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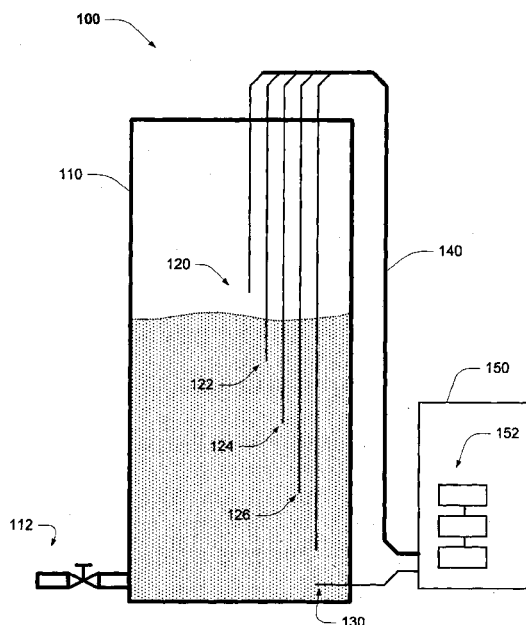


FIG. 1

(57) Abstract: An apparatus and method of sensing fluid level in reservoir for calculating fluid flow there from. The method comprising the steps of: receiving a plurality of fluid level signals each indicative of respective fluid level state at a predetermined location within the reservoir; identifying change of a first fluid level state; recording a relative first time, with respect to fluid flow duration, at which the first fluid level state changed; and calculating fluid dispensed from the reservoir using the fluid flow duration and an average fluid flow rate associated with the respective fluid level location within the reservoir. The apparatus comprising: a plurality of fluid level probe elements located within the reservoir, each adapted to provide a respective fluid level signal; and a processor module adapted to receive receiving a plurality of fluid level signals.



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METHOD AND APPARATUS FOR WATER LEVEL SENSING

FIELD OF THE INVENTION

The present invention relates to fluid level sensing and in particular to methods and apparatus for fluid level sensing in a domestic appliance.

- 5 The invention has been developed primarily as a method and apparatus to sense fluid level in a reservoir for calculating fluid flow there from, and will be described hereinafter with reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use.

BACKGROUND OF THE INVENTION

- 10 Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of the common general knowledge in the field.

Known devices for calculating or measuring fluid flow from a reservoir include inline calibrated flow meters. For consumer items, this method of measuring fluid flow
15 typically does not satisfy cost constraints applied to respective designs.

There is a need in the art for an alternative method and apparatus in calculating fluid flow from a reservoir.

OBJECT OF THE INVENTION

- It is an object of the present invention to overcome or ameliorate at least one of the
20 disadvantages of the prior art, or to provide a useful alternative.

It is an object of the invention in its preferred form to provide a method and apparatus to sense fluid level in reservoir for calculating fluid flow there from.

SUMMARY OF THE INVENTION

According to an aspect of the invention there is provided a method of sensing fluid level in reservoir for calculating fluid flow there from, the method comprising the steps of:

- receiving a plurality of fluid level signals each indicative of respective fluid level state at a predetermined location within the reservoir;
- identifying change of a first fluid level state;
- recording a relative first time, with respect to fluid flow duration, at which the first fluid level state changed;
- calculating fluid dispensed from the reservoir using the fluid flow duration and an average fluid flow rate associated with the respective fluid level location within the reservoir.

According to an aspect of the invention there is provided a method of sensing fluid level in reservoir for calculating fluid flow there from, the method comprising the steps of:

- receiving a plurality of fluid level signals each indicative of respective fluid level state at a predetermined location within the reservoir;
- identifying change of a first fluid level state;
- recording a relative first time, with respect to fluid flow duration, at which the first fluid level state changed;
- identifying change of a second fluid level state;
- recording a relative second time, with respect to fluid flow duration, at which the second fluid level state changed;
- calculating average fluid flow rate from the reservoir using, at least, a known volume held by the reservoir between the change of the first fluid level state and the change of the second fluid level state and the fluid flow duration between the first time and the second time;
- associating the average fluid flow rate with the fluid level location within the reservoir.

Preferably, the average fluid flow rate being associated with the second fluid level location or state. Alternatively, the average fluid flow rate being associated with the first fluid level location or state. Most preferably, the average fluid flow rate being related to fluid flow while the level is between the first level location and the second fluid level location.

Preferably, the first fluid level state is indicative of a first predetermined location within the reservoir, and the second fluid level state is indicative of a second predetermined location within the reservoir. More preferably, the first predetermined location and second predetermined location are adjacent or neighbouring.

- 5 According to an aspect of the invention there is provided a method that includes the step of: receiving data indicative of a selected fluid volume. Preferably, the method includes the step of: calculating a primary flow time for delivering a selected fluid volume, the flow time being at least dependant on an average fluid flow rate. More preferably, the method includes calculating a compensated flow time, including any one or more of the
- 10 following: preheat compensation time; ambient temperature compensation time; heater temperature compensation time; reservoir head compensation time; and mains input voltage compensation time. Most preferably, the selected fluid volume can be dispensed.

According to an aspect of the invention there is provided a method that includes the step

15 of: receiving data indicative of a selected fluid volume. Preferably, the method includes the step of: calculating a primary flow time for delivering a selected fluid volume, the flow time being at least dependant on an average fluid flow rate. More preferably, fluid volume dispensed can be calculated using flow time multiplied by a fluid flow rate. Most preferably, the selected fluid volume can be dispensed.

- 20 Preferably, a selected fluid volume can be dispensed using method steps of:

 multiplying an initial flow time by a fluid flow rate associated with the respective fluid level location within the reservoir to calculate an initial volume;

 multiplying a plurality of volume quantum corresponding to the distance between consecutive (or neighbouring) probe elements, the plurality of volume quantum

25 added to the initial volume being less than that of the selected fluid volume, the plurality of volume quantum added to the initial volume being subtracted from the selected fluid volume being a remainder volume less than one volume quantum, an intermediate flow time being the time duration for the plurality of fluid states to change;

30 the final flow time, being a flow time from a final state change, is calculated from the remainder volume divided by a final average flow rate associated with the respective final fluid level location within the reservoir;

the total flow time for dispensing a selected volume being the sum of the initial flow time, the intermediate flow time and final flow time.

Preferably, the reservoir has a constant cross section. The probe elements for producing the fluid level signals are preferably located (or distributed) uniformly through the depth of the reservoir. Most preferably, the distance between consecutive (or neighbouring) probe elements represents a volume quantum of 150ml.

Preferably, the probe elements for producing the fluid level signals are located (or distributed) through the depth of the reservoir such that fluid level state changes with respect to a quantised representation of the reservoir volume. More preferably, the quantised representation of the reservoir volume is uniformly distributed between consecutive fluid level state changes. Most preferably, the uniformly distributed consecutive fluid level state changes define a constant volume quantum there between.

Preferably, each average flow rate is retained or stored (or accumulated or averaged). More preferably, each average flow rate is initialised and stored. Most preferably, each average flow rate is calculated or adaptively updated during use and stored. Alternatively, each average flow rate is initialised or pre calibrated and stored.

Preferably, the fluid is a liquid. Most preferably, the fluid is liquid water.

According to an aspect of the invention there is provided an apparatus for sensing fluid level in a reservoir to calculate fluid flow there from, the apparatus comprising:

- a plurality of fluid level probe elements located within the reservoir, each adapted to provide a respective fluid level signal; and
- a processor module adapted to receive receiving a plurality of fluid level signals; the processor module being adapted to perform a method as herein disclosed.

Preferably, the processor module being adapted to perform a method of sensing fluid level in reservoir for calculating fluid flow there from. More preferably, the processor module being adapted to calculate a flow time for dispensing a selected fluid volume from the reservoir. Most preferably, the processor module being adapted to dispense a selected fluid volume from the reservoir.

According to a further aspect of the invention there is provided a computer program product stored on a computer usable (or readable) medium, the computer program

product for operation with a processor device and being adapted to provide a method of sensing fluid level in reservoir for calculating fluid flow there from as herein described. Preferably the computer usable (or readable) medium is non-transient. The computer usable (or readable) medium comprising computer code for executing a method as
5 herein described. The computer program product comprising a computer readable program means for executing a method as herein described.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

- 10 FIG. 1 is a schematic view of an embodiment apparatus for sensing fluid level in reservoir;
- FIG. 2A is a flow diagram for an embodiment method of sensing fluid level in reservoir;
- FIG. 2B is a flow diagram for an embodiment method of sensing fluid level in
15 reservoir;
- FIG. 3 is a flow diagram for an embodiment method of sensing fluid level in reservoir;
- FIG. 4 is a partial schematic circuit diagram of an embodiment apparatus for sensing fluid level in reservoir;
- FIG. 5 is a schematic diagram of an embodiment apparatus for sensing fluid level in
20 reservoir;
- FIG. 6 is a schematic diagram of an embodiment apparatus for sensing fluid level in reservoir;
- FIG. 7 is a flow diagram for an embodiment method of sensing fluid level in reservoir;
- FIG. 8 is a perspective view of a fluid reservoir with capacitive level sensing;
- 25 FIG. 9(a) is a side elevation of a removable reservoir with pivoting draw tube that incorporates a capacitive level sensor;
- FIG. 9(b) shows the device of Figure 9(a) with the draw tube partially withdrawn; and

FIG. 9(c) illustrates the device depicted in Figures 9(a) and 9(b) with the draw tube pivoted fully out of the removable reservoir.

PREFERRED EMBODIMENT OF THE INVENTION

Referring initially to FIG. 1 of the drawings, an embodiment apparatus 100 is shown for
5 sensing fluid level in reservoir 110.

The apparatus 100 is adapted for sensing fluid level in a reservoir 110 to calculate fluid flow there from 112. This apparatus comprises:

a plurality of fluid level probe elements 120 (for example 122, 124, 126) located within the reservoir, each adapted to provide a respective fluid level signal (via
10 140), each fluid level signal being indicative of respective fluid level state at a predetermined location within the reservoir; and
a processor module 150 adapted to receive receiving a plurality of fluid level signals; the processor module being adapted to perform a method 152 as herein disclosed.

15 In this embodiment, by way of example, a plurality of fluid level probe elements 120 (for example 122, 124, 126) are each adapted to provide signals indicative of respective fluid level state at a predetermined location within the reservoir. In this embodiment, a common (or transmitter) probe element 130 provides a common source operatively associated with each fluid level probe element. A plurality of fluid level signals, each
20 indicative of respective fluid level state at a predetermined location within the reservoir, are communicated (via a signal path 140) to a processor module 150.

The processor module 150 being adapted to identify a change in a first fluid level state and recording a relative first time, with respect to fluid flow duration, at which the first fluid level state changed. The processor module being further adapted to calculate an
25 average fluid flow rate from the reservoir using the fluid flow duration and the first time. The processor module being further adapted to calculate an average fluid flow rate from the reservoir using the fluid flow duration and a pair of times indicating respective change of fluid level state at distinct predetermined locations within the reservoir. The processor module being further adapted to calculate fluid dispensed from the reservoir

using the fluid flow duration and, by way of example at least, an average fluid flow rate associated with the respective fluid level location within the reservoir.

It will be appreciated that by extending the probe elements downward, into the reservoir, the full extent of the probe element can be used to sense the presence of the fluid,
5 thereby sensing whether (or not) the fluid is at least at (or above) the end extremity of the probe element.

By way of example only, the reservoir has a constant cross section. The probe elements for producing the fluid level signals are located (or distributed) uniformly through the depth of the reservoir, such that the distance between consecutive probe elements
10 represents a respective volume there between of 150mL.

In an embodiment, probe elements for producing the fluid level signals are located (or distributed) through the depth of the reservoir. The distance between consecutive probe element can represent a constant volume quantum, such as 150ml. By way of example only, an assembly can include a plurality of probe elements- including one common
15 (transmitter) probe element and at least one active (receiver) probe elements.

In this embodiment apparatus 100, thirteen active (receiver) probe elements are spaced in the reservoir at heights corresponding to 150ml intervals starting from 0 through to 1800ml. As the fluid level passes between two probe elements a relative time is monitored and stored. This relative time duration can be used to calculate an average
20 flow rate between the two probe elements (typically consecutive probe elements). Each instance where fluid passes between the same pair of probe elements, the previous timing data and/or average flow rate data can be overwritten.

A method of controlling fluid volume dispensed by an apparatus can includes observing the time taken by the apparatus (pump) to dispense a known volume of fluid from a
25 reservoir, having a particular fluid head height. This timing data can be used to determine the required flow time that the pump needs to dispense a selected fluid volume. By way of example only, the pump can be a vapour lift pump.

The volume dispensed can be user selected, or can be automatically selected. Automatic selection can be based on the capacity of fluid receptacle located for receiving the fluid,
30 as detected by the apparatus. Typically the fluid is a relatively electrically conductive fluid, such as drinking (or potable) water.

In an example embodiment, the apparatus 100 is adapted to deliver a fluid having a selected volume (for example a cup – *selected_volume*).

The apparatus can retrieve an average flow rate for the starting reservoir level. A timer can continue to maintain an initial flow time with respect to a relative start time, the processor element identifies the relative time (or flow duration) as the fluid level passes below the next probe element. For example this flow duration is determined as *initial_probe_time* seconds. The processor can calculate the fluid volume delivered, on the basis of a previously recorded flow rate *initial_flow_rate*, as (*initial_probe_time* x *initial_flow_rate* at a specific fluid level).

10 The processor can then calculate how many more probe elements need to be passed (for example having an incremental volume of 150ml).

Any residual volume required to complete the selected (or required) volume to be delivered can then be calculated. The residual volume (*residual_volume*) being the required volume less the volume dispensed reaching the initial probe element and less any discrete probe element volume quantum (*discrete_probe_volume*), can be expressed as represented in the equation below.

$$\begin{aligned} \text{residual_volume} = & \text{selected_volume} - (\text{initial_flow_rate} \times \text{initial_probe_time}) \\ & - (N \times \text{discrete_probe_volume}) \end{aligned}$$

The residual flow duration (*residual_probe_time*) for dispensing the residual volume, can be expressed as represented in the equation below.

$$\text{residual_probe_time} = \text{residual_volume} / \text{residual_flow_rate}$$

The flow duration can then be established (or calculated)

$$\text{flow_duration} = \text{initial_probe_time} + \text{discrete_probe_time} + \text{residual_probe_time}$$

25 It will be appreciated that, in this embodiment, the times *initial_probe_time* and *discrete_probe_time* are typically measured, while *residual_probe_time* is typically a controlled duration parameter. Typically the smallest selectable disposed volume is greater than the volume quantum represented by consecutive probe elements.

Referring to FIG 2, a flow chart of an embodiment method 210 of sensing fluid level in reservoir for calculating fluid flow there from. The method comprising the steps of:

- STEP 211: receiving a plurality of fluid level signals each indicative of respective fluid level state at a predetermined location within the reservoir;
- 5 STEP 212: identifying change of a first fluid level state;
- STEP 213: recording a relative first time, with respect to fluid flow duration, at which the first fluid level state changed;
- STEP 214: calculating fluid dispensed from the reservoir using the fluid flow duration and an average fluid flow rate associated with the respective fluid level location within the reservoir.

Referring to FIG 2B, a flow chart of an embodiment method 220 of sensing fluid level in reservoir for calculating fluid flow there from. The method comprising the steps of:

- STEP 221: receiving data indicative of a selected fluid volume;
- STEP 222: calculating a primary flow time for delivering a selected fluid volume, the flow time be at least dependant on an average fluid flow rate;
- 15 STEP 223: controlling the fluid volume dispensed.

In an embodiment, the fluid volume dispensed can be calculated and/or controlled using method steps of:

- 20 ➤ multiplying an initial flow time by a fluid flow rate associated with a respective fluid level location within the reservoir to calculate an initial volume;
- multiplying a plurality of volume quantum corresponding to the distance between consecutive (or neighbouring) probe elements, the plurality of volume quantum added to the initial volume being less than that of the selected fluid volume, the plurality of volume quantum added to the initial volume being subtracted from the selected fluid volume being a remainder volume less than one volume quantum, an intermediate flow time being the time duration for the plurality of fluid states to change;
- 25 ➤ the final flow time, being a flow time from a final state change, is calculated from the remainder volume divided by a final average flow rate associated with the respective final fluid level location within the reservoir;

- the total flow time for dispensing a selected volume being the sum of the initial flow time, the intermediate flow time and final flow time.

Referring to FIG 3, a flow chart of an embodiment method 220 of sensing fluid level in reservoir for calculating fluid flow there from. The method comprising the steps of:

- 5 STEP 311: receiving a plurality of fluid level signals each indicative of respective fluid level state at a predetermined location within the reservoir;
- STEP 312: identifying change of a first fluid level state;
- STEP 313: recording a relative first time, with respect to fluid flow duration, at which the first fluid level state changed;
- 10 STEP 314: identifying change of a second fluid level state;
- STEP 315: recording a relative second time, with respect to fluid flow duration, at which the second fluid level state changed;
- STEP 316: calculating average fluid flow rate from the reservoir using, at least, a known volume held by the reservoir between the change of the first
- 15 fluid level state and the change of the second fluid level state and the fluid flow duration between the first time and the second time;
- STEP 317: associating the average fluid flow rate with the fluid level location within the reservoir.

In an embodiment, the average fluid flow rate being associated with the second fluid

20 level location or state. Alternatively, the average fluid flow rate being associated with the first fluid level location or state. The average fluid flow rate is related to fluid flow while the level is between the first level location and the second fluid level location.

The first fluid level state can be indicative of a first predetermined location within the reservoir, and the second fluid level state is indicative of a second predetermined

25 location within the reservoir, wherein the first predetermined location and second predetermined location are adjacent or neighbouring.

In an embodiment, the reservoir has a constant cross section, and the probe elements are located (or distributed) uniformly through the depth of the reservoir, wherein the distance between consecutive (or neighbouring) probe elements represents a known

30 volume quantum (such as 150ml).

In an embodiment, an average flow rate is pre initialised and stored. Each calculated average flow rate is typically retained or stored (or accumulated or averaged), wherein each average flow rate is calculated or adaptively updated during use and stored.

Alternatively, as best shown in FIG. 7, a method can calculate fluid flow or dispensed
5 fluid volume, as a compensated_volume_flow_time. This compensated_volume_flow_time can include: compensated_volume_flow_time being a predetermined selected_volume_flow_time + preheat_compensation_time + ambient_temperature_compensation_time + heater_temperature_compensation_time + reservoir_head_compensation_time + input_voltage_compensation_time.

10 FIG. 4 shows an embodiment schematic circuit diagram for an apparatus 400 that senses fluid level in reservoir for calculating fluid flow there from. This embodiment requires that the fluid is appropriately electrically conductive, such as potable water.

In this embodiment, the circuit includes a plurality of probe elements 410. Each probe elements is coupled to a voltage potential at 412 through a respective one of a plurality
15 of pull-up resistors 414. The probe elements are operatively associated with a common probe element 416.

In this embodiment, the circuit includes one or more registers 420,422 (for example 74HC165 8 Bit COMS shift out register) having a high impedance voltage input, such that when $V_{in} < 2.1V$ the signal is interpreted as low input and when $V_{in} > 2.4V$ the
20 signal is interpreted as high input. It would be understood that inputs can be read/retrieved by providing clock pulse through an output pin as a series pulse reading.

With a voltage potential coupled (for example via a micro-controller) to each of the probe elements:

- if fluid is in contact with a probe element, the fluid makes a connection between
25 the level sensing probe element and common probe element (typically grounded), thereby applying a respective level signal to the registers below 2.1V, which is interpreted as a low signal; and
- if there is no fluid in contact with a probe element, a respective level signal is pulled high (for example about 5V), thereby applying a respective level signal to
30 the registers above 2.4V, which is interpreted as a high signal.

To restrict corrosion of the probe elements, the voltage potential at 412 and the ground connection of 414 is applied only for limited time periods for (or when) making measurements. In an attempt to discharge/dislodge particles coupled to the probe elements, the polarity to the prove element voltage supplies are temporarily reversed
5 (preferably applying each polarity for a similar time period). In this embodiment, the voltage potential is provided from an output pin of a processor element 430.

In this example embodiment, two shift registers are used for identifying twelve fluid levels, a dry reservoir. The processor element 430 reads/retrieves the signal from each register 420,422 in a conventional manner. The processor element being adapted to
10 dispense a fluid from a reservoir according to a method as herein described.

FIG. 5 and FIG. 6 each show a schematic diagram of a respective embodiment beverage making apparatus (500, 600) that senses fluid level in a reservoir. These embodiments include:

- a grinder 510 speed is measured for recording by the processor (or controller)
15 module to determine the real time rpm;
- a steep release brew chamber 520 coupled to receive grinds from the grinder;
- a processor (or controller) module 530 being adapted to use one or more of the identified variables to determine the actuation of the recycle valve;
- a plurality of fluid level probe elements 540 used to sense fluid level in a
20 reservoir to determine head height, wherein reservoir level sensing (via 542) is identified by determining the rate of change of the head height in ml/sec by the microcontroller;
- one or more flow-through fluid heater module 550, typically with embedded element, wherein fluid temperature of the flow through element is measured (via
25 552) and recorded by the processor element, and power input is measured and recorded (via 554) by the processor element;
- a recycle valve 560 controlled by the processor element to inhibit or allow a determined fluid temperature within the riser to pass towards the brew chamber or reservoir;

- a valve 570 allows or restricts fluid from progressing to the heater; and
- a receptacle 580 receives a user selected volume, delivered at a relatively accurate (and/or consistent) pre-determined temperature and extraction strength.

FIG. 6 shows schematic view of an embodiment apparatus 600 using capacitance level
5 sensing 640 and an element wrapped riser.

Referring to FIG. 7, a method 710 can calculate fluid flow or dispensed fluid volume, as a compensated_volume_flow_time.

This compensated_volume_flow_time can include: compensated_volume_flow_time being a predetermined selected_volume_flow_time + preheat_compensation_time +
10 ambient_temperature_compensation_time + heater_temperature_compensation_time + reservoir_head_compensation_time + input_voltage_compensation_time.

A method 710 can, by way of example, includes the steps of:

- STEP 711: calculating a primary flow time for delivering a selected fluid volume, the flow time being at least dependant on an average fluid flow rate;
- 15 STEP 712: calculating a compensated flow time, including any one or more of the following: preheat compensation time; ambient temperature compensation time; heater temperature compensation time; reservoir head compensation time; and mains input voltage compensation time; and
- 20 STEP 713: dispensing the selected fluid volume.

As shown in Figure 8, a removable reservoir 800 has at least one flat side 801. Parallel capacitive strips 802, 803 may be adhered or otherwise incorporated onto the interior surface of a flat side 801 of the reservoir 800. The reservoir 800 is thus compatible with any of the aforementioned examples and technology. As the water level inside the
25 reservoir 800 changes, the capacitance between the strips 802, 803 also changes. These changes are transmitted by electrical leads 804 to the appropriate terminal, signal processor device or microprocessor 805. In some embodiments, one wall 806 of a removable reservoir 800 incorporates a pocket or recessed portion 807 that extends substantially the full useful "H" height of the removable reservoir 800. In this example,
30 the reservoir 800 has a generally rectangular cross section and the recess 807 is also

rectangular, in cross section. The recess 807 has spaced apart but parallel sides 808, 809. The interior surfaces of the spaced apart and preferably parallel sides 808, 809 have conductive, capacitive strips 810, 811 adhered, affixed or otherwise incorporated onto them. According, the recess 807 allows the flat surfaces of the conductive strips 810, 811 to face one another and to be spaced apart by a distance that is less than the effective "W" width of the reservoir 800. In preferred embodiment the recess 807 is centrally located between the opposing walls 812, 813 that are adjacent to the side 806 that incorporates the recess 807. This locates the vertical centre line of the recess 87 approximately mid way along the effective width of the removable reservoir.

As shown in Figure 9, a removable reservoir 900 may be associated with a draw tube or liquid conveyor tube 901 that pivots into and out of position. As shown in Figure 9(a) the draw tube 901 is vertical when the reservoir is installed and ready to use. The draw tube or conveyor 901 incorporates, along its length, a level sensing device such as a capacitive strip arrangement 902 that provides an electric signal to a signal processor or micro processor 903. In this way, the vertical draw tube 902 provides information to a beverage making device about not only the presence of liquid in the reservoir 900 but also the level of the liquid in the reservoir. The draw tube 901 is also used by the device's pump apparatus 904 for drawing liquid from the reservoir 900 used by the machine into which it is incorporated. As shown in Figures 9(b) and (c) removing the reservoir 905 causes or allows the draw tube 901 to pivot 906 to a horizontal position. In this example, the pivot point is external to the reservoir 900. As shown in Figure 9(c), the pivoting draw tube 901 is completely removed from the reservoir so that the reservoir can be removed from the device into which it is installed. The draw tube assembly may incorporate a bumper 907 that makes contact with and is guided by an external surface 908 of the reservoir. In this way, re-inserting the reservoir causes the surface 908 to contact the bumper 907 and thus urge pivot or rotate the draw tube 901 into a more vertical orientation. The tube eventually comes to rest in a fully vertical orientation as suggested by Figures 9(b) and 9(a).

It will be appreciated that the illustrated embodiments disclose one or more methods and apparatus for sensing fluid level in reservoir to calculating fluid flow there from.

It would be appreciated that, some of the embodiments are described herein as a method or combination of elements of a method that can be implemented by a processor of a

computer system or by other means of carrying out the function. Thus, a processor with the necessary instructions for carrying out such a method or element of a method forms a means for carrying out the method or element of a method. Furthermore, an element described herein of an apparatus embodiment is an example of a means for carrying out
5 the function performed by the element for the purpose of carrying out the invention.

In alternative embodiments, the one or more processors operate as a standalone device or may be connected, e.g., networked to other processor(s), in a networked deployment, the one or more processors may operate in the capacity of a server or a client machine in server-client network environment, or as a peer machine in a peer-to-peer or distributed
10 network environment.

Thus, one embodiment of each of the methods described herein is in the form of a computer-readable carrier medium carrying a set of instructions, e.g., a computer program that are for execution on one or more processors.

Unless specifically stated otherwise, as apparent from the following discussions, it is
15 appreciated that throughout the specification discussions utilizing terms such as “processing”, “computing”, “calculating”, “determining” or the like, can refer to the action and/or processes of a computer or computing system, or similar electronic computing device, that manipulate and/or transform data represented as physical, such as electronic, quantities into other data similarly represented as physical quantities.

20 In a similar manner, the term “processor” may refer to any device or portion of a device that processes electronic data, e.g., from registers and/or memory to transform that electronic data into other electronic data that, e.g., may be stored in registers and/or memory. A “computer” or a “computing machine” or a “computing platform” may include one or more processors.

25 The methodologies described herein are, in one embodiment, performable by one or more processors that accept computer-readable (also called machine-readable) code containing a set of instructions that when executed by one or more of the processors carry out at least one of the methods described herein. Any processor capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken is
30 included.

Unless the context clearly requires otherwise, throughout the description and the claims, the words “comprise”, “comprising”, and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of “including, but not limited to”.

- 5 Similarly, it is to be noticed that the term “coupled”, when used in the claims, should not be interpreted as being limitative to direct connections only. The terms “coupled” and “connected”, along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. Thus, the scope of the expression a device A coupled to a device B should not be limited to devices or systems
- 10 wherein an output of device A is directly connected to an input of device B. It means that there exists a path between an output of A and an input of B which may be a path including other devices or means. “Coupled” may mean that two or more elements are either in direct physical or electrical contact, or that two or more elements are not in direct contact with each other but yet still co-operate or interact with each other.
- 15 As used herein, unless otherwise specified the use of the ordinal adjectives “first”, “second”, “third”, etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.
- 20 Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment, but may refer to
- 25 the same embodiment. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to one of ordinary skill in the art from this disclosure, in one or more embodiments.

Similarly it should be appreciated that in the above description of exemplary embodiments of the invention, various features of the invention are sometimes grouped

30 together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various

inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, 5 the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of this invention.

Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different 10 embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

In the description provided herein, numerous specific details are set forth. However, it is understood that embodiments of the invention may be practiced without these specific 15 details. In other instances, well-known methods, structures and techniques have not been shown in detail in order not to obscure an understanding of this description. Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

20 It will be appreciated that an embodiment of the invention can consist essentially of features disclosed herein. Alternatively, an embodiment of the invention can consist of features disclosed herein. The invention illustratively disclosed herein suitably may be practiced in the absence of any element which is not specifically disclosed herein.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of sensing fluid level in reservoir for calculating fluid flow there from, the method comprising the steps of:
receiving a plurality of fluid level signals each indicative of respective fluid level
5 state at a predetermined location within the reservoir;
identifying change of a first fluid level state;
recording a relative first time, with respect to fluid flow duration at which the first fluid level state changed; and
calculating fluid dispensed from the reservoir using the fluid flow duration and an
10 average fluid flow rate associated with the respective fluid level location within the reservoir.
2. A method of sensing fluid level in reservoir for calculating fluid flow there from, the method comprising the steps of:
receiving a plurality of fluid level signals each indicative of respective fluid level
15 state at a predetermined location within the reservoir;
identifying change of a first fluid level state;
recording a relative first time, with respect to fluid flow duration, at which the first fluid level state changed;
identifying change of a second fluid level state;
20 recording a relative second time, with respect to fluid flow duration at which the second fluid level state changed;
calculating average fluid flow rate from the reservoir using a known volume held by the reservoir between the change of the first fluid level state and the change of the second fluid level state and the fluid flow duration between the first time and the
25 second time; and
associating the average fluid flow rate with the fluid level location within the reservoir.
3. The method according to claim 1 or claim 2, wherein the average fluid flow rate is associated with the second fluid level location.

4. The method according to claim 1 or claim 2, wherein the average fluid flow rate is associated with the first fluid level location.
5. The method according to any one of the preceding claims, wherein the average fluid flow rate is related to fluid flow while the level is between the first level location
5 and the second fluid level location.
6. The method according to any one of the preceding claims, wherein the first fluid level state is indicative of a first predetermined location within the reservoir, and the second fluid level state is indicative of a second predetermined location within the reservoir.
- 10 7. The method according to claim 6, wherein the first predetermined location and second predetermined location are neighbouring predetermined locations.
8. The method according to any one of the preceding claims, the method including the step of:
receiving data indicative of a selected fluid volume; and
15 dispensing the selected fluid volume.
9. The method according to claim 8, the method including the step of:
calculating a primary flow time for delivering a selected fluid volume, the flow time is dependant on an average fluid flow rate.
10. The method according to claim 8 or claim 9, the method including the step of:
20 calculating a compensated flow time using any one or more of the following:
preheat compensation time; ambient temperature compensation time; heater temperature compensation time; reservoir head compensation time; and mains input voltage compensation time.
11. The method according to claim 8 or claim 9, wherein the fluid volume dispensed
25 can be calculated using flow time multiplied by a fluid flow rate.

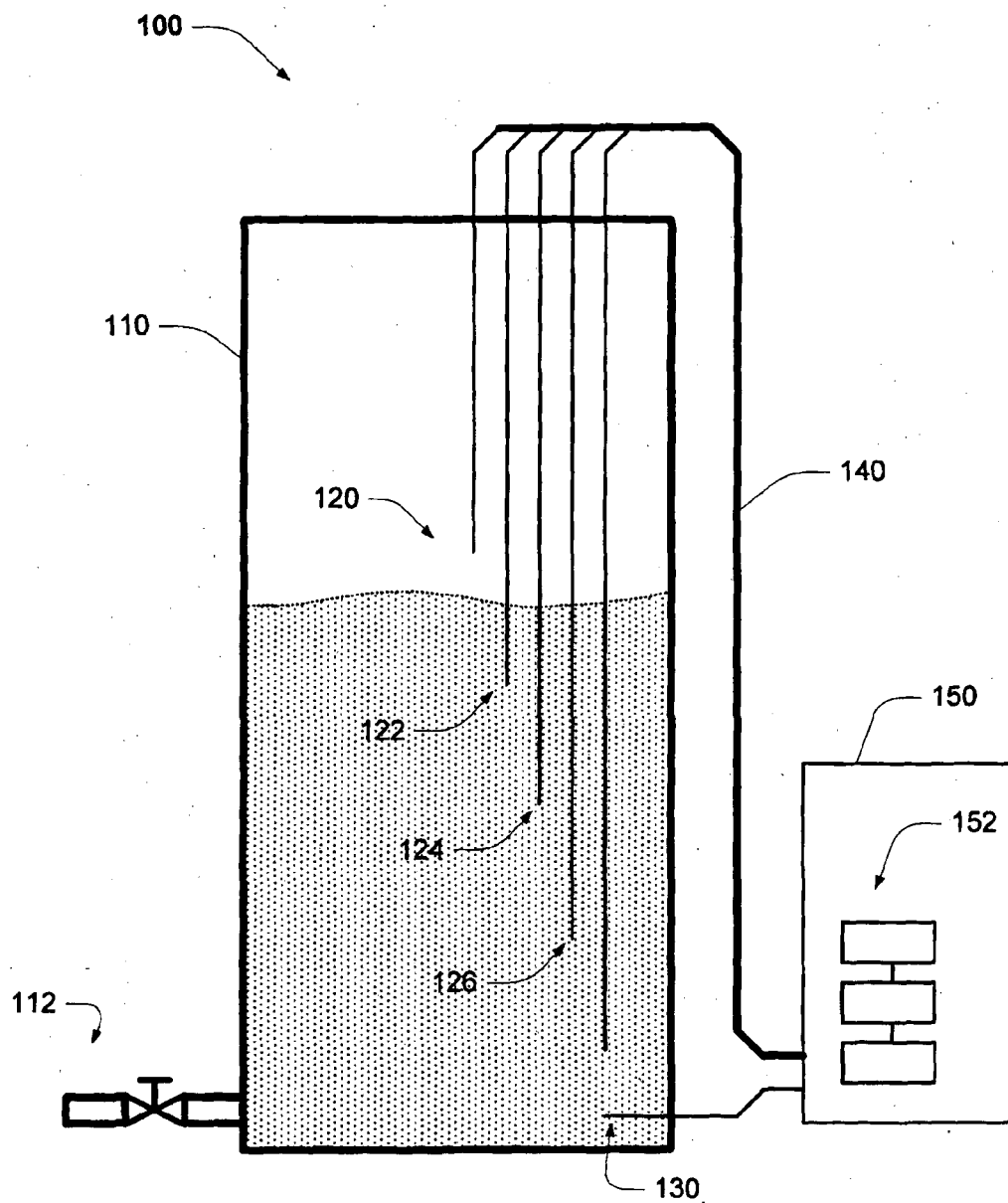
12. A method of sensing fluid level in reservoir for calculating fluid flow there from, the method comprising the steps of:
- multiplying an initial flow time by a fluid flow rate associated with the respective fluid level location within the reservoir to calculate an initial volume;
- 5 multiplying a plurality of volume quantum corresponding to the distance between consecutive neighbouring probe elements, the plurality of volume quantum added to the initial volume is less than the selected fluid volume, the plurality of volume quantum added to the initial volume is subtracted from the selected fluid volume is a remainder volume less than one volume quantum, an intermediate flow time is the
- 10 time duration for the plurality of fluid states to change;
- the final flow time, is a flow time from a final state change, is calculated from the remainder volume divided by a final average flow rate associated with the respective final fluid level location within the reservoir; and
- the total flow time for dispensing a selected volume is the sum of the initial flow
- 15 time, the intermediate flow time and final flow time.
13. The method according to any one of the preceding claims, wherein the reservoir has a constant cross section.
14. The method according to any one of the preceding claims, wherein probe elements produce the fluid level signals, the probe elements is located uniformly through the
- 20 depth of the reservoir, wherein the distance between consecutive probe elements represents a volume quantum.
15. The method according to any one of claims 1 to 13, wherein probe elements produce the fluid level signals; the probe elements are located through the depth of the reservoir such that fluid level state changes with respect to a quantised
- 25 representation of the reservoir volume, and the quantised representation of the reservoir volume is uniformly distributed between consecutive fluid level state changes.
16. The method according to any one of claims 15, wherein the uniformly distributed consecutive fluid level state changes define a constant volume quantum there
- 30 between.

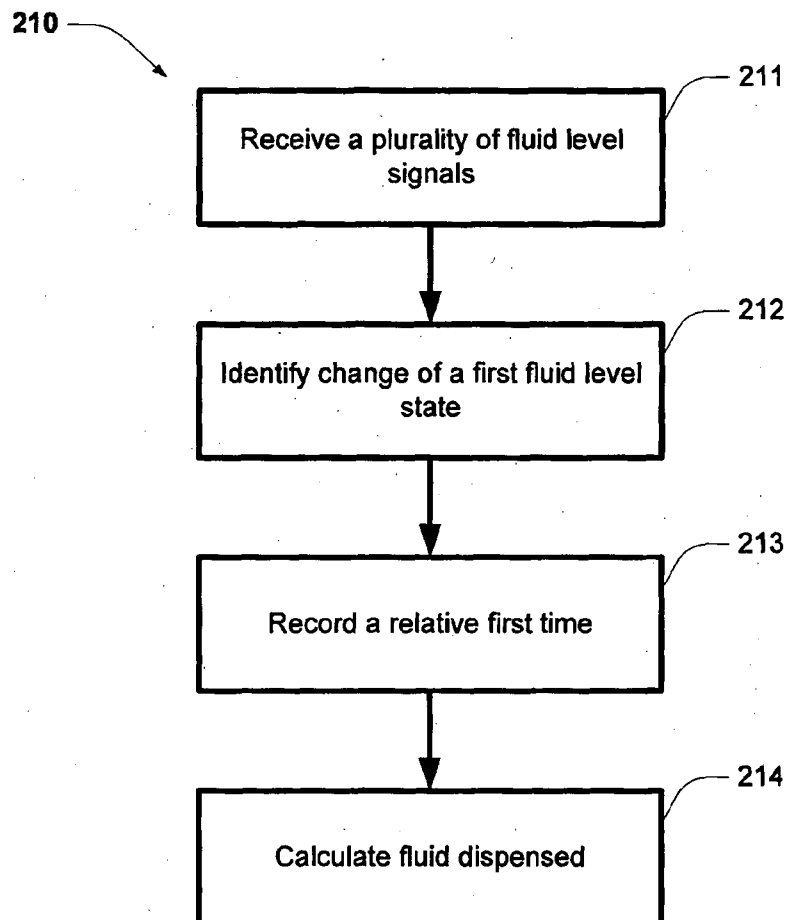
17. The method according to any one of the preceding claims, wherein each average flow rate is initialised and stored; and each average flow rate is adaptively updated during use and stored.
18. The method according to any one of the preceding claims, wherein the fluid is liquid water.
19. A method of sensing fluid level in reservoir for calculating fluid flow there from, substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.
20. An apparatus for sensing fluid level in a reservoir to calculate fluid flow there from, the apparatus comprising:
a plurality of fluid level probe elements located within the reservoir, each adapted to provide a respective fluid level signal; and
a processor module adapted to receive receiving a plurality of fluid level signals.
21. The apparatus according to claim 20, wherein the processor module is adapted to perform a method of sensing fluid level in reservoir for calculating fluid flow there from, according to any one of claims 1 to 19.
22. The apparatus according to claim 20 or claim 21, wherein the processor module is adapted to calculate a flow time for dispensing a selected fluid volume from the reservoir and dispense a selected fluid volume from the reservoir.
23. The apparatus according to any one of claims 20 to 22, wherein the reservoir has a constant cross section.
24. The apparatus according to any one of claims 20 to 23, wherein the probe elements is located uniformly through the depth of the reservoir, wherein the distance between consecutive probe elements represents a volume quantum.
25. The apparatus according to any one of claims 20 to 23, wherein the probe elements are located through the depth of the reservoir such that fluid level state changes with

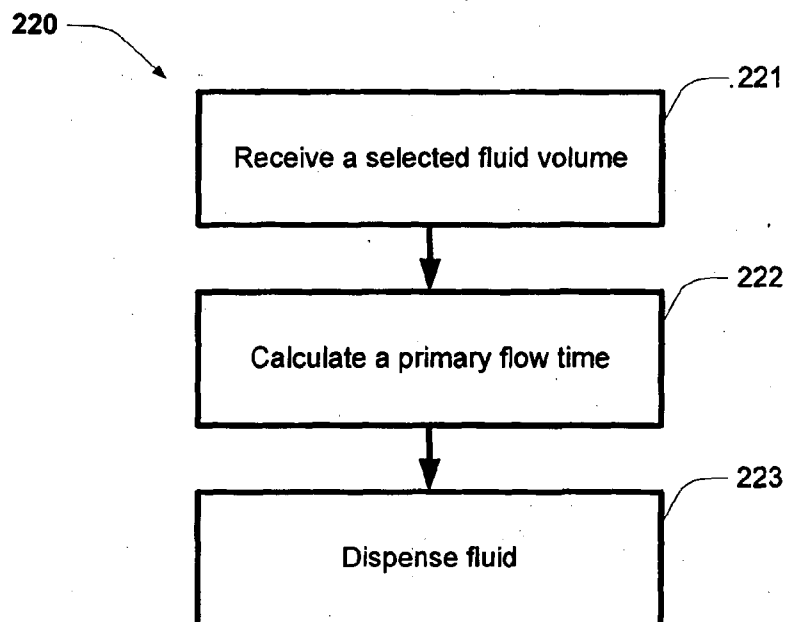
respect to a quantised representation of the reservoir volume, and the quantised representation of the reservoir volume is uniformly distributed between consecutive fluid level state changes.

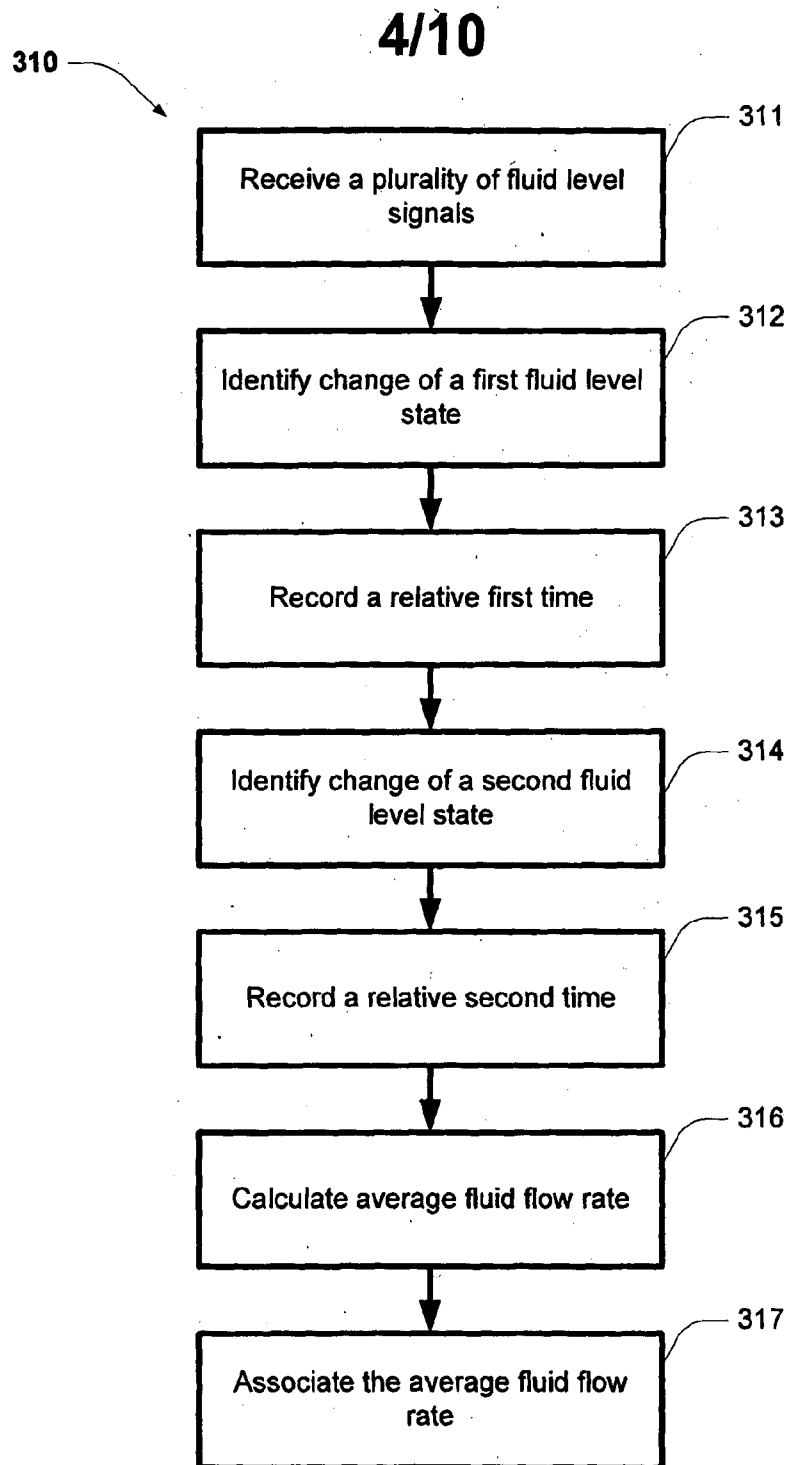
26. The apparatus according to any one of claim 25, wherein the uniformly distributed consecutive fluid level state changes define a constant volume quantum there between.
27. A apparatus for sensing fluid level in reservoir for calculating fluid flow there from, substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.
28. A computer program product stored on a computer readable medium, the computer program product for operation with a processor device and is adapted to provide a method of sensing fluid level in reservoir for calculating fluid flow there from, according to any one of claims 1 to 19.
29. A computer program product stored on a computer readable medium, the computer program product for operation with a processor device and is adapted to provide a method of sensing fluid level in reservoir for calculating fluid flow there from, substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.

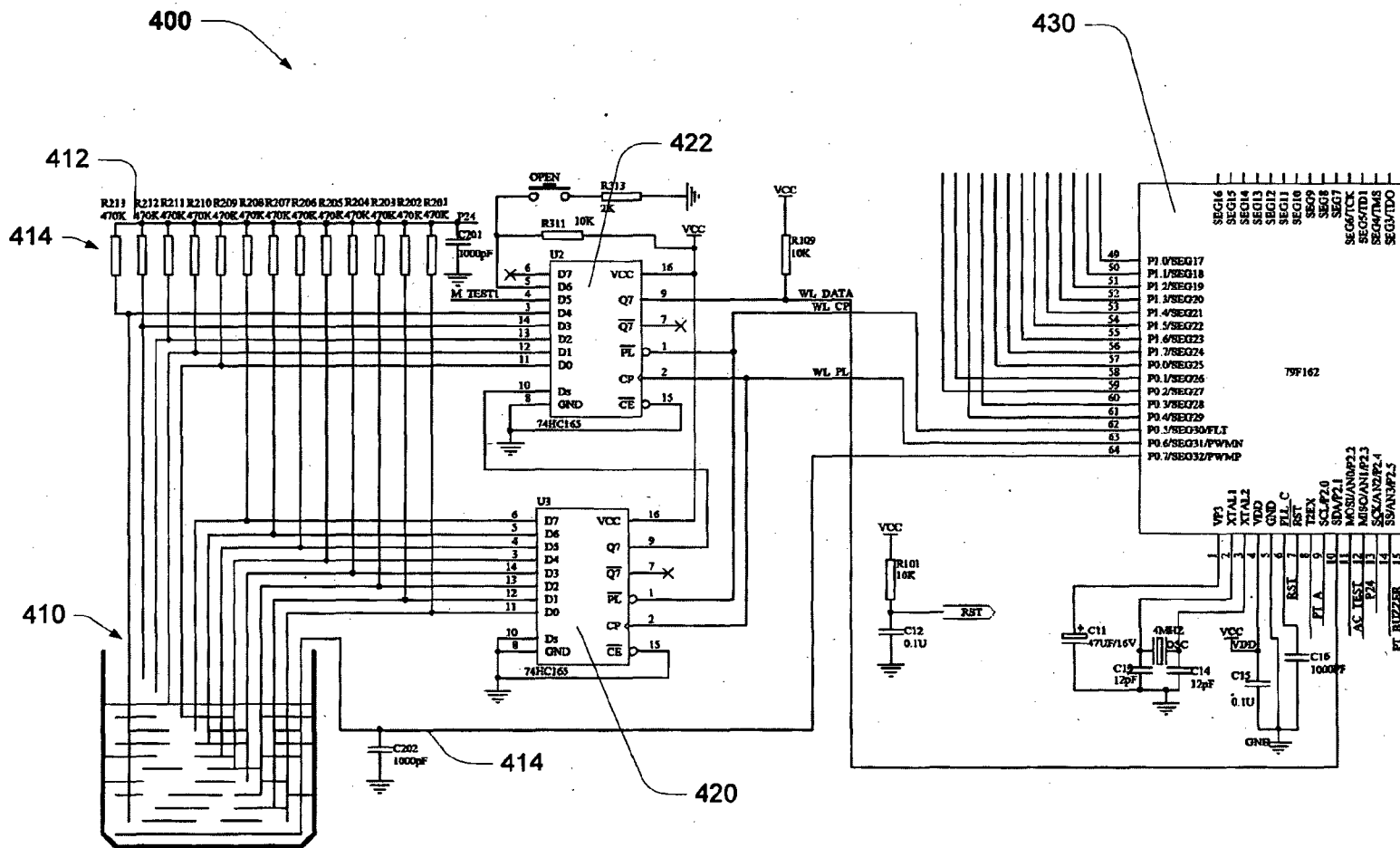
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**FIG. 1**

2/10**FIG. 2**

3/10**FIG. 2B**

**FIG. 3A**

Substitute Sheet
(Rule 26) RO/AU

6/10

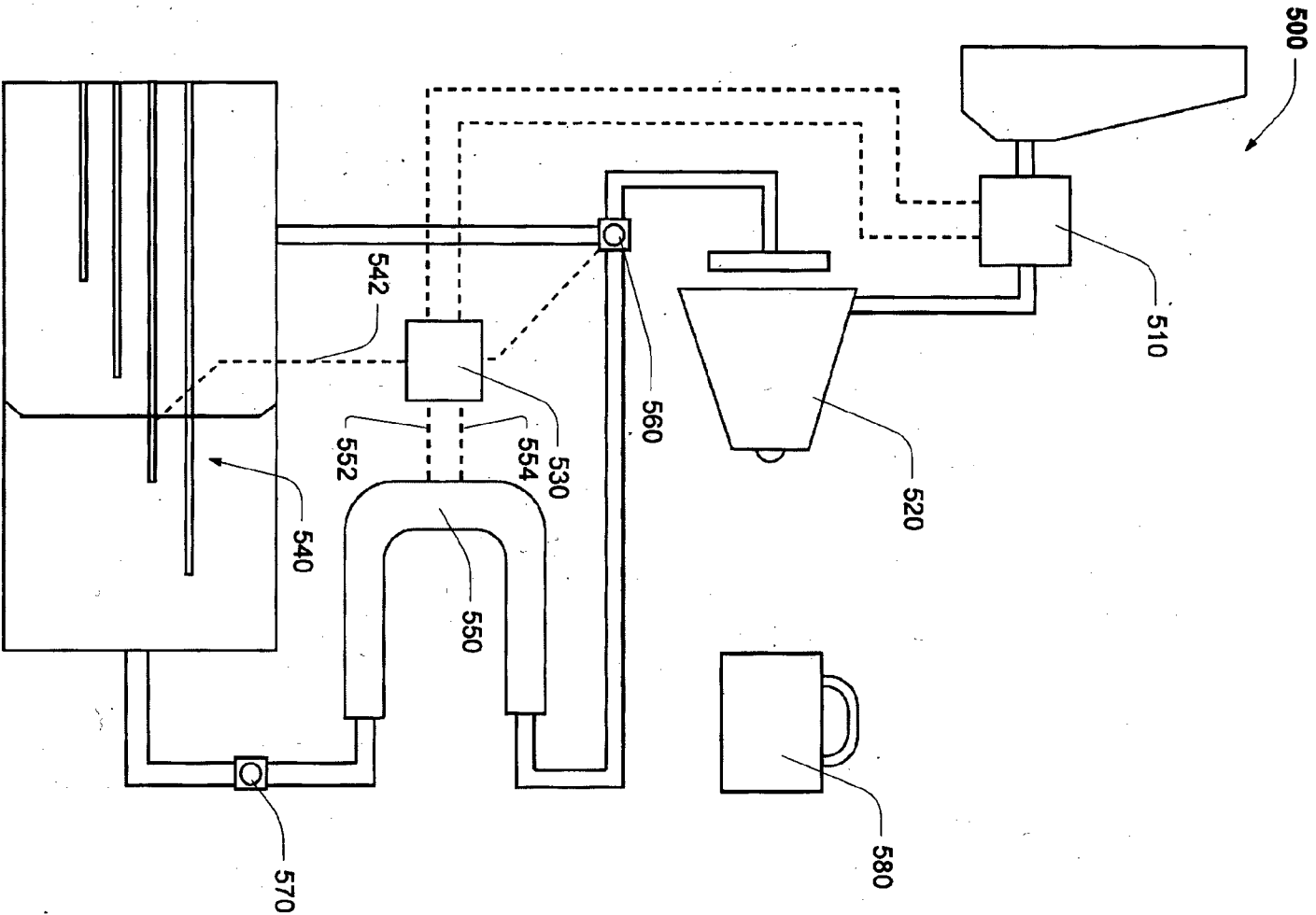


FIG. 5

Substitute Sheet
(Rule 26) RO/AU

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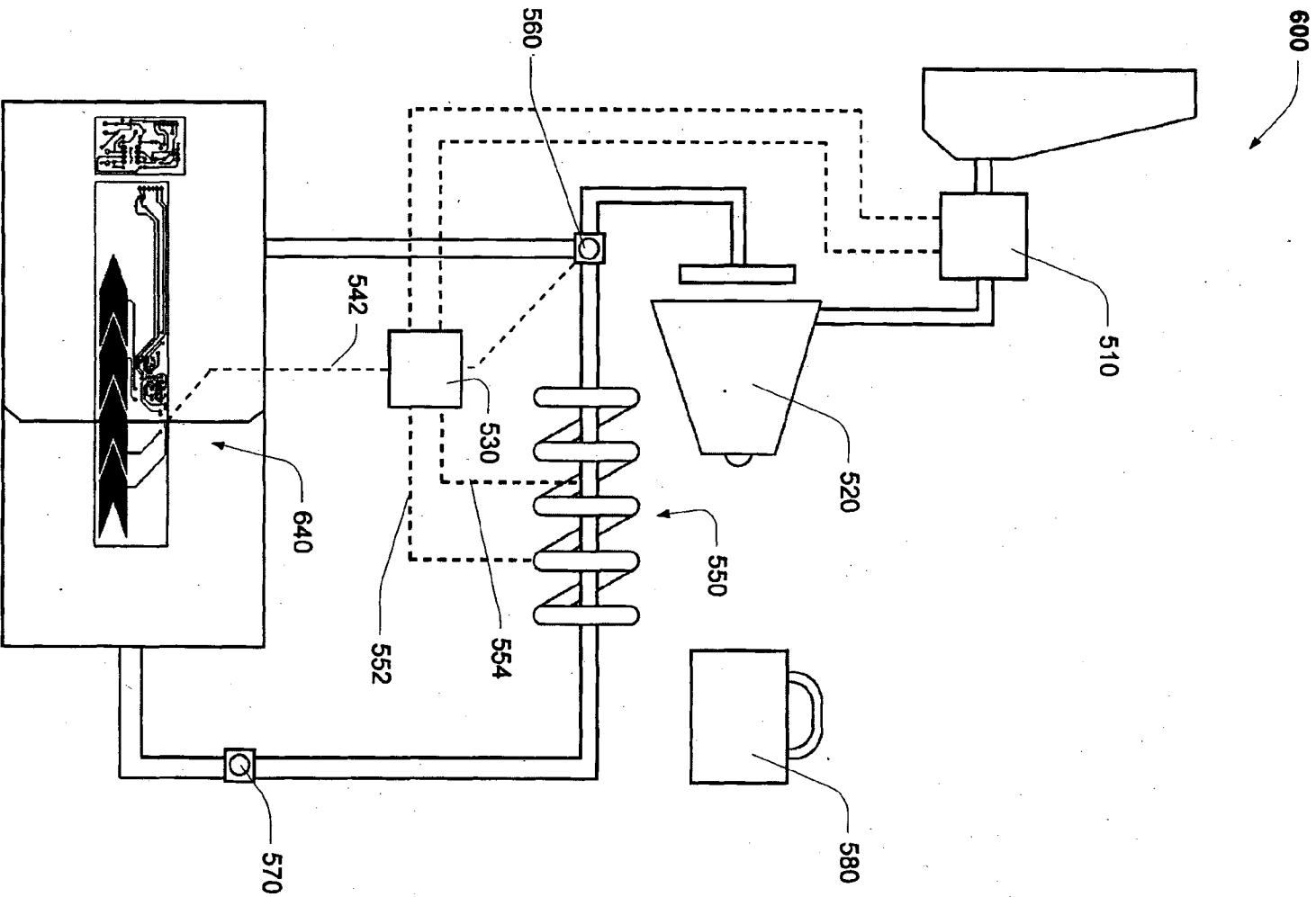
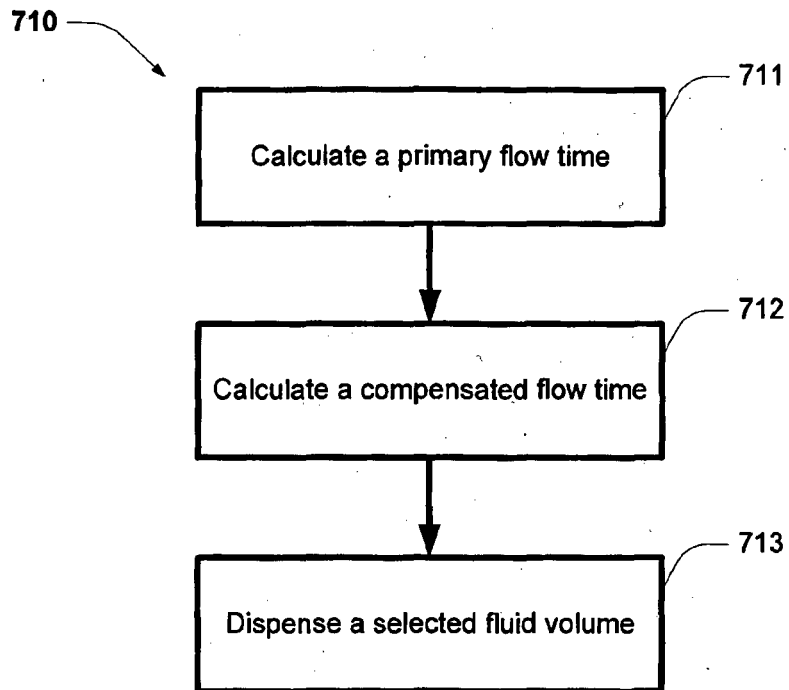


FIG. 6

8/10**FIG. 7**

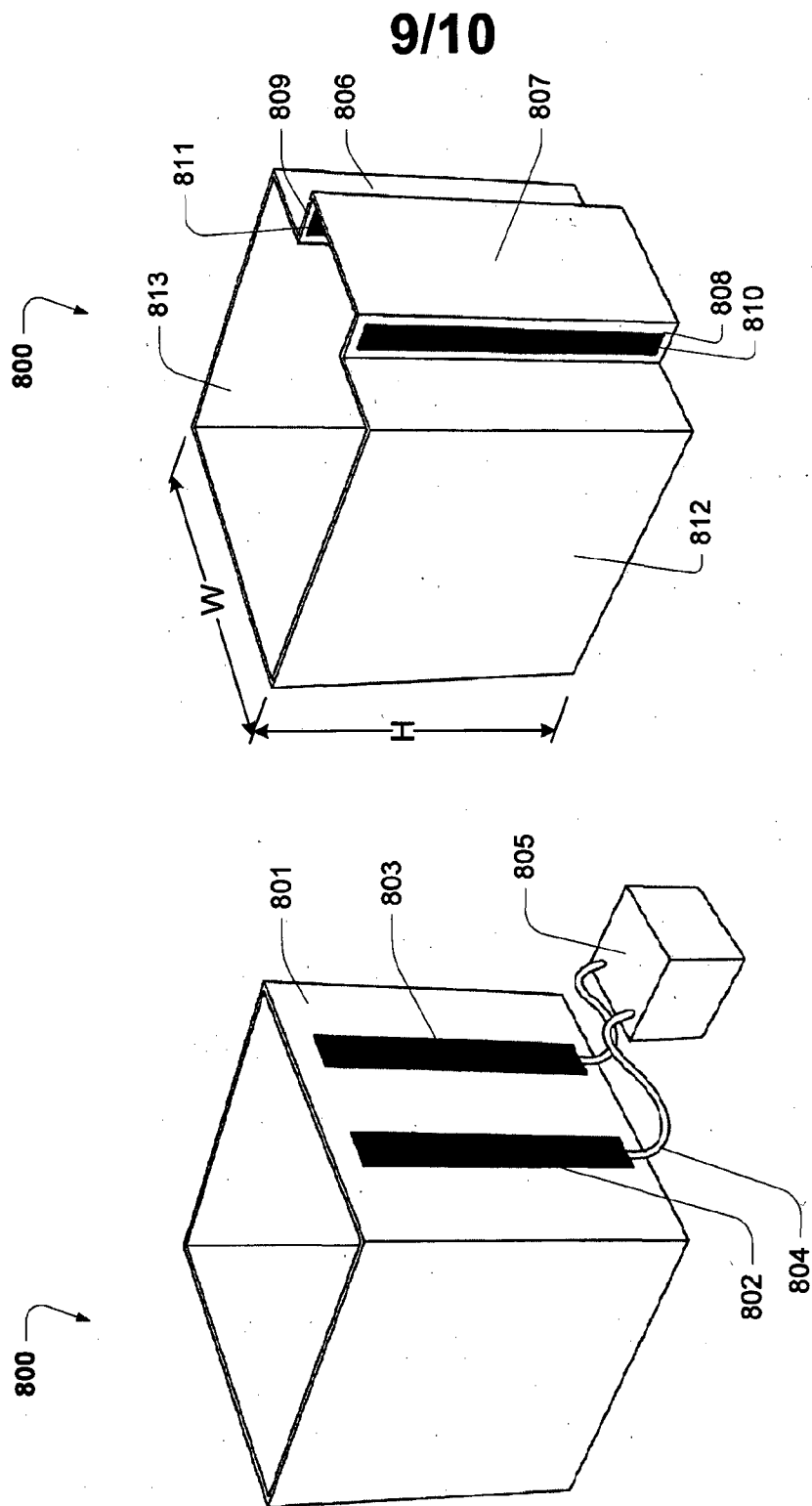
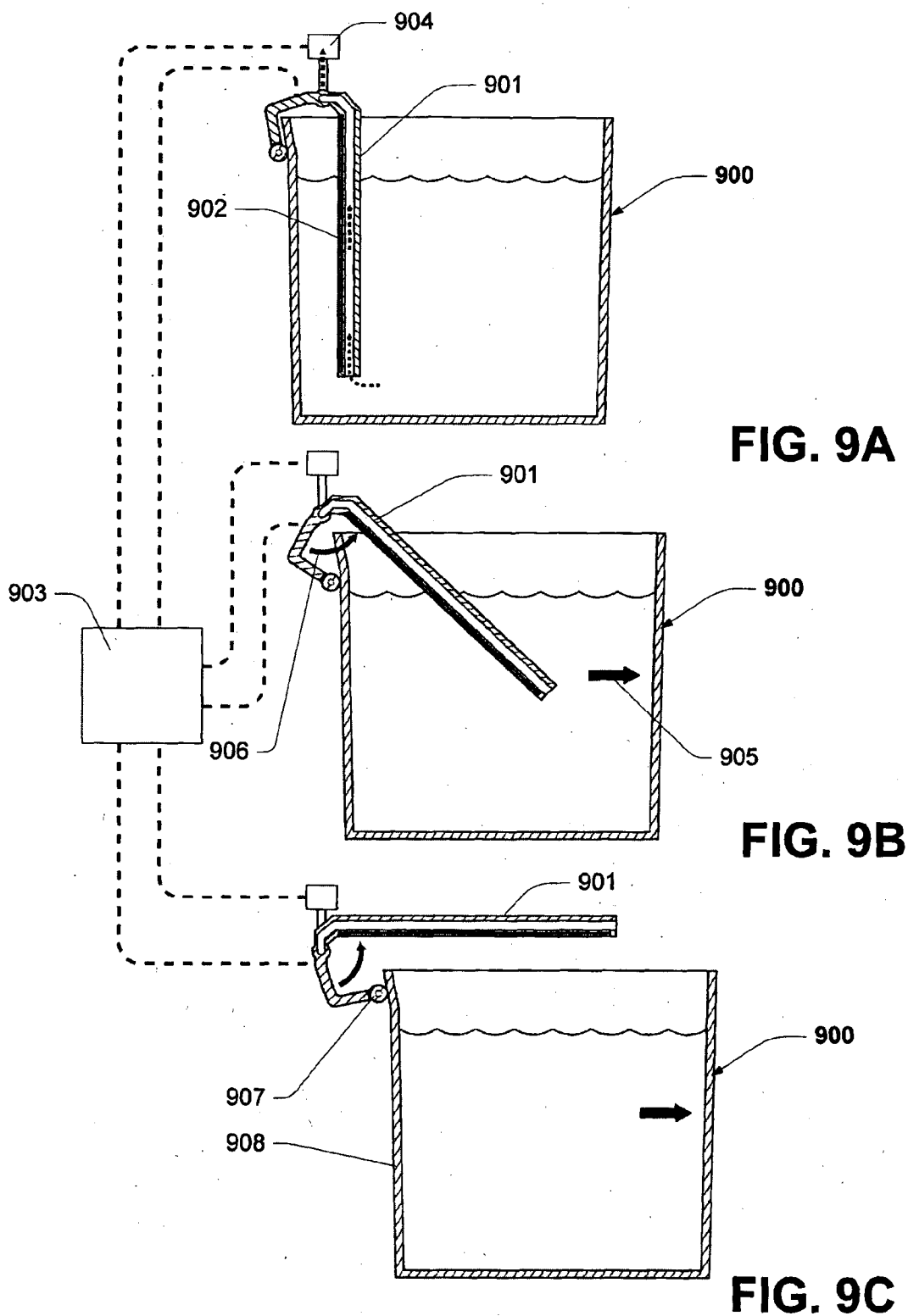


FIG. 8

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INTERNATIONAL SEARCH REPORT

 International application No.
PCT/AU2012/000783
A. CLASSIFICATION OF SUBJECT MATTER

A47J 31/41 (OCT 2005) G01F 13/00 (OCT 2005)

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)

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)

WPI, EPODOC, Google patents (keywords): G01F, A47J, plural, array, flow; level, drop, reservoir, volume, rate, time and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

☒ Further documents are listed in the continuation of Box C

☒ See patent family annex

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

 Date of the actual completion of the international search
 12 July 2012

 Date of mailing of the international search report
 19 July 2012
Name and mailing address of the ISA/AU
 AUSTRALIAN PATENT OFFICE
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 (ISO 9001 Quality Certified Service)
 Telephone No. 0262223612

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000783**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: **19, 27 and 29**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
The claims do not comply with Rule 6.2(a) because they rely on references to the description and/or drawings.
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2012/000783
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/0282898 A1 (Knepler) 20 November 2008 abstract, figure 1, paragraphs 19-27	1-11, 13, 14, 17, 18, 20-24, 28
X	GB 2050626 A (Societe Nationale D'Etude et de Construction de Moteurs d'Aviation) 07 January 1981 abstract, figures 1 and 2, pages 1 and 2	1-7, 13-16, 20, 21, 23-26
A	US 2003/0106370 A1 (Fearnside et al.) 12 June 2003 abstract, figures 1 and 2	

Form PCT/ISA/210 (fifth sheet) (July 2009)

Supplemental Box

Continuation of: **Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claim 1 (Claims 20-26, and appended claims 3-11, 13-18 and 28 when appended to claim 1) are directed towards a method of sensing fluid level for calculating fluid flow comprising receiving a plurality of fluid level signals whereby an average fluid flow rate is associated with a fluid level location. The feature of calculating fluid dispensed from the reservoir using fluid flow duration and average fluid flow rate is specific to claim 1
- Claim 2 (Claims 20-26, and appended claims 3-11, 13-18 and 28 when appended to claim 2) are directed towards a method of sensing fluid level for calculating fluid flow comprising receiving a plurality of fluid level signals whereby an average fluid flow rate is associated with a fluid level location. The feature of identifying changes in first and second fluid states and using these changes and a known volume to calculate an average flow rate is specific to claim 2
- Claim 12 (Claims 20-26, and appended claims 13-18 and 28 when appended to claim 12) are directed towards a method of sensing fluid level for calculating fluid flow comprising a reservoir with a plurality of volume quantum elements between neighbouring probe elements whereby an average fluid flow rate is associated with a respective fluid level. The feature of calculating a required remainder volume using an initial volume and quantised volume subtracted from a selected volume is specific to claim 12

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is a method of level sensing in a fluid reservoir including a plurality of probe elements providing level indication, whereby an average flow rate is associated with a respective fluid level.

However this feature does not make a contribution over the prior art because it is disclosed in:

D1 (US 2008/0282898 A1) and D2 (GB 2050626 A).

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

INTERNATIONAL SEARCH REPORT

International application No. .

PCT/AU2012/000783**Supplemental Box**

Form PCT/ISA/210 (Supplemental Box) (July 2009)

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/AU2012/000783	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
US 2008/0282898 A1	20 Nov 2008	CA 2626484 A1	03 May 2007
		CN 101437430 A	20 May 2009
		CN 101437430 B	11 Jul 2012
		EP 1940267 A2	09 Jul 2008
		US 2008282898 A1	20 Nov 2008
		US 8210093 B2	03 Jul 2012
		WO 2007051200 A2	03 May 2007
GB 2050626 A	07 Jan 1981	DE 3018601 A1	27 Nov 1980
		FR 2456940 A1	12 Dec 1980
		FR 2456940 B1	04 Jun 1982
		GB 2050626 A	07 Jan 1981
US 2003/0106370 A1	12 Jun 2003	GB 2379991 A	26 Mar 2003
		US 2003106370 A1	12 Jun 2003
End of Annex			