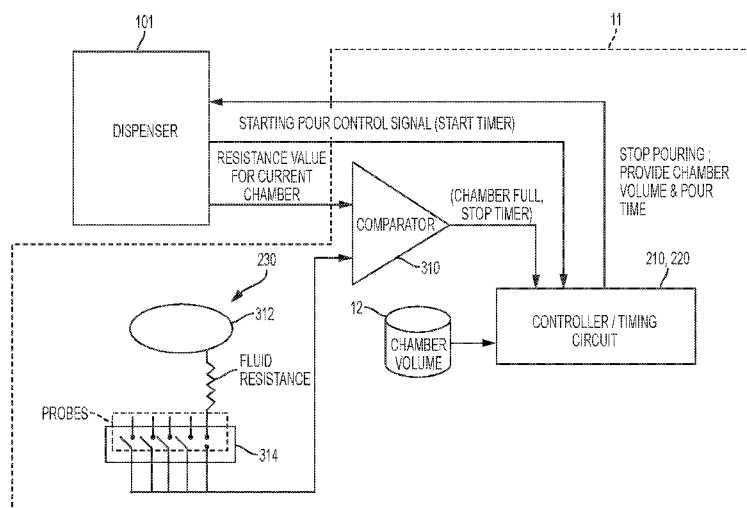


FIG. 10B

- (57) Abstract:** Determining an error coefficient associated with a pump system may be provided. A positive displacement pump may be continuously cycled to dispense fluid into a measuring device until it is full. The actual flow rate of the pump may be determined based on how long or how many pump cycles it took to fill the measuring device. An error coefficient may be determined based on a difference between a projected flow rate and the actual flow rate. The error coefficient may be loaded into the pump system.

DISPENSER PUMP CALIBRATION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[001] This application is being filed as a PCT International Patent application and claims priority to U.S. Provisional patent application No. 62/308,263, filed 15 March 2016 and U.S. Provisional patent application No. 62/382,488, filed 01 September 2016, the entire disclosure of both of which are incorporated by reference in their entirety.

BACKGROUND

[002] Positive displacement pumps may typically deliver a fixed volume of liquid for each cycle of pump operation. In practice, variations may exist between the theoretical flow rate and the actual flow rate due primarily to influences from the volumetric efficiency of the pump, pump slippage (internal fluid bypass from the outlet to the inlet), system pressure, and fluid viscosity. The variations between the theoretical flow rate and the actual flow rate may lead to a drift in the pump calibrations. Typically, pumps may not be calibrated while in their operating environment, but rather replaced with a new pump and calibrated remotely, such as at the point of manufacture of the pump.

[003] Pumps requiring recalibration may be removed and shipped to the manufacturing to be evaluated and recalibrated. Typically, recalibration may include dispensing a test sample into a metering cup marked with a minimum and maximum line. If the test sample fills the metering cup between the minimum and maximum line, the recalibration may result in a pass, otherwise the recalibration may result in a fail.

SUMMARY

[004] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended

to identify key features or essential features of the claimed subject matter, nor is it intended as an aid in determining the scope of the claimed subject matter.

[005] Determining an error coefficient associated with a pump system may be provided. A positive displacement pump may be continuously cycled until a fixed volume vessel in a measuring device is measured to be filled. Based on the measurements from the measuring device an actual flow rate or volume per cycle of the pump may be determined. An error coefficient may be determined based on a difference between a projected volume and the actual volume. The error coefficient may be loaded into the pump system.

[006] These and other features and advantages will be apparent from a reading of the following detailed description and a review of the associated drawings. It is to be understood that both the foregoing general description and the following detailed description are illustrative only and are not restrictive of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[007] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate various embodiments of the present disclosure. In the drawings:

[008] FIG. 1A is a block diagram of an exemplary operating environment for identifying a calculated dispensing error coefficient as is described herein;

[009] FIG. 1B is a block diagram of a beverage dispensing system for determining and implementing an error coefficient to automatically calibrate a pump system as is described herein;

[010] FIG. 2 is a schematic view of a measuring device as is described herein;

[011] FIGS. 3-9 show various views of an example metering cup as is described herein;

[012] FIG. 10A is a schematic view of an example metering cup as is described herein;

[013] FIG. 10B is another schematic view of a dispensing system and metering cup as is described herein;

[014] FIG. 11 is a flow chart of a method for determining and implementing an error coefficient to automatically calibrate a pump system as is described herein;

[015] FIG. 12 is a flow chart of a method of controlling a pump to dispense a projected volume of liquid into a measuring device;

[016] FIG. 13 is a flow chart of another method of controlling a pump to dispense a projected volume of liquid into a measuring device;

[017] FIGS. 14A & 14B are another method for determining and implementing an error coefficient to automatically calibrate a pump system as is described herein; and

[018] FIGS. 15-21 show various calibration screens shown on an interactive display for calibrating the pump system.

DETAILED DESCRIPTION

[019] The following detailed description refers to the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the following description to refer to the same or similar elements. While embodiments of the disclosure may be described, modifications, adaptations, and other implementations are possible. For example, substitutions, additions, or modifications may be made to the elements illustrated in the drawings, and the methods described herein may be modified by substituting, reordering, or adding stages to the disclosed methods. Accordingly, the following detailed description does not limit the disclosure. Instead, the proper scope of the disclosure is defined by the appended claims.

[020] FIG. 1A is a block diagram of an operating environment 100 for identifying a calculated dispensing error coefficient for a pump. As shown in FIG. 1, the operating environment 100 may comprise a measuring device 10, a pump system 20, a computing device 30, a network 40, and a server 50. The pump system 20 may include a plurality of pumps. The measuring device 10 may include a plurality of vessels for receiving fluid pumped by the

plurality of pumps shown in more detail in FIG. 2. The measuring device 10 may attach to the pump system 20 or one or more components, such as a nozzle, downstream of the pump system 20. Each of the plurality of pumps may be in fluid communication with a corresponding one of the plurality of vessels. Accordingly, multiple samples may be collected from the pump system 20 at the same time.

[021] In some embodiments, two or more pumps may be in fluid communication with the same corresponding one of the plurality of vessels. In such embodiments, one of the two or more pumps may be calibrated at any given time. Accordingly, the pumps may be grouped in such a manner that all of the pumps in a given group may be calibrated at the same time.

[022] Moreover, the measuring device 10 may include or be in communication with one or more sensors for measuring when each of the vessels is full. For example, each vessel in the measuring device 10 may include a probe that protrudes into the bottom of the vessel. The measuring device 10 may also include a grounding plate positioned at the top of the vessel. Upon fluid filling the vessel with fluid, a circuit may be completed between the probe and the grounding plate such that it may be detected that the vessel is full.

[023] The error coefficient for each of the pumps in the pump system 20 may be determined by the measuring device 10, the pump system 20, a local computing device 30 in communication with the measuring device 10 and the pump system 30, a remote server 50 accessed via one or more networks 40, or combinations thereof.

[024] The pump system 20 may include a control system 15. The control system 15 may be a microprocessor or any other type of conventional control system 15. The control system 15 may have a memory or other type of data storage device associated therewith. The control system 15 may be a special purpose control system 15 such as a fluid dispensing control system, a beverage dispensing control system, or a post-mix beverage dispensing control system. For example, the control system 15 may be configured as described in US Patent Application No.

15/109,876, "Dispenser Control Architecture," to Sawhney et al., hereby incorporated by reference in its entirety.

[025] The control system 15 may receive dispensing error coefficients and be configured to re-calibrate the corresponding pumps in the pump system 20. That is, each pump may have a corresponding dispensing error coefficient determined for the pump based upon the systems and methods described herein. Once the dispensing error coefficient is on the pump system 20, the pump system 20 may be calibrated to dispense ingredients based on the measured actual flow rate of each of the pumps. Where an individual pump has previously been calibrated, the determined dispensing error coefficient may be compared to determine the pump system 20 error coefficient. Furthermore, an individual pump may previously possess manufacturing coefficients. The manufacturing coefficients may be overwritten in the pump system 20 with the new dispensing error coefficients. The manufacturing coefficients may also be maintained along with the determined dispensing error coefficients, averaged with the determined dispensing error coefficients, or otherwise combined with the determined dispensing error coefficients. Similarly, if a pump is replaced in the field, the individual pump may be calibrated as opposed to recalibrating the entire pump system 20.

[026] Determining the dispensing error coefficients for the pump system in the field allows for immediate recalibration. The entire pump system 20 may be calibrated, not just an individual pump. Moreover, determining the dispensing error coefficients in the field takes into account the actual fluid, the actual working conditions, the actual tubing in fluid communication with the pump and a fluid source, and other variables. This may eliminate the inaccuracy due to testing in an isolated environment such as at the point of manufacture of the pump.

[027] For example, a pump may have a nominal volume per cycle of 30 microliters per cycle, but may be determined to have an actual volume per cycle of 25 microliters per cycle. Therefore, in order to pump 750 microliters of fluid, the pump may nominally be programmed to cycle 25 times at the nominal volume per cycle of 30 microliters per cycle. Using the dispensing

error coefficient determined based on the measured actual volume per cycle of the pump, the pump system 20 may be calibrated so as to cycle the pump 30 times at the actual volume per cycle of 25 microliters per cycle to dispense the desired 750 microliters.

[028] FIG. 1B is a block diagram of a beverage dispensing system 101 for determining an error coefficient to automatically calibrate a beverage ingredient pump system 20. The beverage dispensing system 101 may accommodate different types of beverage ingredients, each with distinct flow characteristics, such as viscosity and density. For example, the beverage dispensing system 101 may dispense beverage ingredients for carbonated soft drinks, sport beverages, juices, waters, coffees, teas, flavorings, additives, or any other types of beverages or beverage additives. The beverage ingredients may be finished beverages, beverage concentrates, base beverage component concentrates, or flavors.

[029] The beverage concentrates and flavors may be convention single brand concentrates, flavor concentrates, or sweetener concentrates. The conventional single brand concentrates may generally be referred to as macro-ingredients. A number of beverage concentrates and flavors may be available to produce a number of standard core beverages and flavor modifiers. The beverage concentrates and flavors may have varying levels of concentration. Generally described, the macro-ingredients may have reconstitution ratios in the range of about 3:1 to about 6:1. The viscosities of the macro-ingredients typically range from about 100 centipoise or greater. Macro-ingredients may include sugar syrup, HFCS (High Fructose Corn Syrup), standard or high yield carbonated or still beverage concentrates, juice concentrates, and similar types of fluids.

[030] Alternatively, the beverage concentrates and/or flavors may be micro-ingredients. The micro-ingredients may have a reconstitution ratio ranging from about ten to one (10:1), twenty to one (20:1), thirty to one (30:1), or higher. Specifically, many micro-ingredients may be in the range of fifty to one (50:1) to three hundred to one (300: 1). The viscosities of the micro-ingredients typically range from about 1 to about 100 centipoise or so. Examples of micro-

ingredients include natural and artificial flavors; flavor additives; natural and artificial colors; artificial sweeteners (high potency or otherwise); additives for controlling tartness, e.g., citric acid, potassium citrate; functional additives such as vitamins, minerals, herbal extracts; nutraceuticals; and over-the-counter (or otherwise) medicines such as acetaminophen and similar types of materials. Beverage micro-ingredients may also include separately stored acid and acid-degradable components of a non-sweetened beverage concentrate or unsweetened beverage component concentrates. The micro-ingredients may be liquid, powder (solid), or gaseous form and/or combinations thereof. In some embodiments, the beverage ingredients may include both macro-ingredient and micro-ingredients.

[031] Positive displacement pumps that are design to pump beverage macro-ingredients may have a nominal dispensed volume per cycle of about 200 to 500 microliters per cycle. In some embodiments, the nominal dispensed volume per cycle of a macro-ingredient positive displacement pump may be about 250 to 350 microliters per cycle or about 300 microliters per cycle. In such embodiments, the volume of the vessels in the measuring device 10 that correspond to macro-ingredient positive displacement pumps may be about 20 milliliters to about 50 milliliters, about 25-35 milliliters, or about 30 milliliters. The volume of the vessels in the measuring device 10 that correspond to macro-ingredient positive displacement pumps may be greater than 50 milliliters. In some embodiments, the volume of the vessels in the measuring device 10 that correspond to macro-ingredient positive displacement pumps may be sized so as to be able to hold about 100 cycles of the corresponding positive displacement pump.

[032] Other numbers of cycles of the positive displacement pump may be used, such as anywhere from greater than or equal to 10 cycles to less than or equal to 1,000 cycles. The positive displacement pumps may also be cycled greater than or equal to 20 cycles and less than or equal to 600 cycles, or greater than or equal to 50 cycles and less than or equal to 500 cycles. Moreover, the number of cycles may be different for different pumps. For example, for higher volume per cycle positive displacement pumps, such as those designed to pump macro-

ingredients, the number of cycles may be less than the number of cycles used for a lower volume per cycle positive displacement pump, such as those designed to pump micro-ingredients, and vice versa.

[033] Positive displacement pumps that are design to pump beverage micro-ingredients may have a nominal dispensed volume per cycle of about 20 to 50 microliters per cycle. In some embodiments, the nominal dispensed volume per cycle of a micro-ingredient positive displacement pump may be about 25 to 35 microliters per cycle or about 30 microliters per cycle. In such embodiments, the volume of the vessels in the measuring device 10 that correspond to micro-ingredient positive displacement pumps may be about 2 milliliters to about 5 milliliters, about 2.5-3.5 milliliters, or about 3 milliliters. The volume of the vessels in the measuring device 10 that correspond to micro-ingredient positive displacement pumps may be greater than 5 milliliters. In some embodiments, the volume of the vessels in the measuring device 10 that correspond to micro-ingredient positive displacement pumps may be sized so as to be able to hold about 100 cycles of the corresponding positive displacement pump.

[034] Other numbers of cycles of the positive displacement pump may be used, such as anywhere from greater than or equal to 10 cycles to less than or equal to 1,000 cycles. The positive displacement pumps may also be cycled greater than or equal to 20 cycles and less than or equal to 600 cycles, or greater than or equal to 50 cycles and less than or equal to 500 cycles. Moreover, the number of cycles may be different for different pumps. For example, for higher volume per cycle positive displacement pumps, such as those designed to pump macro-ingredients, the number of cycles may be less than the number of cycles used for a lower volume per cycle positive displacement pump, such as those designed to pump micro-ingredients, and vice versa.

[035] The distinct flow characteristics of the beverage ingredients may cause variations in volumetric efficiency of the pumps in the pump system 20 due to differences in pump slippage (internal fluid bypass from the outlet to the inlet), pump wear, and other such factors. Because

each of the pumps may be pumping different beverage fluids or other materials and/or under different operating conditions (e.g., more or less frequently), the variation in volumetric efficiency over time is different for each of the pumps in the pump system 20. Therefore, the pumps in the pump system 20 may be periodically recalibrated to account for the variation in volumetric efficiency over time.

[036] The pump system 20 may include a number of beverage ingredient sources 21A – 21N and associated pumps 22A – 22N. The beverage ingredient sources 21A – 21N may be conventional bag-in-box containers, micro-ingredient cartridges or cartons, conventional water connections, or any other type of beverage storage, supply, or delivery device. The pumps 22A – 22N and the beverage ingredient sources 21A – 21N may be connected in any convenient low, slight negative, or non-pressurized manner. The beverage dispensing system 101 may have a selection device so as to select the desired fluid source, such as described in more detail below with reference to FIGS. 15-21.

[037] The pumps 22A-22N may be any type of positive displacement pump. For example, the pumps 22A-22N may be a solenoid pump, a piston pump, a nutating pump, a vibratory pump, a gear pump, an annular pump, a peristaltic pump, a syringe pump, a piezo pump or any other type of positive displacement device that is intended to pump a fixed displacement for each pump cycle. The pumps 22A-22N may be operated in any conventional manner such as electric, pressure, or otherwise. Other operating means such as a stepper motor operated by a given number of cycles also may be used. Any type of pump operating means may be used and accommodated herein. In an embodiment, the pumps 22A – 22N may pump beverage ingredients from the beverage ingredient sources 21A – 21N to a nozzle 60 so as to dispense beverages from the beverage dispensing system 101.

[038] The measuring device 10 may attach to the nozzle 60 or otherwise place the vessels of the measuring device 10 in fluid communication with one or more fluid ports on the nozzle. During a calibration operation, the pumps 22A-22N may operate to dispense fluid from

the nozzle 60 via the fluid ports and into the vessels of the measuring device 10. The beverage dispensing system 101 may be configured to dispense a diluent (not shown), such as still or carbonated water, along with one or more of the beverage ingredients from the beverage ingredient sources 21A – 21N in order to dispense a finished beverage. During the calibration operation, the beverage dispensing system 101 may not dispense a diluent and instead only dispense beverage ingredients from the beverage ingredient sources 21A – 21N corresponding to the pumps 22A – 22N that are being calibrated. Alternatively, the measurement device 10 may include a flow director to divert the dispensed diluent stream to a drain (not shown) and away from the vessels of the measuring device 10.

[039] FIG. 2 is a schematic view of a measuring device 10 in more detail consistent with embodiments of the disclosure. The measuring device 10 may include a metering cup 11, or other known types of containers. The metering cup may be a single vessel for collecting fluid (e.g., a cylinder, graduated or non-graduated) or, as shown in FIG. 2, may be a collection of vessels 12 for collecting multiple samples at once. For example, the metering cup may have 40 vessels configured to receive 40 dispensed samples at a time from the pump system 20. The metering cup may be a controlled item that is precision manufactured so that highly precise measurements can be taken. In addition, the metering cup may be available in various sizes for different uses. For instance, a larger metering cup may be utilized for collecting macro ingredients, whereas a smaller metering cup may be utilized for collecting micro ingredients. While the metering cup is shown such that all of the vessels are the same size, in some embodiments one or more of the vessels may be different sizes. For example, on a beverage dispensing system 101 that dispenses both macro-ingredients and micro-ingredients, the vessels may be sized according to the type beverage ingredients that will be dispensed into the vessel. As discussed above, vessels 12 that correspond to fluid ports on the nozzle 60 that dispense macro-ingredients may be sized to hold about 20 milliliters to about 50 milliliters of fluid. Vessels that correspond to fluid ports on the nozzle 60 that dispense micro-ingredients may be sized to hold

about 2 milliliters to about 5 milliliters of fluid. Therefore, the metering cup may have one or more vessels sized for receiving micro-ingredients such that they may hold about 2 milliliters to about 5 milliliters of fluid as well as one or more vessels sized for receiving macro-ingredients such that they may hold about 20 milliliters to about 50 milliliters of fluid.

[040] For example, referring now to FIGS. 3-9, one example of a metering cup 11 is shown. In this example, the metering cup 11 includes a plurality of vessels 12 into which the micro-ingredients are pumped, as described above. Further, the metering cup 11 includes vessels 15 for receiving macro-ingredients and a port 13 for receiving the dispensed diluent stream. The metering cup 11 also includes a port 14 that seals around a data cable (e.g., USB cable) that is connected between the metering cup 11 and the dispensing system 101.

[041] Referring now to FIG. 10, the example metering cup 11 includes a timer module 210, a pump controller module 220, and a liquid detection module 230.

[042] The timer module 210 of the metering cup 11 measures an amount of time that elapses for a certain volume of liquid to be received by one or more of the vessels 12 of the metering cup 11. In some examples, the timer module 210 measures the time that elapses between when a signal by the metering cup 11 is sent to start one or more pumps (e.g., pumps 22A – 22N) and a signal is sent by the metering cup 11 to stop one or more of the pumps. In some examples, the timer module 210 measures the time that elapses between when a signal is received from the pump system 20 indicating that the pump has started pumping fluid to one or more of the vessels on the metering cup 11 and when the metering cup 11 detects that the vessel(s) is full.

[043] The pump controller module 220 communicates with one or more of the pumps 22A – 22N of the 100 of the pump system 20 to turn on and off the pumps. The pump controller module 220 can, for example, send a signal to start the pumps at a desired time (such as when the timer module 210 is started) and send a signal to turn off the pumps at a desired time (such as when the liquid detection module 230 indicates that one or more of the vessels 12 are full).

[044] The liquid detection circuit 230 is configured to detect the presence of liquid. In one example, the liquid detection circuit 230 includes an operational amplifier comparator circuit that is used to sense when the liquid in a vessel reaches a given height, thereby filling a known volume of the vessel.

[045] In some examples, the resistive values associated with the operational amplifier comparator circuit can be modified as desired depending on the composition of the liquids being used. For example, a liquid having a higher concentration of water may require a higher resistive value for the operational amplifier comparator circuit to sense. In some examples, each liquid can include a “resistive value” that is set so that the operational amplifier comparator circuit can be tuned to optimize sensing of the respective liquid and thereby the filling of the vessel. This can be desirable to minimize the highly conductive ingredients from “tripping” (i.e., causing a false positive) the operational amplifier comparator circuit whenever a “bridging” condition exists. A bridging condition is when a thin trace/ or film layer of highly conductive ingredient connects the top detection ring to the main volume of ingredient prior to the main volume reaching the detection ring.

[046] For example, many of the liquids being measured include minerals and corrosive properties. Over time, these elements can cause undesirable functioning of the metering cup, such as improper sensing of a full state of a vessel. For instance, a constant voltage applied to a liquid that includes the minerals could attract those minerals to a measuring probe and/or plate, thereby causing them to change properties over time and become ineffective.

[047] In some embodiments, the acids associated with micro-ingredients could create a low power battery when voltage was applied. Thus, the changing chemical properties of the fluid could result in unstable resistance values – i.e., the resistance would increase rapidly as a voltage was applied and it would not decrease until the polarity was reversed. This could make the detection process difficult using solely a DC signal. In some embodiments, an AC signal can be used to sample whether or not the vessel is full.

[048] Referring to FIG. 10B, another schematic of the dispensing system 101 and the metering cup 11 are shown. In this example, the resistance values for a given liquid that is being poured for a vessel is supplied by the dispensing system 101 to a comparator circuit 310 of the metering cup 11.

[049] The metering cup 11 includes a channel selector 314 and a ground ring 312. The metering cup 11 measures a resistance between a probe selected by the channel selector 314 corresponding to the desired vessel being filled and the ground ring 312. This resistance value is compared by the comparator circuit 310 to the resistance value.

[050] When the vessel is not filled, an open circuit is presented between the probe and ground, and the comparison fails. When the fluid fills the vessel and reaches the probe, the circuit is completed and the fluid resistance is equal to the reference resistance. The comparator 310 provides a detected full condition to the timing and controller modules 210, 220 of the metering cup 11.

[051] As noted, the reference resistance corresponds to the fluid resistance of the fluid being pumped by the pump that is currently being calibrated. By allowing this reference resistance to be set based upon the specific liquid being pumped, flexibility is provided in the types of fluids that can be calibrated for the dispensing system.

[052] FIG. 11 is a flow chart setting forth the general stages involved in a method 400 consistent with an embodiment of the disclosure for identifying a calculated dispensing error coefficient for a pump. Method 400 may be implemented using a measuring device 10, a pump system 20, a computing device 30, a network 40, and a server 50 as described in more detail above with respect to FIGS. 1-2. Ways to implement the stages of method 400 will be described in greater detail below.

[053] Method 400 may begin at starting block 405 and proceed to stage 410 where a pump within the pump system 20 may be cycled to dispense a projected volume of fluid into a measuring device 10. The pump system 20 may include a number of beverage ingredient sources

21A – 21N and associated pumps 22A – 22N. The beverage ingredient sources 21A – 21N may be conventional bag-in-box containers, micro-ingredient cartridges or cartons, conventional water connections, or any other type of beverage storage, supply, or delivery device, as described above.

[054] The pumps 22A-22N may be any type of positive displacement pump, as described above. In an embodiment, the pumps 22A – 22N may pump beverage ingredients from the beverage ingredient sources 21A – 21N to a nozzle 60 so as to dispense beverages from the beverage dispensing system 101. Where the pump system 20 includes positive displacement pumps, the actual dispensed volume in a given period of time may be determined as an actual dispensed volume per cycle of the positive displacement pump. Each time a positive displacement pump is pulsed or otherwise instructed to operate through a pumping cycle, a fixed volume of fluid is discharged from the pump. For example, in a vibratory or piston pump, each time the pump is pulsed or otherwise instructed to operate, a piston may be cycled within the pump to discharge a volume of fluid from an outlet and to draw in the volume of fluid from the inlet. In some examples, the actual dispensed volume in a given period of time may be determined as a flow rate of the pump.

[055] The measuring device 10 may attach to the nozzle 60 or otherwise place the vessels of the measuring device 10 in fluid communication with one or more fluid ports on the nozzle. During a calibration operation, the pumps 22A-22N may operate to dispense fluid from the nozzle 60 via the fluid ports and into the vessels of the measuring device 10. The beverage dispensing system 101 may be configured to dispense a diluent (not shown), such as still or carbonated water, along with one or more of the beverage ingredients from the beverage ingredient sources 21A – 21N in order to dispense a finished beverage. During the calibration operation, the beverage dispensing system 101 may not dispense a diluent and instead only dispense beverage ingredients from the beverage ingredient sources 21A – 21N corresponding to the pumps 22A – 22N that are being calibrated. Alternatively, the measurement device 10 may

include a flow director to divert the dispensed diluent stream to a drain (not shown) and away from the vessels of the measuring device 10.

[056] From stage 410, a pump may be cycled, method 400 may advance to stage 420 where an actual dispensed volume per cycle or flow rate may be determined. The actual dispensed volume per cycle for a given pump may be determined based on measurements taken by the measuring device 10 of a volume dispensed by the pump. In some embodiments, the volume measured by the measuring device 10 is a fill volume. The fill volume is a predetermined fixed volume of fluid within a vessel of the measuring device 10. During a calibration operation, once the measuring device 10 determines that a pump within the pump system 20 has dispensed the fill volume within a vessel corresponding to the pump, the measuring device 10 may provide a feedback signal to the pump system 20 to stop pumping the pump. The actual flow rate or actual dispensed volume per cycle may then be determined based on the measurements, such as how long it took to fill each of the vessels in the measuring device 10 or how many times a pump was cycled to dispense the fill volume.

[057] From stage 420, where an actual flow rate or actual dispensed volume per cycle may be determined, method 400 may advance to stage 430 where an error coefficient may be determined based on a difference between the projected volume per cycle and the actual volume per cycle. Once the actual flow rate or dispensed volume per cycle is determined, the dispensing error coefficient may be calculated. For example, if the actual dispensed volume per cycle is supposed to be 0.25 cm^3 but was determined to be 0.26 cm^3 , the pump delivered more fluid than it was intended to deliver. As a result, the computing device 30 may determine new calibration data that may be the coefficients of calibration curves or new calibration curves.

[058] From stage 430, where an error coefficient may be determined, method 400 may advance to stage 440 where the error coefficient may be loaded into the pump system 20. The pump system's 20 software controlling the pumps may be updated with the new calibration data. This new calibration data may be the coefficients of calibration curves or new calibration curves.

For example, to generate new calibration curves, test samples may be repeatedly dispensed and measured for differing test sample sizes to generate multiple data points. The multiple data points may be used to generate a new calibration curve via regression analysis or averages of the measured data.

[059] Referring now to FIG. 12, additional details are provided about the stage 410 when one or more of the pumps within the pump system 20 are cycled to dispense a projected volume of fluid into a measuring device 10. Generally, in this embodiment, the pump(s) are cycled in a predetermined manner to measure a fill time for the vessels of the metering cup.

[060] Specifically, at stage 510, the positive displacement pump is run continuously at a given flow-rate (e.g., full speed) until the one or more vessels associated with the pumps are filled approximately a predetermined amount. This predetermined amount can be, for example, approximately fifty percent full, approximately seventy-five percent full, or approximately ninety percent full. In this specific example, seventy-five percent full is achieved.

[061] Next, at stage 520, the pump(s) are slowed so that the pump functions to fill the remainder of the vessel(s) at an incremental (i.e., slower) rate. In some examples, this includes cycling the pump in a drip-by-drip manner until the vessel(s) are full.

[062] Finally, once the vessel(s) are full, the pumps are turned off at stage 530.

[063] Referring now to FIG. 13, additional details are provided about another method for the stage 410 in which one or more of the pumps within the pump system 20 are cycled to dispense a projected volume of fluid into a measuring device 10. This method is similar to that described above, except it does not require incrementally cycling the pump(s).

[064] Specifically, at stage 610, the positive displacement pump or pumps are run continuously at a given flow-rate (e.g., full speed) until the one or more vessels associated with the pumps are filled. Once filled, the pump or pumps are turned off at stage 620.

[065] More details on the method shown in FIG. 13 are provided in FIGS. 14A and 14B, which shows an example flow chart setting forth the general stages involved in a method 700.

[066] Specifically, at stages 702, 704, 706 the metering cup's revision level is queried and returned. The revision level informs the dispenser of the hardware with which the dispenser is communicating. Metering cups with different hardware, software and/or functionality may exist. The revision level allows the dispenser to execute the proper sequence of events based on the available level of functionality of the metering cup. Further, if the revision level indicates that the software is out-of-date, the dispenser may execute a sequence that includes upgrading the software for the metering cup.

[067] Next, at stage 708, the resistance values for each of the vessels to be poured are sent to the metering cup. Specifically, the electrical resistance properties of various liquids can differ, as noted above. Values are provided to the metering cup based upon the type(s) of liquid(s) that will be received in each of the vessels so that the metering cup can reliably determine when each of the vessels is full.

[068] Next, at stage 710, the pour is started for one or more of the vessels of the metering cup. In one example, only a single vessel is filled. In another, multiple vessels can be filled simultaneously.

[069] At stage 712, the metering cup is notified that the pump or pumps have started so that the timing can begin. Next, at stage 714, the metering cup polls each of the vessels to determine when one is full.

[070] Upon a full vessel, timing is stopped and the metering cup returns a full status at stage 718, and the pump is turned off at stage 720.

[071] Next, at stage 722, if not all of the desired vessels have been filled, control is passed back to stage 710. Otherwise, control is passed to stages 724, 726, and the metering cup reports the fill times and associated volumes for each filled vessel.

[072] At stage 728, the system calculates a value for each pump using the volume and time values returned by the metering cup: $\text{Value} = (\text{volume} * \text{time}) / \text{frequency}$.

[073] Next, at stage 730, a determination is made as to how many times a given pump/vessel has been tested. In this example, each pump is tested at least twice. If the desired number of tests (e.g., two) have not been performed, control is passed to stage 740, and the user interface is updated with the partial values that have been obtained. In some examples, each pump may be only tested once and control is passed to stage 734.

[074] If two test have been performed, control is passed to stage 732, and the results are averaged. Next, at stage 734, the value is compared to a specific range to determine if the value is within the range. If not, control is passed to stage 736 and an error is indicated on the user interface. If the value falls within the range, control is instead passed to stage 738 and the user interface is updated to indicate successful calibration of the pump. The pump system 20 may then use the value to calibrate the pump, as described above.

[075] In embodiments where the volume measured by the measuring device 10 is a fill volume, a series of samples (e.g., multiple tests, such as two) may be obtained for each of the vessels during the pumping in the calibration operation to determine when the vessel is full. The series of samples may be obtained proportional to the operating frequency of the pump. For example, the series of samples may be determined each time a pump is cycled. Also, the series of samples may be determined less frequently, such as one sample every ten times a pump is cycled, when the calibration operation is just starting and the series of samples may be determined more frequently as the fill volume is anticipated to be reached.

[076] As discussed below in conjunction with FIGS. 15-21, various calibration screens 800 may be shown on an interactive display 802. For example, the interactive display 802 may be displayed on a touchscreen of the pump system 20. Alternatively, the interactive display 802 may be displayed on a display screen of the pump system 20 or an external computing device and interacted with via conventional user interface devices such as a keyboard and/or mouse.

[077] As shown in FIG. 15, a technician may calibrate the pump system 20 by navigating to a technician screen. To navigate to the technician screen, the technician may be

required to log into the pump system 20 as a technician. Once on the technician screen, the technician may select a settings option 804 and then select a calibration option.

[078] Upon selecting the calibration option, the pump system 20 may display the calibration screen shown in FIGS. 16 and 17. As discussed above, two or more pumps may be in fluid communication with the same corresponding one of the plurality of vessels. As such, one of the two or more pumps may be calibrated at any given time. Accordingly, the pumps may be grouped in such a manner that all of the pumps in a given group may be calibrated at the same time. In the example shown in FIGS. 16 and 17, there are two groups – an A Group and a B Group. FIG. 16 shows the selection of the A Group and FIG. 17 shows the selection of the B Group. As shown in FIGS. 16 and 17, different pumps are shown on the calibration screen depending on the pump group selected. On the calibration screen, the technician can choose either an A Group or B Group pump grouping 810. By choosing a pump grouping 810, the screen will display all the pumps that are part of that grouping. The calibration screen will also present an option 812 for the technician to select all pumps within a currently selected pump group and an option 814 to deselect all the pumps within a currently selected pump group.

[079] Once a pump group has been chosen, the technician also has the capability to select individual pumps by selecting an individual pump location on the screen. By selecting an individual pump, the pump will alternate its selection state (e.g., selected or deselected). For example, if an individual pump is currently unselected and a technician selects that individual pump, the pump will alternate its selection state to selected, and vice versa. Selection of an individual pump will not modify the selection state of any of the other pumps shown. The technician can individually select multiple pumps within a grouping.

[080] To enable the START button 816 for calibration, at least one pump must be selected. Once the technician selects START, the calibration process will commence for the selected pumps. As shown in FIG. 18, a progress bar 820 will display showing status of the entire

calibration process, along with text informing the technician that the calibration process is underway.

[081] Once the process is completed, the screen shown in FIG. 19 will display the calibration status 830 for each pump (i.e. Green = Successful, Red = Unsuccessful or any other marking or indication of successful and unsuccessful pump calibrations), and inform the technician that the process is completed. All calibration values for successfully calibrated pumps will be written to the appropriate place in memory on the measuring device 10 and/or communicated to the pump system 20 for internal storage of the calibration values.

[082] Once the calibration process has been started, the pump system 20 will provide the capability to stop the process, at the earliest stoppable point, up until the first pump is successfully calibrated. If the technician selects a stop button 822 in FIG. 18, the pump system 20 will inform the user that the process is stopping. If a pump has been successfully calibrated, the ability to stop will become disabled for the remainder of the process. Once stopped, the pump system 20 will inform the user that the process has been stopped, and no pump will be calibrated. Once the process has been completely stopped, the Start button will become enabled, as there is no resume capability.

[083] If the system detects errors that require the entire group to be recalibrated, the pump system 20 will abort the calibration process, display all pumps in the group as failed, and provide detailed error messaging text 840, as shown in FIG. 20. Such errors may include the calibration cup not being correctly connected to the pump system 20, an unhandled software error, if a vessel filled within a threshold time of initiating calibration (e.g., vessel filled in less time than a threshold minimum calibration time), if a vessel is already full upon initiating calibration, or other such errors.

[084] If the system detects errors that only require certain pumps to be recalibrated, the pump system 20 will complete the calibration process, display successfully calibrated pumps, display failed pumps, and provide detailed messaging text 850 as shown in FIG. 21. Multiple

error messages will be shown, if they occur. Such errors may include if the initial cup volume pour failed, if the shots pour to chamber failed, the calibration taking longer than a maximum amount of time or a maximum number of times a pump is cycled, a calibration value is out of an accepted calibration value range, or other such errors.

[085] Once the calibration process has been started, the technician will not be able to navigate away from the calibration screen until: 1) the calibration process had been completed; 2) the calibration process has been stopped by the system as a result of an error; or 3) the calibration process has been stopped as a result of a manual stop by the technician.

[086] While certain screens are shown in FIGS. 15-21, it will be understood that more or fewer screens may be used in the calibration process.

[087] In the examples described herein, one or more of the measuring device 10, pump system 20, computing device 30, network 40, and server 50 can include one or more computing devices. A computing device can be any type of computer, such as a desktop, laptop, tablet, or mobile telephone. The computing device includes at least one central processing unit ("CPU") and a system memory. The system memory includes a random access memory and a read-only memory. A basic input/output system that contains the basic routines that help to transfer information between elements within the computing device, such as during startup, is stored in the ROM. The computing device further includes a mass storage device. The mass storage device is able to store software instructions and data. Although the description of computer-readable data storage media contained herein refers to a mass storage device, such as a hard disk or solid state disk, it should be appreciated by those skilled in the art that computer-readable data storage media can be any available non-transitory, physical device or article of manufacture from which the central display station can read data and/or instructions. Computer-readable data storage media include volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage of information such as computer-readable software instructions, data structures, program modules or other data. Example types of computer-readable

data storage media include, but are not limited to, RAM, ROM, EPROM, EEPROM, flash memory or other solid state memory technology, CD-ROMs, digital versatile discs (“DVDs”), other optical storage media, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the pump system.

[088] While the present disclosure has been described in terms of particular preferred and alternative embodiments, it is not limited to those embodiments. Alternative embodiments, examples, and modifications which would still be encompassed by the disclosure may be made by those skilled in the art, particularly in light of the foregoing teachings. Further, it should be understood that the terminology used to describe the disclosure is intended to be in the nature of words of description rather than of limitation.

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

CLAIMS:

1. A method of calibrating a pump system, comprising:
cycling a positive displacement pump continuously to pump a liquid into a vessel of a measuring device;
determining when the vessel in the measuring device is full; and
determining an actual flow rate of the positive displacement pump based on a volume of the vessel and an amount of time the positive displacement pump is run to fill the vessel.
2. The method of claim 1, further comprising:
determining an error coefficient based on a difference between a projected flow rate and the actual flow rate; and
loading the error coefficient into the pump system.
3. The method of claim 1, further comprising simultaneously cycling a plurality of positive displacement pumps.
4. The method of claim 1, cycling the pump to deliver the liquid as a portion of a beverage.
5. The method of claim 1, further comprising:
starting a timer when the positive displacement pump is started;
stopping the timer when the vessel is determined to be full; and
determining the amount of time as a time that elapsed between the starting and stopping of the timer.

6. The method of claim 1, further comprising:
determining a plurality of error coefficients for the positive displacement pump; and
calculating a final error coefficient from the plurality of error coefficients.
7. The method of claim 6, further comprising averaging two error coefficients to calculate the final error coefficient.
8. The method of claim 1, further comprising using an operational amplifier comparator circuit to sense the liquid in the vessel.
9. The method of claim 8, further comprising receiving a resistance of the amplifier comparator circuit based upon a type of the liquid being pumped into the vessel.
10. The method of claim 1, further comprising simultaneously estimating a plurality of amounts of time for a plurality of vessels of the measuring device.
11. A beverage dispensing system, comprising:
a plurality of beverage ingredient packages in fluid communication with a nozzle;
a plurality of pumps for pumping a beverage ingredient from the plurality of beverage ingredient packages, wherein each pump is positioned between each of the plurality of beverage ingredient packages and the nozzle; and
a measurement device including a plurality of vessels and being adapted to securely attach to the nozzle and receive the beverage ingredients from the plurality of beverage ingredient packages, the measuring device adapted to determine an actual flow rate of one of the plurality of pumps by continuously running the pump to fill a known volume of a corresponding one of the plurality of vessels of the measuring device.

12. The system of claim 11, wherein the measurement device further comprising a processor and memory encoding instructions that, when executed by the processor, cause the processor to:
- start a timer when the pump is started;
 - stop the timer when the corresponding vessel is full; and
 - determine an amount of time that elapsed between the start and the stop of the timer.
13. The system of claim 12, wherein the memory encodes further instructions that, when executed by the process, cause the processor to:
- determine a plurality of an error coefficients for the pump; and
 - calculate a final error coefficient from the plurality of an error coefficients.
14. The system of claim 13, wherein the memory encodes further instructions that, when executed by the process, cause the processor to average two error coefficients to calculate the final error coefficient.
15. The system of claim 11, further comprising at least one comparator circuit to sense when the corresponding vessel of the measuring device is full.
16. The system of claim 15, wherein the memory encodes further instructions that, when executed by the process, cause the processor to receive a resistance of the at least one comparator circuit based upon a type of the beverage ingredients being pumped into the plurality of vessels of the measuring device.

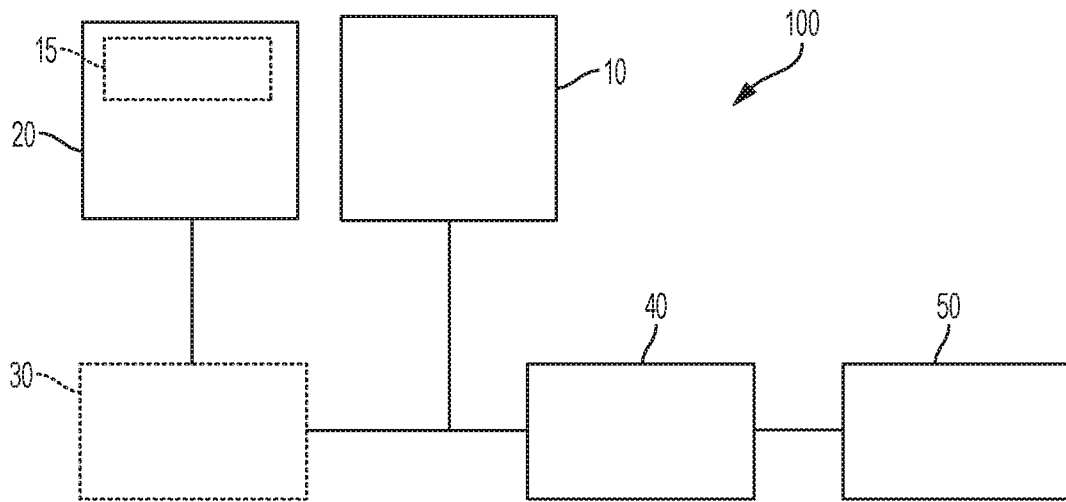


FIG. 1A

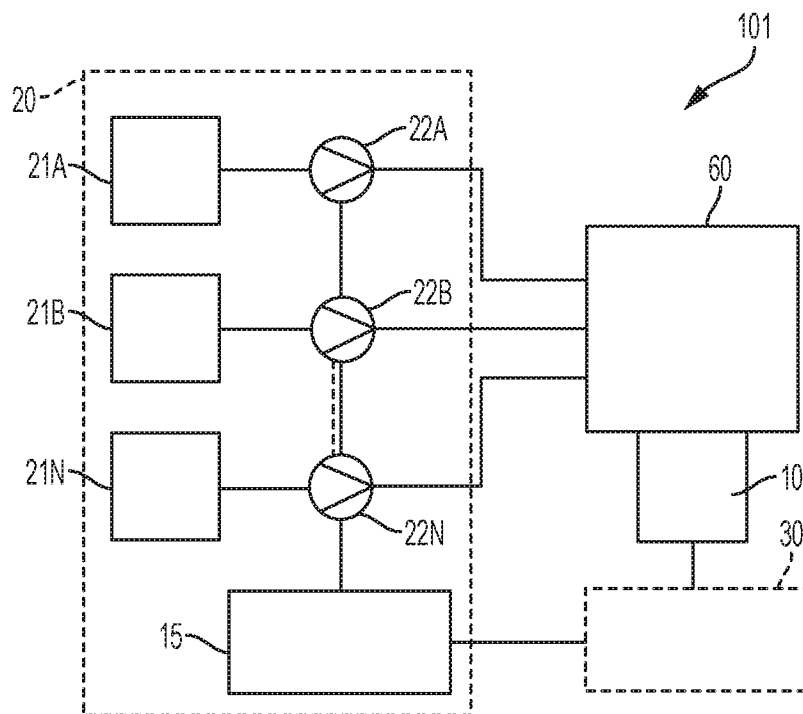


FIG. 1B

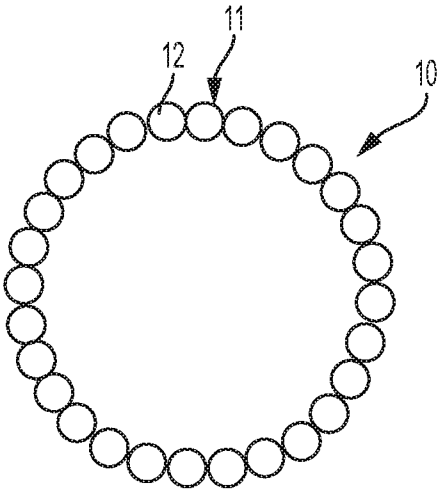
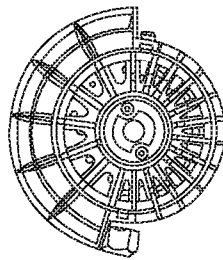
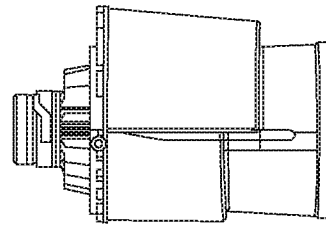
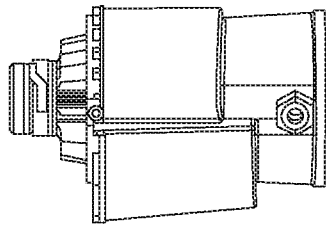
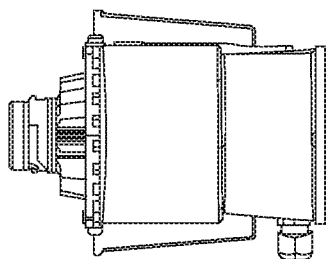
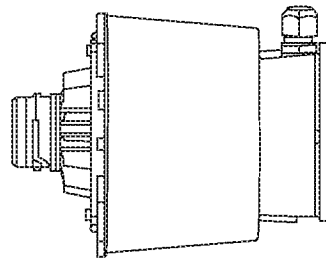
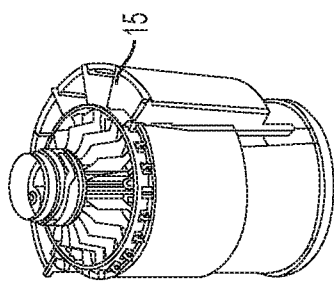
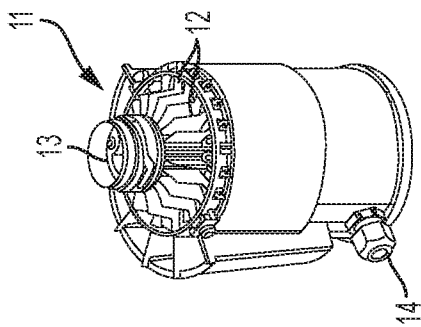


FIG. 2



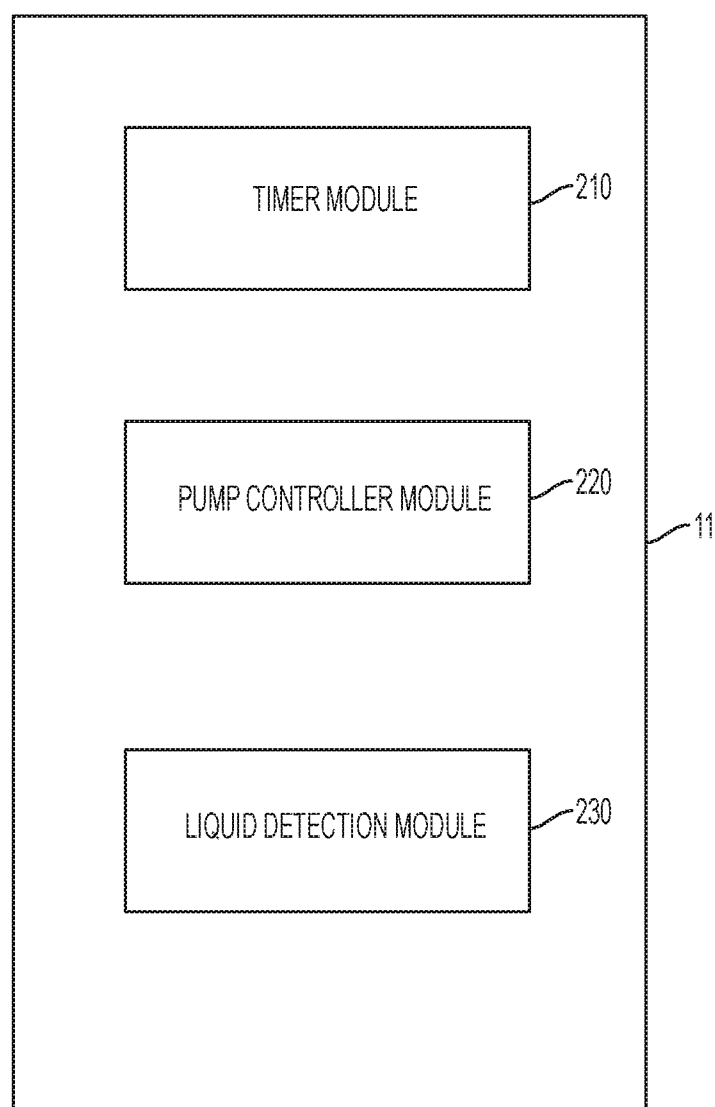


FIG. 10A

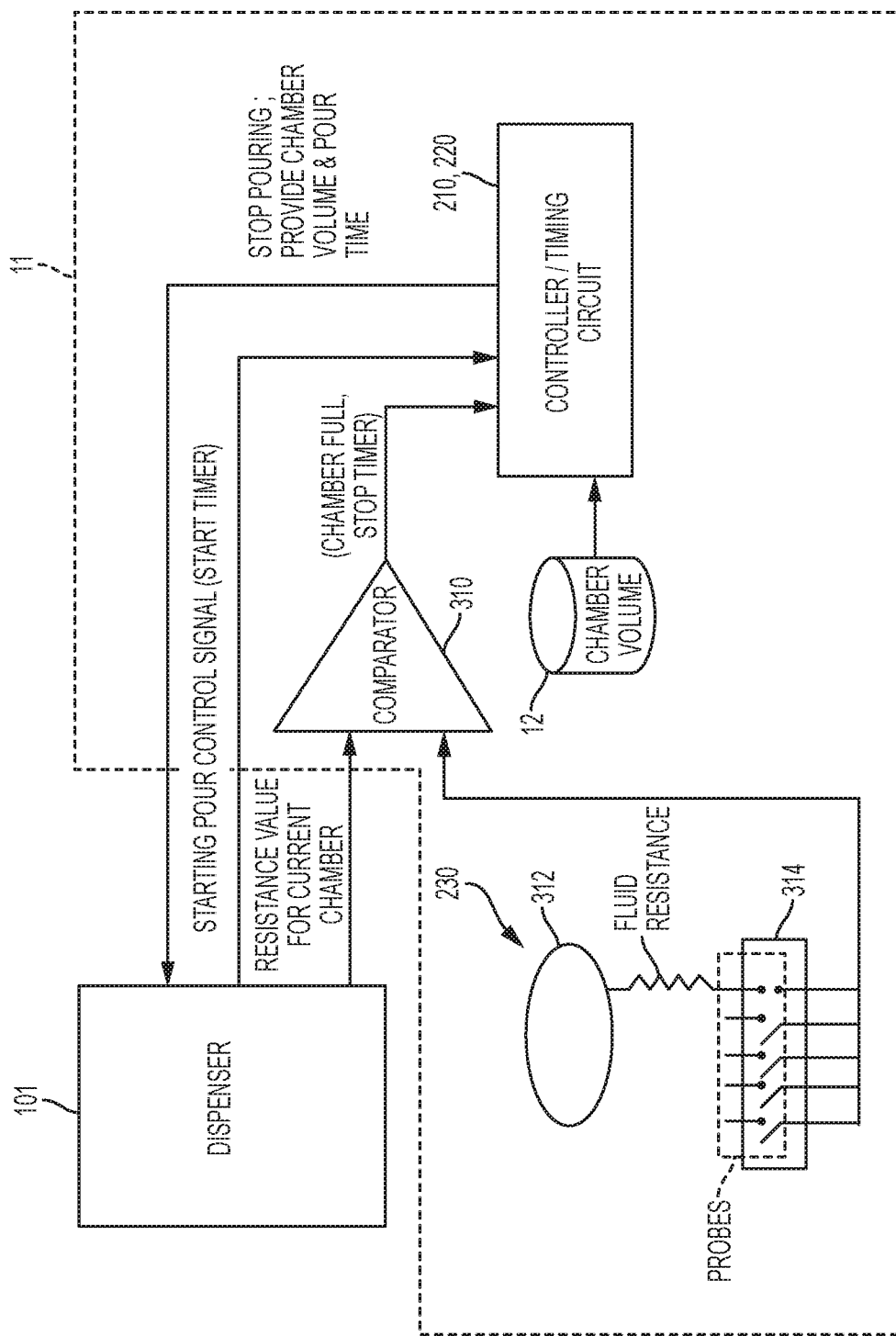


FIG. 10B

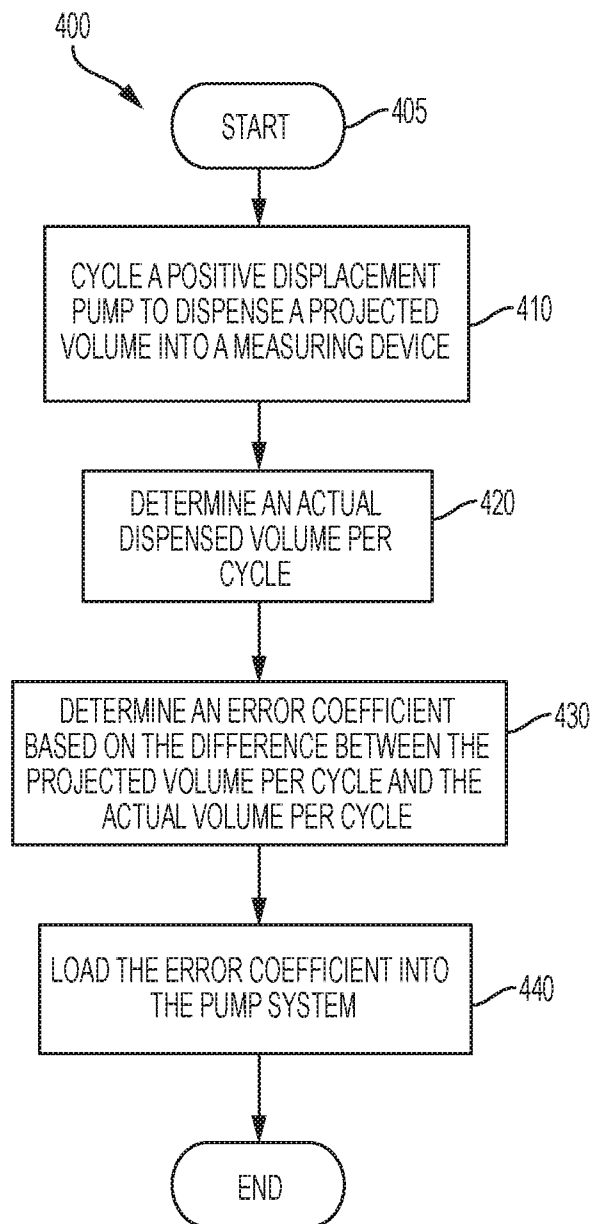


FIG. 11

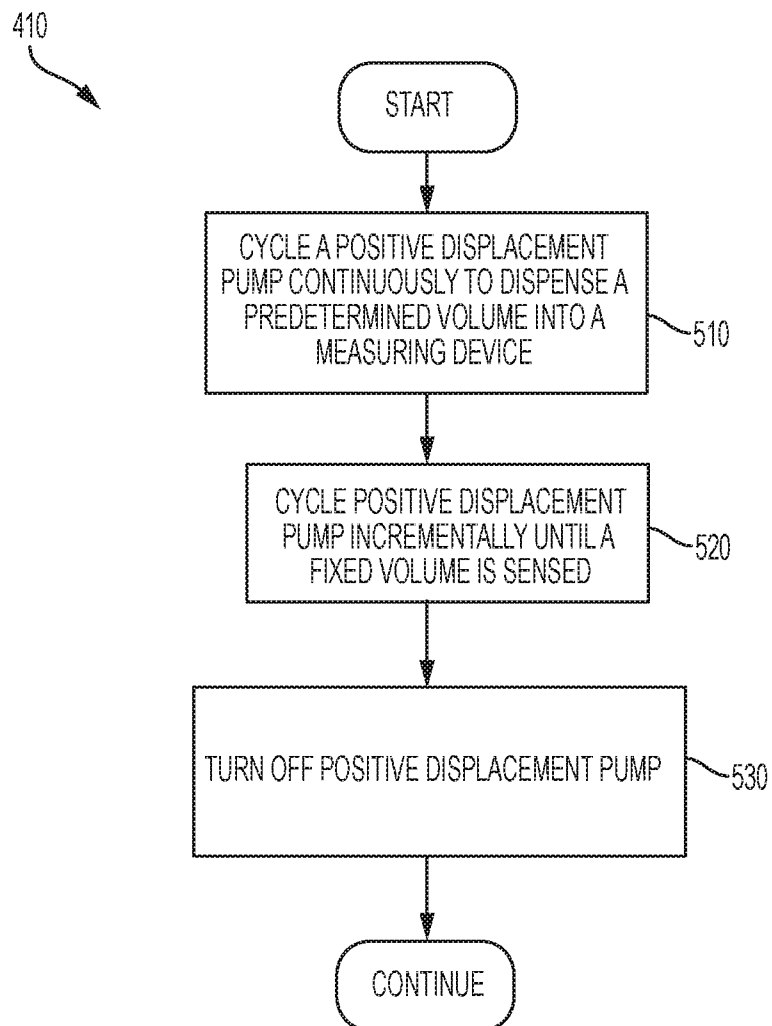


FIG. 12

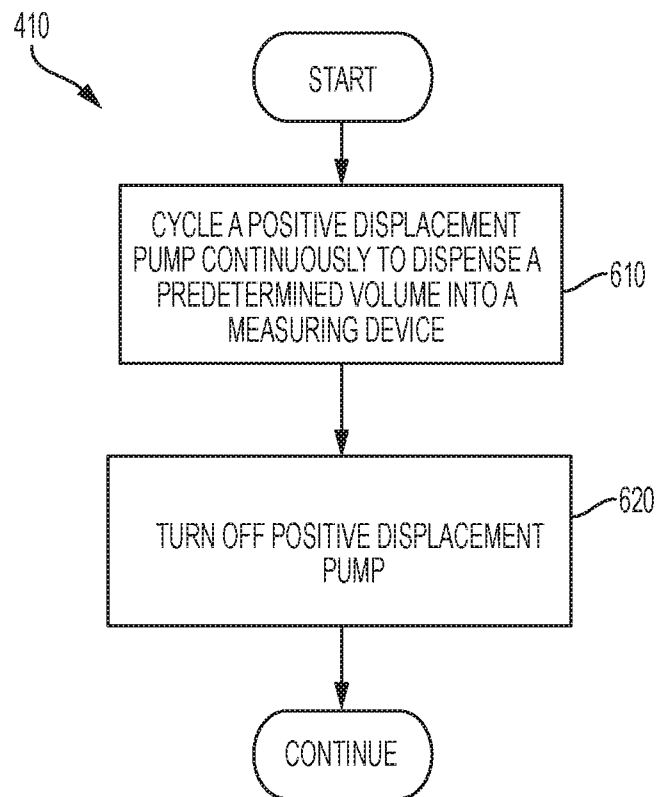


FIG. 13

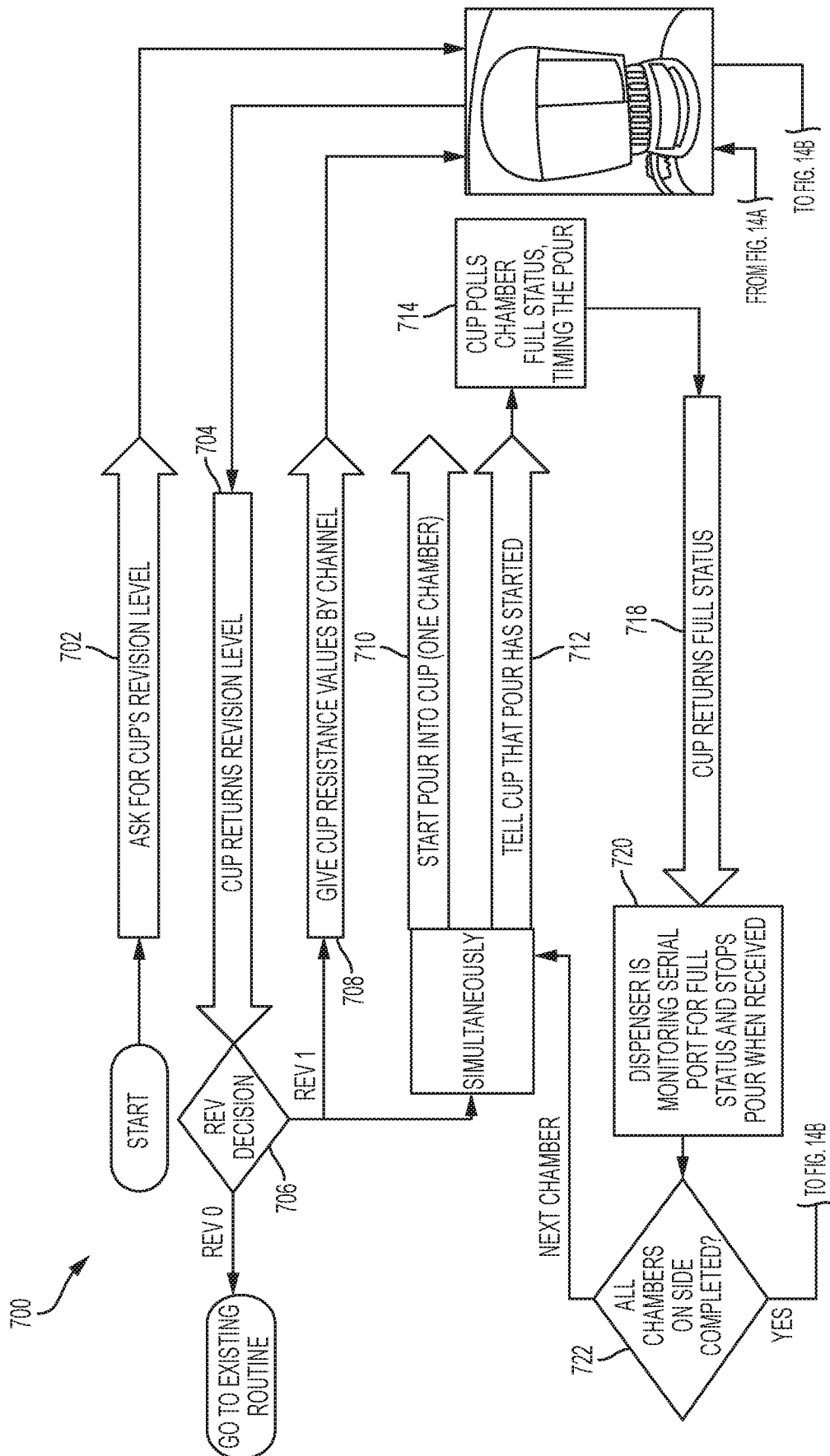


FIG. 14A

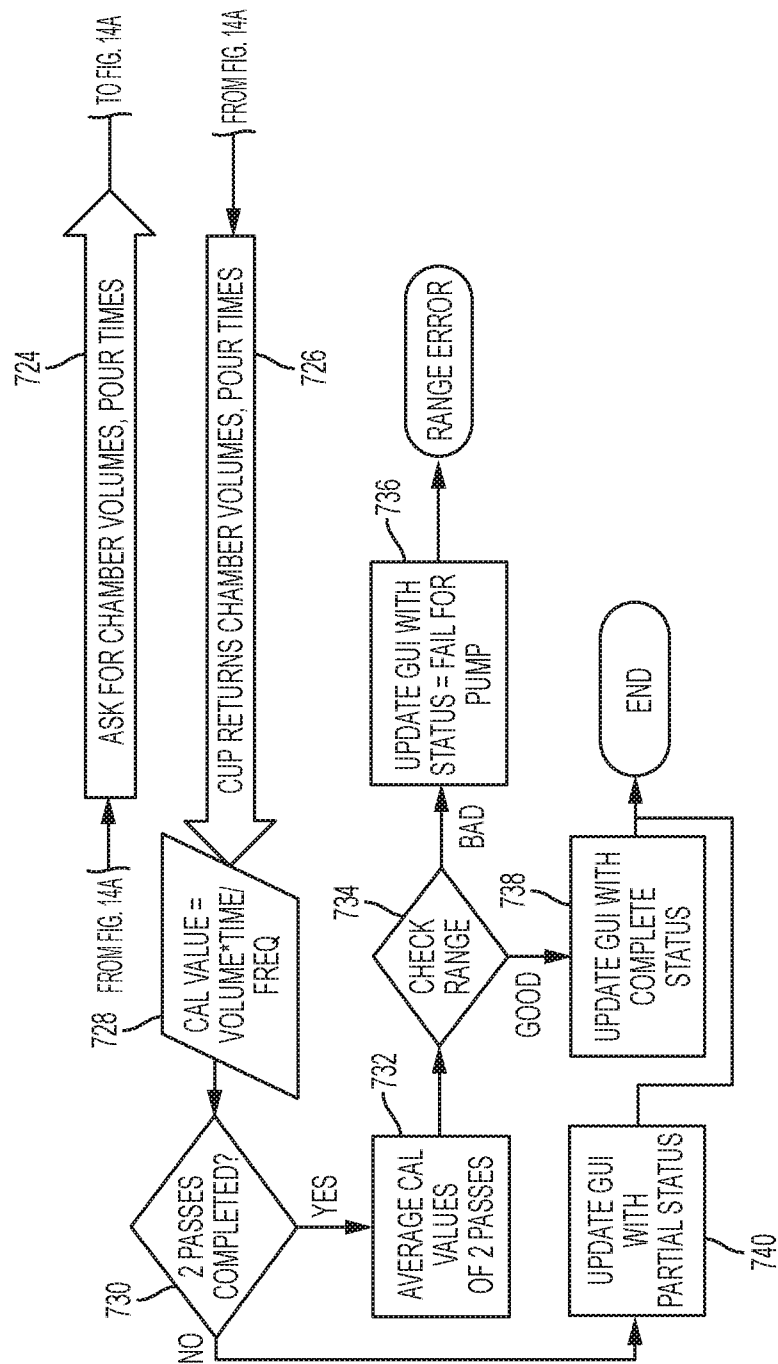


FIG. 14B

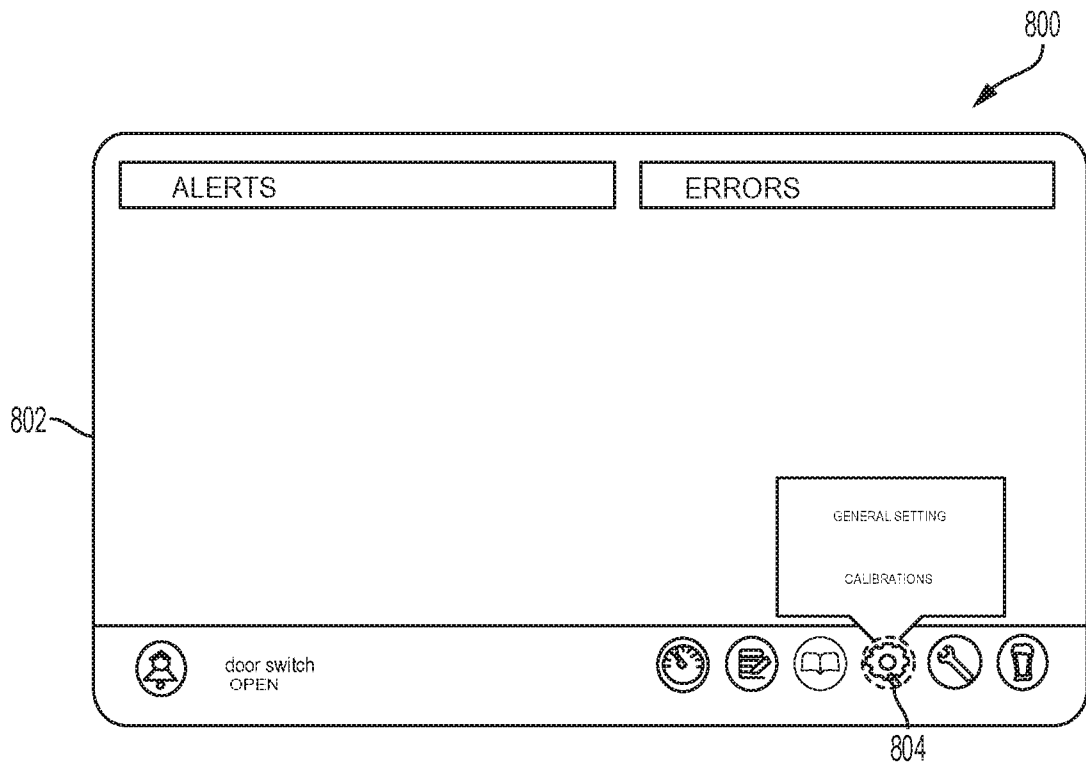


FIG. 15

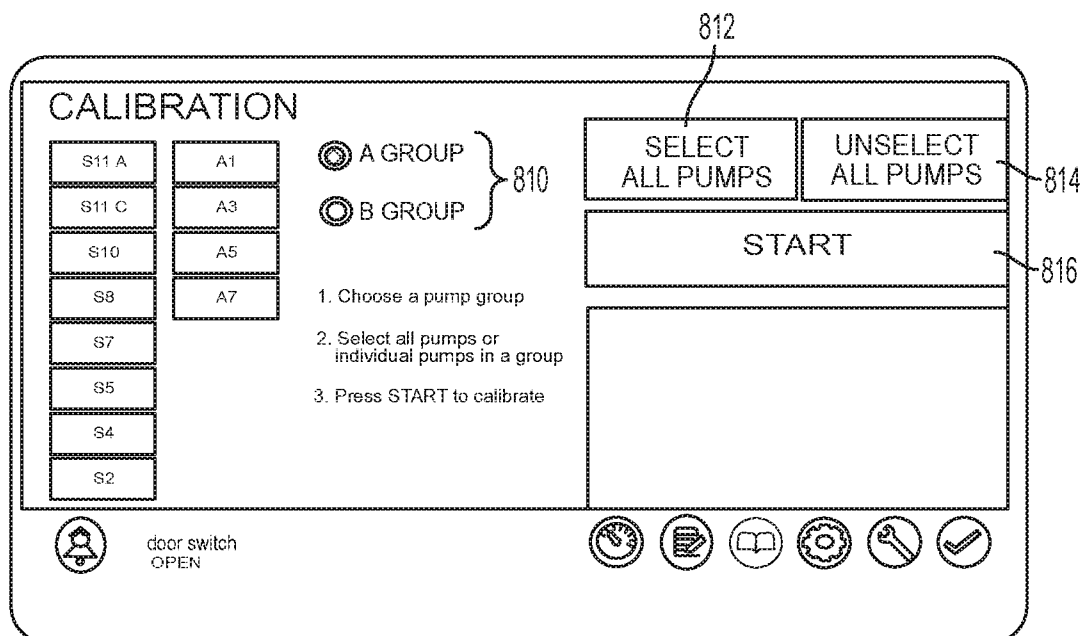


FIG. 16

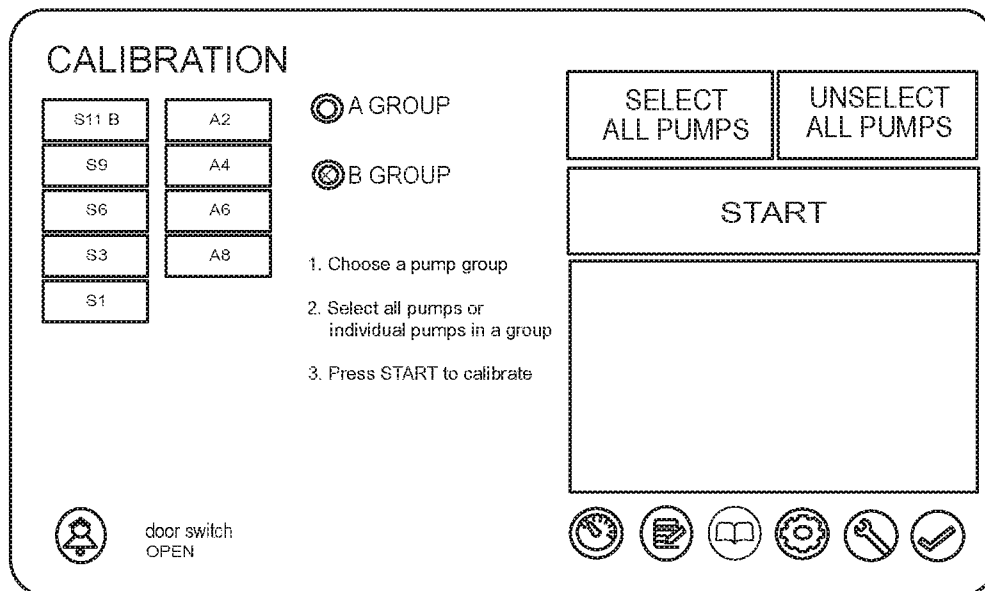


FIG. 17

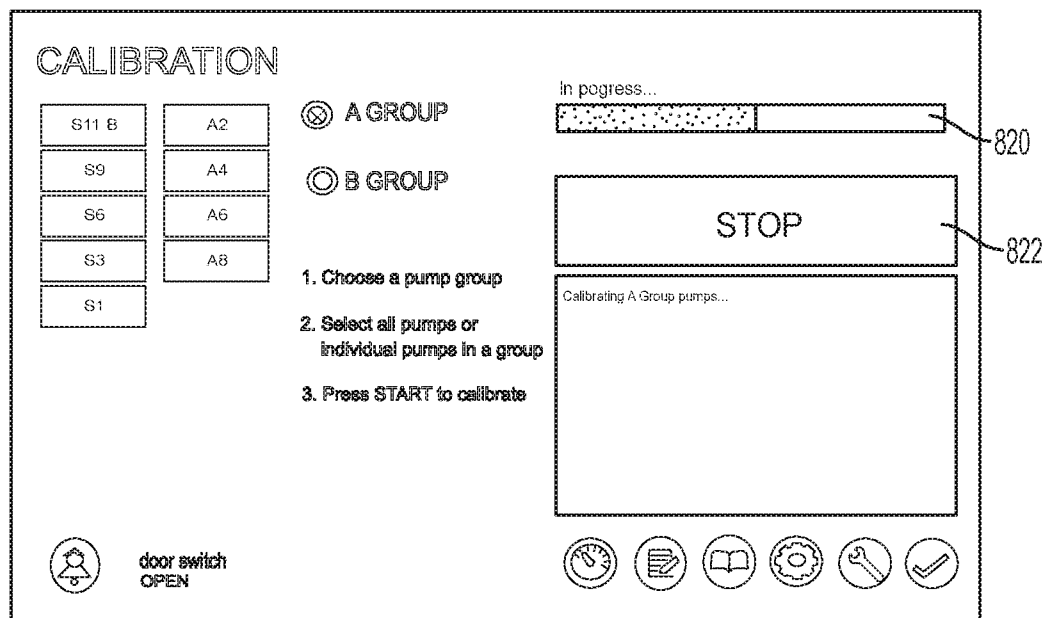


FIG. 18

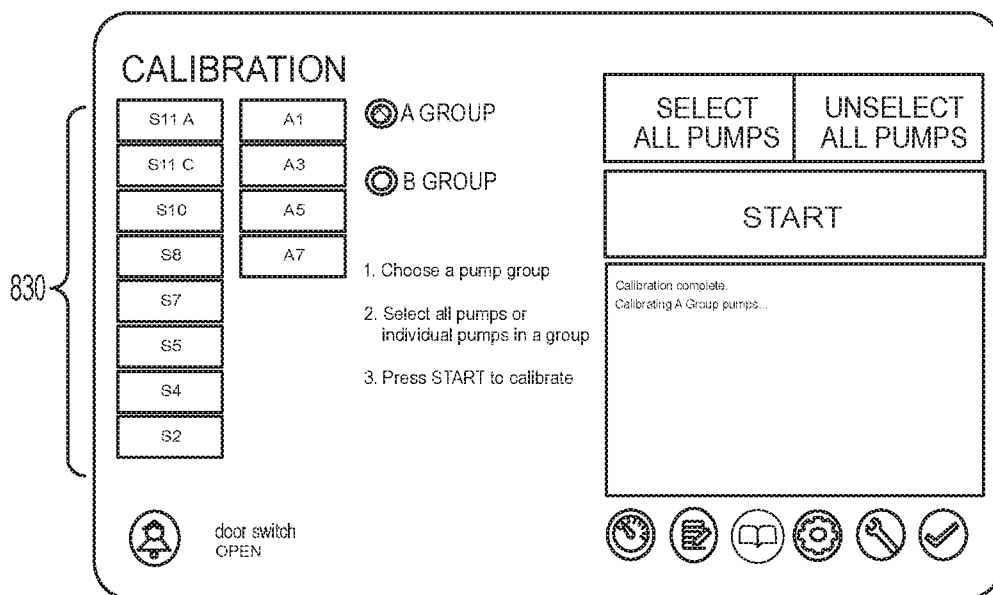


FIG. 19

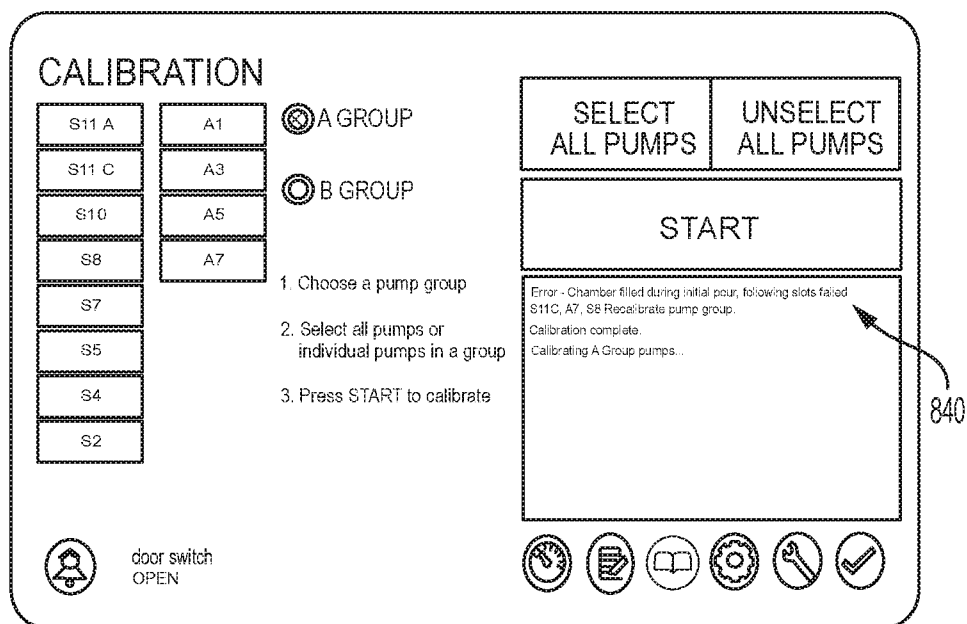


FIG. 20

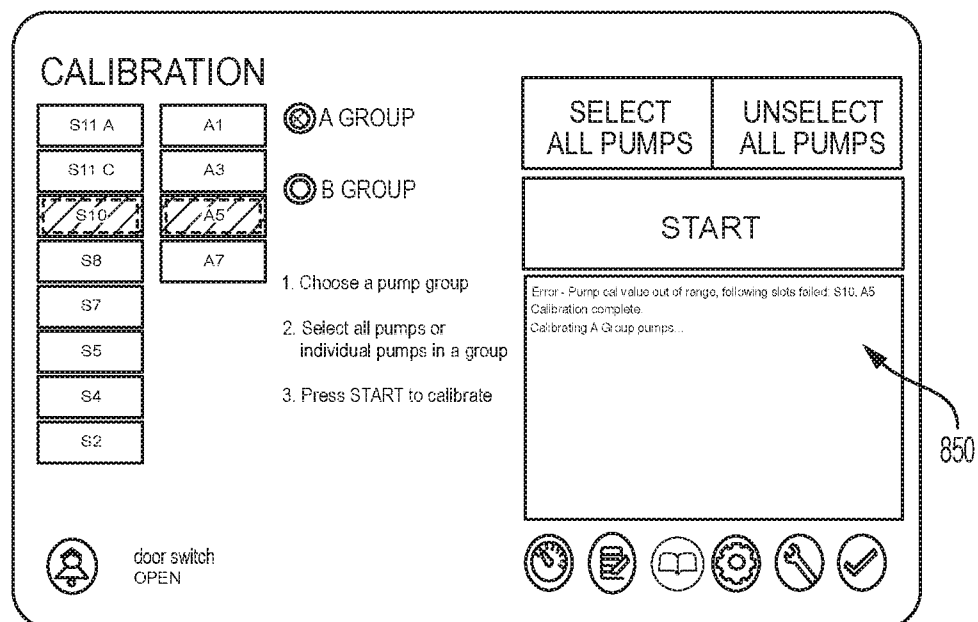


FIG. 21

A. CLASSIFICATION OF SUBJECT MATTER**F04B 49/06(2006.01)i, F04B 51/00(2006.01)i, F04B 13/02(2006.01)i, F04B 23/04(2006.01)i**

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)

F04B 49/06; G12B 13/00; B67D 7/74; G01F 23/24; B05B 7/26; B67D 5/08; F04B 51/00; F04B 13/02; F04B 23/04

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: calibrating, pump, vessel, measuring device, actual, projected, flow rate, error coefficient, beverage, nozzle**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4925096 A (GILL, DAVID C.) 15 May 1990 See column 3, line 27 - column 5, line 13, claims 1, 8, and figures 1-2.	1,2,5-7,10
Y		3,4,8,9,11-16
Y	US 2012-0074168 A1 (NEWMAN, DAVID R.) 29 March 2012 See paragraph [0032], claim 8 and figure 1.	3,4,11-16
Y	US 4706497 A (REGAN, THOMAS O.) 17 November 1987 See abstract and claims 1, 6.	8,9,15,16
A	US 4830218 A (SHIRKHAN, HAMID) 16 May 1989 See abstract, claim 1, and figure 1.	1-16
A	US 7428838 B2 (GUGARATSHAN et al.) 30 September 2008 See claim 1 and figure 1.	1-16



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

20 June 2017 (20.06.2017)

Date of mailing of the international search report

20 June 2017 (20.06.2017)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/022404

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4925096 A	15/05/1990	AT 87094 T	15/04/1993
		AU 2754088 A	06/07/1989
		AU 607835 B2	14/03/1991
		BR 8806984 A	05/09/1989
		CA 1316506 C	20/04/1993
		DE 3879446 T2	24/06/1993
		DK 731088 A	01/07/1989
		EP 0323205 A1	05/07/1989
		EP 0323205 B1	17/03/1993
		ES 2040875 T3	01/11/1993
		GB 2214164 A	31/08/1989
		GB 2214164 B	04/09/1991
		GB 2214164 C	31/03/1995
		JP 01-215367 A	29/08/1989
		JP 6079692 B2	12/10/1994
		NO 885835 A	03/07/1989
		NZ 227406 A	26/04/1990
		PT 89348 A	14/09/1989
		PT 89348 B	30/11/1993
		ZA 8809663 B	25/10/1989
US 2012-0074168 A1	29/03/2012	AU 2011-312669 A1	18/04/2013
		CN 103153837 A	12/06/2013
		EP 2621850 A1	07/08/2013
		JP 2013-537871 A	07/10/2013
		MX 2013003457 A	29/08/2013
		RU 2013117723 A	10/11/2014
		US 8973785 B2	10/03/2015
		WO 2012-047521 A1	12/04/2012
US 4706497 A	17/11/1987	None	
US 4830218 A	16/05/1989	None	
US 7428838 B2	30/09/2008	US 2008-0053209 A1	06/03/2008