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(54) **WASHING APPLIANCE WITH IMPROVED DETERMINATION OF INLET VALVE FAULT CONDITIONS**

WASCHVORRICHTUNG MIT VERBESSERTER BESTIMMUNG VON
EINLASSVENTILFEHLERZUSTÄNDEN

APPAREIL DE LAVAGE AVEC DÉTERMINATION AMÉLIORÉE DE CONDITIONS DE DÉFAUT DE
VANNE D'ENTRÉE

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Description

Field of the invention

[0001] The solutions according to embodiments of the present invention relate to the field of washing appliances. More particularly, the embodiments of the present invention relates to a dishwasher.

Background of the invention

[0002] A dishwasher is a washing appliance configured to wash items such as dishes, cutlery, drinking glasses.

[0003] A conventional dishwasher comprises a tub configured to house the items to be washed, and a sump in fluid communication with a bottom portion of the tub. The sump is configured to collect a washing fluid reaching the tub and detergent discharged from a detergent compartment.

[0004] A conventional dishwasher further comprises a circulation pump in fluid communication with the sump (and, hence, with the tub), and configured to circulate the washing fluid in the tub. Particularly, when the circulation pump is rotated in a predefined direction, the washing fluid leaves the sump and re-enters the tub by means of proper spray devices.

[0005] A conventional dishwasher further comprises an inlet valve operable to selectively cause new washing fluid (e.g., fresh water provided by a water inlet) be loaded into the tub.

[0006] A conventional dishwasher further comprises a drain pump configured to selectively cause washing fluid in the sump to be drained from the dishwasher, for example through a corresponding drain outlet.

[0007] These components of a conventional dishwasher are properly driven based on phases of an, e.g., user-selected, washing cycle, being carried out by the dishwasher.

[0008] Reliably determining (e.g., an indication of) the actual level of washing fluid inside the tub is of the utmost importance to ensure correct operation of the dishwasher when the abovementioned components of a conventional dishwasher are being driven.

[0009] For this purpose, conventional dishwashers are provided with a dedicated sensor configured to determine the level of washing fluid in the tub, such as for example a pressure sensor.

[0010] US20060219262A1 discloses a control device and method for detecting and controlling a water fill level in a dishwasher or other similar appliance that includes a pump motor is provided. The control monitors the pump motor current over time, determines a current change, and compares the current change to a threshold current change that is indicative of the water level.

[0011] US20170347855A1 discloses a domestic appliance and a method at the domestic appliance for detecting presence of process water in a pump of the do-

mestic appliance are provided. The method of detecting process water in a pump of a domestic appliance may include operating the pump to rotate in a first direction, recording a first response of the pump rotating in the first direction based on a measured pump operation parameter, operating the pump to rotate in a second direction, and recording a second response of the pump rotating in the second direction based on the measured pump operation parameter. The method may further include comparing the first response and the second response and determining the presence of water in the pump based on the comparison of the first and second response.

[0012] WO2014106801A1 discloses a method for controlling filling with water of a water- conducting electric household appliance having a control system, such as a dishwashing machine or a laundry washing machine. After the start of a treatment program of the electric household appliance: a) the control system controls opening of a loading valve set on a line for conveying water to a treatment container of the electric household appliance; b) the control system monitors a sensor prearranged for detecting conveyance of water to the treatment container ; c) in the absence of a signal from the sensor until the end of a first time interval after the opening of the loading valve, the control system controls activation of a signaling ; and d) in the absence of a signal from the sensor also until the end of a second time interval that follows the first time interval, the control system controls ending of the treatment program.

[0013] US20190174989A1 discloses a method of detecting a change in process water flow of a circulation pump in an appliance for washing and rinsing goods, and an appliance performing the method. An appliance for washing and rinsing goods may be provided including a circulation pump, a sensing arrangement arranged to measure a property indicating torque of the circulation pump, and a controller. The controller may be arranged to average a first set of values of the measured property, thereby creating a first average, average at least a further set of values of the measured property, thereby creating at least one further average, compare the first average with the at least one further average, and to detect change in process water flow of the circulation pump based on a difference between the first average and the at least one further average.

Summary of the invention

[0014] Applicant has found that the known solutions implemented in conventional dishwasher providing for exploiting a dedicated sensor configured to determine the level of washing fluid in the tub are not satisfactory, being affected by drawbacks.

[0015] Installing a dedicated sensor is indeed costly, not only because of the cost of the sensor itself, but also because the sensor need to be properly installed in the dishwasher, such as at the sump thereof.

[0016] Moreover, in order to properly operate, a fluid

level sensor need to be suitably supplied with electric power, and be capable of exchanging data with a control unit of the dishwasher. For these reasons, a sensor of this kind requires the installation of proper wirings.

[0017] Furthermore, since the inside of a dishwasher is a harsh environment, in which hot water, bubbles, and soil particles are present, a fluid level sensor is subjected to serious wear during the operation of the dishwasher. Therefore, in order to preserve the correct operation of the fluid level sensor, the latter should be subjected to inspection and maintenance operations with a not negligible frequency.

[0018] In view of the above, Applicant has devised a dishwasher capable of reliably operating without requiring the presence of a dedicated fluid level sensor.

[0019] An aspect of the present invention relates to a washing appliance according to claim 1.

[0020] The washing appliance comprises a tub configured to house items to be washed.

[0021] The washing appliance further comprises an inlet valve operable to be selectively switched between an open condition for causing washing fluid to be loaded into the tub and a closed condition for preventing washing fluid be fed to the appliance.

[0022] The washing appliance further comprises a sump in fluid communication with the tub for collecting washing fluid from the tub.

[0023] The washing appliance further comprises a circulation pump in fluid communication with the sump and configured to circulate the washing fluid in the tub during a washing cycle when the circulation pump is controlled to rotate in a first direction.

[0024] The washing appliance comprises a control unit configured to control the load of washing fluid into the tub by carrying out the following sequence of operations:

- control the circulation pump to rotate in a second direction opposite to the first direction at a first speed;
- cause the inlet valve to switch to the open condition;
- determine the presence of washing fluid inside the sump based on a comparison between an electric parameter of the circulation pump during a first time period before the inlet valve switched to the open condition and said electric parameter of the circulation pump during a second time period after the inlet valve switched to the open condition.

[0025] By exploiting the way said electric parameter of the circulation pump evolves during said first and second time periods, it is advantageously possible to efficiently determine if washing fluid has been correctly filled in the sump without requiring the presence of a pressure sensor for the determination of the current level of washing fluid inside the tub.

[0026] Applicant has verified that using said electric parameter of the circulation pump is more efficient than exploiting the output of a fluid level sensor, and is more precise, especially in case of modern dishwashers hav-

ing a sump of reduced size for environmental purposes.

[0027] According to an embodiment of the present invention, the control unit is configured to calculate an average of said electric parameter of the circulation pump during the first time period, and determine the presence of washing fluid inside the sump based on a comparison between said average and said electric parameter of the circulation pump during the second time period.

[0028] The average of the electric parameter has been observed to be a very reliable reference point for the determination of a filled condition of the sump.

[0029] According to an embodiment of the present invention, the control unit is configured to determine the presence of washing fluid inside the sump if the electric parameter of the circulation pump during the second time period is higher than said average by a first threshold.

[0030] In this way, false determinations of a filled condition of the sump are advantageously prevented, or at least reduced.

[0031] According to an embodiment of the present invention, the control unit is configured so that, if the condition j) is true:

j) the electric parameter of the circulation pump during the second time period is not higher than said average by said first threshold,

the control unit controls the circulation pump to rotate in said second direction at a second speed having an absolute value higher than an absolute value of said first speed, and determines that washing fluid was already present inside the sump before the inlet valve switched to the open condition based on a comparison between said average and the electric parameter of the circulation pump during a third time period after the second time period.

[0032] In this way, incorrect results are advantageously avoided in case washing fluid was already present inside the sump before the inlet valve switched to the open condition.

[0033] According to an embodiment of the present invention, the control unit is configured to determine that washing fluid was already present inside the sump before the inlet valve switched to the open condition if, in addition to have the condition a) that is true, the electric parameter of the circulation pump during the third time period is higher than said average by a second threshold higher than said first threshold.

[0034] In this way, false determinations of a filled condition of the sump are advantageously prevented, or at least reduced.

[0035] According to an embodiment of the present invention, the washing appliance further comprises a water softening system configured to reduce hardness of water used for generating said washing fluid.

[0036] According to an embodiment of the present invention, the washing appliance further comprises a drain pump configured to be activated for causing washing fluid in the sump to be drained from the washing appliance.

[0037] According to an embodiment of the present in-

vention, the control unit is configured to carry out the following operations:

- control the circulation pump to rotate in said second direction at said second speed, and
- determine that washing fluid was already present inside the sump before the inlet valve switched to the open condition based on a comparison between said average and the electric parameter of the circulation pump during said third time period,

if, in addition to have the condition j) that is true, at least one of the following two conditions k) and l) is true:

- k) said water softening system has not been subjected to a regeneration procedure;
- l) said drain pump has been activated after that said water softening system has been subjected to a regeneration procedure.

[0038] In this way, it is advantageously avoided that brine comprising salt generated during a previous regeneration procedure is sprayed in the tub, soiling the latter.

[0039] According to an embodiment of the present invention, the control unit is further configured to cause the inlet valve to switch to the closed condition if the control unit has determined the presence of washing fluid inside the sump.

[0040] In this way, it is avoided to fill an excessive amount of washing fluid into the tub.

[0041] According to an embodiment of the present invention, the control unit is further configured to stop the circulation pump if the control unit has determined the presence of washing fluid inside the sump.

[0042] According to an embodiment of the present invention, said electric parameter of the circulation pump comprises:

- an electric current drawn by the circulation pump;
- a voltage developed across the circulation pump;
- an electric power consumed by the circulation pump.

[0043] Advantageously, these electric parameters of the circulation pump can be measured in a reliable way.

[0044] According to an embodiment of the present invention, the washing appliance is a dishwasher comprising at least one basket provided in the tub for accommodating the items to be washed.

[0045] According to an embodiment of the present invention, the washing appliance is a dishwasher comprising a set of spray devices for receiving washing fluid from the circulation pump and for accordingly spray received washing fluid into the tub.

Brief description of the annexed drawings

[0046] These and other features and advantages of the present invention will be made apparent by the following description of some exemplary and non limitative embodiments thereof; for its better intelligibility, the following description should be read making reference to the attached drawings, wherein:

Figure 1 schematically illustrates a dishwasher in which concepts according to embodiments of the present invention can be applied;

Figure 2 illustrates in terms of functional blocks some of the routines that can be carried out by a control unit of the dishwasher of Figure 1 for controlling the operations of said dishwasher according to an embodiment of the present invention;

Figure 3A shows an exemplary condition of a sump of the dishwasher of Figure 1 in which a circulation pump of the dishwasher is in a saturation state;

Figure 3B shows an exemplary condition of a sump of the dishwasher of Figure 1 in which a circulation pump of the dishwasher is in a starvation state;

Figure 4A illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit of the dishwasher of Figure 1 when a controlled circulation routine is being carried out according to an embodiment of the present invention;

Figure 4B is an exemplary time diagram showing how a speed of the circulation pump of the dishwasher of Figure 1 varies over time under the control of the control unit when the latter is carrying out the controlled circulation routine of Figure 4A according to an embodiment of the present invention;

Figure 5 illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit of the dishwasher of Figure 1 when a fill to speed routine is being carried out according to an embodiment of the present invention;

Figure 6 is a schematic functional block showing an interaction between the controlled circulation routine of Figure 4A and the fill to speed routine of Figure 5 according to an embodiment of the present invention;

Figure 7 illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit of the dishwasher of Figure 1 when a drain to speed routine is being carried out according to an embodiment of the present invention;

Figure 8 illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit of the dishwasher of Figure 1 when a drain to empty routine is being carried out according to an embodiment of the present invention;

Figure 9 illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit of the dishwasher of Figure 1 when a fill to speed not empty routine is being carried out according to an embodiment of the present invention;

Figure 10A illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit of the dishwasher of Figure 1 when

an inlet valve checking routine is being carried out according to an embodiment of the present invention;

Figure 10B illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit of the dishwasher of **Figure 1** when an inlet valve checking routine is being carried out according to another embodiment of the present invention.

Detailed description of preferred embodiments of the invention

[0047] With reference to the drawings, **Figure 1** schematically illustrates a simplified (not-in-scale) cross-sectional side view of a washing appliance **100** in which concepts according to the embodiments of the present invention can be applied. According to the embodiment of the invention illustrated in **Figure 1**, the washing appliance **100** is a dishwasher.

[0048] The dishwasher **100** comprises a number of well known hydraulic, electronic, electric and electromechanical components - however, for the sake of description ease and conciseness, only those being relevant for understanding the invention will be introduced and discussed in the following. The operation of these (not illustrated) electronic, electric and electromechanical components of the dishwasher **100** is controlled by one or more control units (only one illustrated in **Figure 1** and identified with reference **105**).

[0049] According to the present invention, the dishwasher **100** comprises a tub **110** configured to house items to be washed, such as dishes, cutlery, drinking glasses.

[0050] According to an embodiment of the present invention one or more baskets are provided in the tub **110** for accommodating the items to be washed. In the exemplary embodiment of the invention illustrated in **Figure 1**, the tub **110** is provided with a first, upper, basket **112**, a second, middle, basket **114** and a third, lower, basket **116**. For example, the first basket **112** may be configured to accommodate cutlery, and the second and third baskets **114**, **116** may be configured to accommodate other kinds of items to be washed, such as plates and drinking glasses.

[0051] According to an embodiment of the present invention, a door (not shown in the figure) is hingedly mounted to a front portion of the dishwasher **100** to provide selective access to the tub **110**, and accordingly to the baskets **112**, **114**, **116**.

[0052] According to an embodiment of the present invention, detergent in the form of tablets, liquid, or powder is stored in a corresponding detergent compartment located at an inside portion of the door (not shown) of the dishwasher **100**. According to an embodiment of the present invention, said stored detergent is controllably discharged, under the control of the control unit **105**, into the tub **110** according to user-selected washing cycle

being carried out by the dishwasher **100** and/or by a phase of said user-selected washing cycle being carried out by the dishwasher **100**.

[0053] According to the present invention, the dishwasher **100** comprises an inlet valve **120** operable by the control unit **105** to be selectively switched between an open condition for causing washing fluid (e.g., fresh water provided by a water inlet **122**) to be loaded into the tub **110** and a closed condition for preventing washing fluid be fed to the dishwasher **100**.

[0054] According to an embodiment of the present invention, the dishwasher **100** comprises a sump, globally identified in **Figure 1** with reference **124**, in fluid communication with a bottom portion of the tub **110**, so that washing fluid reaching the tub **110** - such as fresh water loaded by the inlet valve **120** - is collected in said sump **124**. Fresh water collected in the sump **124** is also mixed therein with the detergent discharged from the detergent compartment, so that the resulting washing fluid - also referred to as process water - turns into a mixture of water and detergent.

[0055] According to an embodiment of the present invention, the dishwasher **100** further comprises a circulation pump **130** in fluid communication with the sump **124** - and therefore with the tub **110** - and configured to circulate the washing fluid in the tub **110** during a user-selected washing cycle being carried out by the dishwasher **100** and/or by a phase of said user-selected washing cycle being carried out by the dishwasher **100**. According to an embodiment of the present invention, the circulation pump **130** is configured to circulate the washing fluid in the tub **110** when the circulation pump **130** is controlled by the control unit **105** to rotate in a first, forward, direction.

[0056] According to an embodiment of the present invention, when the circulation pump **130** is controlled to rotate in the forward direction, washing fluid leaves the sump **124** and re-enter in the tub **110** from above. Particularly, according to an embodiment of the present invention, the washing fluid taken from the sump **124** is pumped by the circulation pump **130** through one or more conduits and sprayed back into the tub **110** by spray devices **132**, **134**, **136** each one associated with a respective basket **112**, **114**, **116**. According to an embodiment of the present invention, each spray device **132**, **134**, **136** comprises a respective wash arm provided with nozzles for causing washing fluid being sprayed onto the items to be washed housed in the respective basket **112**, **114**, **116**.

[0057] According to an embodiment of the present invention, the dishwasher **100** advantageously comprises a flow control device **140** configured to receive the washing fluid pumped by the circulation pump **130** when the latter is controlled to rotate in the forward direction, and to connect - under the control of the control unit **105** - one or more selected spray device(s) **132**, **134**, **136** to the circulation pump **130** in order to provide the washing fluid received by the circulation pump **130** to said selected

spray device(s) **132**, **134**, **136**. In this way, the washing fluid pumped by the circulation pump **130** may be selectively recirculated in the washing tub **110** through one or more selected spray device(s) **132**, **134**, **136**.

[0058] According to an embodiment of the present invention, a filter **150** is advantageously provided at the sump **124** for filtering soil from the washing fluid before the latter is recirculated into the washing tub **110** by the circulation pump **130** through the spray device(s) **132**, **134**, **136**.

[0059] According to an embodiment of the present invention, the dishwasher **100** further comprises a drain pump **160** configured to be operated by the control unit **105** in an activated condition for causing washing fluid in the sump **124** to be drained from the dishwasher **100**, e.g., through a corresponding drain outlet **162**, and in a deactivated condition for preventing washing fluid in the sump **124** to be drained from the dishwasher **100**.

[0060] According to the exemplary embodiment of the present invention illustrated in **Figure 1**, the circulation pump **130** is driven by a corresponding motor system **165** (for example comprising a respective electric motor driven by a respective motor driving unit comprising a respective inverter and a TRIAC) controlled by the control unit **105**.

[0061] Similarly, according to the exemplary embodiment of the present invention illustrated in **Figure 1**, the drain pump **160** is driven by a corresponding motor system **166** (for example comprising a respective electric motor driven by a respective motor driving unit comprising a respective inverter and a TRIAC) controlled by the control unit **105**.

[0062] In this way, the circulation pump **130** and the drain pump **160** may be controlled to operate concurrently and independently.

[0063] However, the concepts of the present invention can be applied to cases in which a single motor system is provided, configured to selectively drive the circulation pump **130** or the drain pump **160**. In this latter case, the circulation pump **130** and the drain pump **160** cannot be controlled to operate concurrently. For example, the electric motors of the circulation pump **130** and of the drain pump **160** may be driven by a same inverter. In this case, a single motor system may be provided comprising the electric motors of the two pumps, the respective TRIACs, and a single inverter. Said single inverter may be selectively coupled (e.g., by means of respective switches) to the TRIAC controlling the motor of the circulation pump **130** or to the TRIAC controlling the motor of the drain pump **160**. According to an embodiment of the present invention, the dishwasher **100** further comprises at least one pump sensor unit **190** configured to measure an electromechanical parameter of the circulation pump **130**, such as an electric current drawn by the circulation pump **130**, a voltage across the circulation pump **130**, the power consumption of the circulation pump **130** and/or a torque of the circulation pump **130**, and provide said measure to the control unit **105**.

[0064] According to an embodiment of the present invention, the dishwasher **100** further comprises a water softening system **195** (for example connected between the water inlet **122** and the inlet valve **120**) configured to reduce hardness of water fed to the appliance through the water inlet **122** and used for generating the washing fluid. Without having to introduce details well known to those skilled in the art, the water softening system **195** comprises a container containing a water softening agent (e.g., a ion-exchange resin) capable of reducing hardness of water by promoting exchange of the minerals dissolved in water causing hardness (e.g., calcium and magnesium) for a soft mineral that does not build up on surfaces, such as sodium. After several uses, the water softening agent gets exhausted, which strongly reduces water softening performance. For this reason, the water softening system **195** comprises a (refillable) container for storing a regenerating agent, usually salt (e.g., Sodium chloride salt), to be used for regenerating the exhausted softening agent during a water softening agent regeneration procedure.

[0065] According to an embodiment of the present invention, the control unit **105** is configured to manage the operation of the dishwasher **100** by carrying out proper software/firmware routines installed/stored in one or more memory units comprised in or associated to the control unit **105**.

[0066] **Figure 2** illustrates in terms of functional blocks some of the routines that can be carried out by the control unit **105** for controlling the operations of the dishwasher according to an embodiment of the present invention.

[0067] As will be described in details in the following, at least some of the routines may be carried out by the control unit **105** concurrently with and/or in alternative to other routines. Moreover, at least some of the routines may interact with other routines, with the operation of a routine that may influence the operation of one or more other different routines.

[0068] As will be described in the following of the description, at least some of the routines are advantageously configured to allow the control unit **105** to efficiently control the operation of the dishwasher **100** without the need that the dishwasher **100** is equipped with a pressure sensor for the determination of the level of washing fluid inside the tub **110**. In this way, a correct and reliable operation of the dishwasher **100** can be guaranteed even if the dishwasher is lacking of a pressure sensor for the determination of the level of washing fluid inside the tub **110**.

[0069] According to an embodiment of the present invention, a routine that can be carried out by the control unit **105**, hereinafter also referred to as "washing cycle routine" and identified in **Figure 2** with reference **210**, provide for controlling the hydraulic, electronic, electric and electromechanical components of the dishwasher **100** for performing user-selected washing cycles. For example, based on a phase of the washing cycle currently being performed by the dishwasher **100**, the washing cy-

cle routine **310** may provide for controlling the discharge of detergent into the tub **110**, set a target speed *TS* for the recirculation pump **130**, selects the activation of one or more spray device(s) **132**, **134**, **136**, set the temperature of the washing fluid, and so on.

[0070] According to an embodiment of the present invention, another routine that can be carried out by the control unit **105**, hereinafter also referred to as "circulation pump operative state routine" and identified in **Figure 2** with reference **220** provides for allowing the control unit **105** to determine an operative state of the circulation pump **130** between:

- a so-called "saturation state" indicative that sufficient washing fluid is present in the tub **110** to prevent air from being drawn out by the circulation pump **130** during its operation, and
- a so-called "starvation state" indicative that insufficient washing fluid is present in the tub **110** to prevent air from being drawn out by the circulation pump **130** during its operation.

[0071] In other words, a saturation state is determined when the amount of washing fluid in the tub is sufficient or high enough to prevent air from being drawn out by the circulation pump **130**, and a starvation state is determined when the amount of washing fluid in the tub is insufficient or not sufficient or not high enough to prevent air from being drawn out by the circulation pump **130**.

[0072] Without entering into excessive details, according to an embodiment of the present invention, through the circulation pump operative state routine **220**, the control unit **105** is configured to determine the operative state of the circulation pump **130** between the saturation state and the starvation state based on at least one electromechanical parameter of the circulation pump **130** sensed by the pump sensor unit **190**, such as for example at least one among:

- an electric current drawn by the circulation pump **130** during its operation;
- a voltage developed across the circulation pump **130** during its operation;
- a power consumption of the circulation pump **130** during its operation;
- a torque of the circulation pump **130** during its operation.

[0073] Indeed, the behavior of these electromechanical parameters of the circulation pump **130** is influenced by the operative state (saturation or starvation) of the circulation pump **130**. Having the circulation pump that is operating at a certain speed *SC*, a starvation state is determined when the current value of the electric current drawn by the circulation pump **130** is subjected to a drop. Similar considerations apply by considering other electromechanical parameters of the circulation pump **130**, such as the voltage, the power or the torque.

[0074] In the exemplary case illustrated in **Figure 3A**, the circulation pump **130** is in the saturation state, with an amount of washing fluid in the sump **124** that is sufficient to prevent air from being drawn out by the circulation pump **130**. In the exemplary case illustrated in **Figure 3B**, the circulation pump **130** is in the starvation state, since it is sucking air during its operation because of an insufficient amount of washing fluid in the sump **124**.

[0075] Returning back to **Figure 2B**, according to an embodiment of the present invention, another routine that can be carried out by the control unit **105**, hereinafter also referred to as "controlled circulation routine" and identified in **Figure 2** with reference **230**, provides for efficiently controlling the current speed *SC* of the circulation pump **130** based on an indication of a target speed *TS* for the recirculation pump **130**. The controlled circulation routine **230** will be described in greater detail in the following of the description.

[0076] According to an embodiment of the present invention, a further routine that can be carried out by the control unit **105**, hereinafter also referred to as "fill to speed routine" and identified in **Figure 2** with reference **240**, provides for controlling the inlet valve **120** to load in the tub **110** amounts of washing fluid dosed in such a way to allow a correct operation of the dishwasher **100** when the latter is operating with the circulation pump **130** at a circulation pump speed *SC* based on said target speed *TS*. The fill to speed routine **240** will be described in greater detail in the following of the description.

[0077] According to an embodiment of the present invention, another routine that can be carried out by the control unit **105**, hereinafter also referred to as "drain to speed routine" and identified in **Figure 2** with reference **250**, provides for controlling the drain pump **160** to drain out from the tub **110** (and from the dishwasher **100**) amounts of washing fluid dosed in such a way to allow a correct operation of the dishwasher **100** when the latter is operating with the circulation pump **130** at a circulation pump speed *SC* based on said target speed *TS*. The drain to speed routine **250** will be described in greater detail in the following of the description.

[0078] According to an embodiment of the present invention, a further routine that can be carried out by the control unit **105**, hereinafter also referred to as "drain to empty procedure" and identified in **Figure 2** with reference **270**, provides for controlling the drain pump **160** to drain out washing fluid so as to empty the tub **110** (and the sump **124**). The drain to empty procedure **270** will be described in greater detail in the following of the description.

[0079] According to an embodiment of the present invention, another routine that can be carried out by the control unit **105**, hereinafter also referred to as "fill to speed not empty", and identified in **Figure 2** with reference **280**, provides for controlling the inlet valve **120** to cause a correct filling of washing fluid in the tub **110** starting from a condition in which the sump **124** is assumed to be empty.

[0080] According to an embodiment of the present invention, another routine that can be carried out by the control unit **105**, hereinafter also referred to as "inlet valve checking procedure" and identified in **Figure 2** with reference **285**, provides for verifying the correct operation of the inlet valve **120**, and particularly to determine if the inlet valve **120** is subjected to a fault causing undesired leakages when in the closed condition. The inlet valve checking procedure **285** will be described in greater detail in the following of the description.

[0081] As graphically illustrated in **Figure 2**, the routines **230**, **240**, **250** and **285** are configured to operate by taking into account the output produced by the routine **220**, i.e., by taking into account the operative state of the circulation pump **130** (saturation state or starvation state).

[0082] In the following sections of the description, some of the routines that can be carried out by the control unit **105** according to embodiment of the present invention will be described in greater detail.

Controlled circulation routine 230

[0083] In general, according to an embodiment of the present invention, the controlled circulation routine **230** provides for causing the speed *SC* of the circulation pump **130** to increase towards the target speed *TS* with a first speed increase rate *R1*. If a starvation state of the circulation pump **130** is determined, and at the same time the inlet valve **120** is in the open condition (causing thus washing fluid being loaded into the tub **110**) before the the speed *SC* of the circulation pump **130** reached the target speed *TS*, the speed *SC* of the circulation pump **130** is set to increase towards the target speed *TS* with a second speed increase rate *R2* lower than the first speed increase rate *R1*.

[0084] **Figure 4A** illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit **105** when the controlled circulation routine **230** is being carried out according to an embodiment of the present invention.

[0085] According to an embodiment of the present invention, the control unit **105** sets a first increase rate *R1* for the speed *SC* of the circulation pump **130** (block **405**).

[0086] Then, according to an embodiment of the present invention, the controlled circulation routine **230** enters in a so-called "initial speed ramp state" in which the control unit **105** causes the speed *SC* of the circulation pump **130** to increase - from a starting value, e.g., equal to zero if the circulation pump **130** is stopped - towards the target speed *TS* with said first increase rate *R1* (block **406**). According to an embodiment of the present invention, the value of the target speed *TS* is set by the washing cycle procedure **210**, depending on a user-selected washing cycle (and/or based on a phase thereof) being currently carried out by the dishwasher **100**.

[0087] According to an embodiment of the present in-

vention, said first increase rate *R1* is higher than 70 RPM/s, such as for example equal to 80 RPM/s.

[0088] According to an embodiment of the present invention, if a starvation state of the circulation pump **130** is determined (by the circulation pump operative state routine **220**) before the speed *SC* of the circulation pump **130** reached the target speed *TS* (block **408**), the control unit **105** initializes a timer *TC* (block **410**) and starts the timer *TC* to count a predetermined time period (e.g., 200 ms). Then, the controlled circulation routine **230** enters in a so-called "starving state" (block **412**), in which the speed *SC* of the circulation pump **130** is caused to increase by the control unit **105** with the actually set increase rate while the circulation pump **130** is determined to be in the starvation state.

[0089] According to an embodiment of the present invention, if the timer *TC* elapses without having a saturation state of the circulation pump **130** be determined by the circulation pump operative state routine **220** (block **414**), the control unit **105** checks if the inlet valve **120** is in the open condition or in the closed position (block **416**). According to an embodiment of the present invention, the condition (open or closed) of the inlet valve **120** is set by the fill to speed routine **240**.

[0090] According to an embodiment of the present invention, if the inlet valve **120** is in the closed position (exit branch **N** of block **416**), meaning that no new washing fluid is being fed into the tub **110** from outside the dishwasher **100**, the control unit **105** causes the increasing rate of the speed *SC* of the circulation pump **130** to be set to zero, and causes the speed *SC* of the circulation pump **130** to be decreased by a corresponding decreasing amount *DSC* (block **418**).

[0091] According to an embodiment of the present invention, if the inlet valve **120** is in the open condition (exit branch **Y** of block **416**), meaning that new washing fluid is being fed into the tub **110** from outside the dishwasher **100**, the control unit **105** checks (block **420**) if the highest value reached by the speed *SC* of the circulation pump **130** has been subjected to any increase for a corresponding time period (e.g., 45s). In case the highest value reached by the speed *SC* of the circulation pump **130** did not increase during said time period (exit branch **N** of block **420**), the control unit **105** stops (block **422**) the circulation pump **130** for a time interval, such as for 5s, for removing air from the circulation pump **130**, and then the operations flow returns to block **405**. In case the highest value reached by the speed *SC* of the circulation pump **130** did increase at least once during said time period (exit branch **Y** of block **420**), the control unit **105** causes the speed *SC* of the circulation pump **130** to increase towards the target speed *TS* with a second increase rate *R2* lower than the first increase rate *R1* (block **430**). According to an embodiment of the present invention, said decreasing amount *DSC* is equal to 100 RPM/s. According to an embodiment of the present invention, said second increase rate *R2* is lower than 10 RPM/s, such as for example equal to 5 RPM/s.

[0092] Then, the control unit **105** reinitializes the timer *TC* and starts the timer *TC* to count a further time period (block **432**), for example 4s.

[0093] At this point, the operations flow returns to block **412**, where the previously described operations are reiterated, with the reinitialised timer *TC* and the new value of the speed *SC* and/or the new value for the increase rate of the speed *SC*.

[0094] According to an embodiment of the present invention, if a saturation state of the circulation pump **130** is determined by the circulation pump operative state routine **220** before the timer *TC* elapses (block **434**), after a further time period is expired (e.g., 2s), the controlled circulation routine **230** enters in a so-called "saturating state" (block **436**), in which the speed *SC* of the circulation pump **130** is caused to increase by the control unit **105** with a third increase rate *R3* lower than the first increase rate *R1* and higher than the second increase rate *R2* while the circulation pump **130** is determined to be in the saturation state. According to an embodiment of the present invention, the value of the third increase rate *R3* depends on the condition (open/closed) of the inlet valve **120**. According to an embodiment of the present invention, if the inlet valve is in the open condition, the third increase rate *R3* is higher than 50 RPM/s, for example equal to 60 RPM/s, while if the inlet valve is in the closed condition, the third increase rate *R3* is lower than 50 RPM/s, for example equal to 40 RPM/s.

[0095] Then, according to an embodiment of the present invention, when a starvation state of the circulation pump **130** is determined again by the circulation pump operative state routine **220** (block **438**), the operations flow returns to block **410**, wherein the control unit **105** reinitializes the timer *TC* and the controlled circulation routine **230** enters again in the starving state (block **412**).

[0096] Returning back to block **406**, according to an embodiment of the invention, if the speed *SC* of the circulation pump **130** reaches the target speed *TS* before a starvation state of the circulation pump **130** is determined by the circulation pump operative state routine **220** (block **440**), the operations flow goes to block **436**, where the controlled circulation routine **230** enters in the saturating state.

[0097] When carrying out the controlled circulation routine **230** according to the embodiments of the invention illustrated in **Figure 4A**, the control unit **105** tries to cause the circulation pump **130** to operate at the target speed *TS* by increasing the speed *SC* of the circulation pump **130** starting from a starting value with a corresponding speed increase rate (blocks **405**, **406**). The target speed *TS* can be reached without causing the circulation pump **130** to enter in the starvation state (block **440**). If the target speed *TS* cannot be reached without causing a starvation state of the circulation pump **130** (block **408**), the control unit **105** controls the speed *SC* to reach the highest speed *SC* capable of maintaining the circulation pump **130** in the saturation state. This is done by slowly

increasing the speed *SC* until a starvation state of the circulation pump **130** is detected, and then:

- if the inlet valve **120** is closed, by lowering the speed *SC* until a saturation state of the circulation pump **130** is restored,
- if the inlet valve **120** is open, by increasing the speed *SC* at a lower speed increase rate until a saturation state of the circulation pump **130** is restored.

[0098] **Figure 4B** is an exemplary time diagram showing how the speed *SC* of the circulation pump **130** varies over time under the control of the control unit **105** when the latter is carrying out the controlled circulation routine **230** according to an embodiment of the present invention.

[0099] In the example illustrated in **Figure 4B**, the circulation pump **130** is initially turned off, and therefore the speed *SC* is equal to zero. At time *tc(1)*, the controlled circulation routine **230** is started, and the control unit **105** causes the circulation pump **130** to increase the speed *SC* of the circulation pump **130** with a corresponding first speed increase rate *R1* (blocks **405**, **406**). At time *tc(2)*, a starvation state of the circulation pump **130** is determined, before the speed *SC* of the circulation pump **130** reached the target speed *TS* (block **408**). At this point, the control unit **105** initializes and starts the timer *TC* to count a predetermined time period (block **410**). In the example considered, the timer *TC* expires at time *tc(3)* before a saturation state of the circulation pump **130** is determined (block **414**). In the example considered, at time *tc(3)* the inlet valve **120** is in the open condition (exit branch *Y* of block **416**), and therefore the control unit **105** verifies if the highest value reached by the speed *SC* of the circulation pump **130** has been subjected to any increase during a past time period from time *tc(3)* (block **420**). Since in the considered example the speed *SC* of the circulation pump **130** was constantly increasing from time *tc(1)* to time *tc(3)*, this condition is verified (exit branch *Y* of block **420**), and therefore the control unit **105** varies the increase rate of the speed *SC* of the circulation pump **130** to a second speed increase rate *R2* lower than the first speed increase rate *R1* (block **430**).

[0100] Thanks to the controlled circulation routine **230** according to the embodiments of the invention it is therefore possible to efficiently control the current speed *SC* of the circulation pump **130** to reach a value corresponding to a requested target speed *TS* without requiring the presence of a pressure sensor for the determination of the level of washing fluid currently inside the tub **110**.

Fill to speed routine 240

[0101] In general, according to an embodiment of the present invention, the fill to speed routine **240** provides for causing the inlet valve **120** to be opened in order to fill washing fluid in the tub **110** when the speed *SC* of the circulation pump **130** is lower than or equal to the target speed *TS* if a starvation state of the circulation pump **130**

is determined. The fill to speed routine **240** also provides for causing the inlet valve **120** to be closed if a saturation state of the circulation pump **130** is determined. According to an embodiment of the present invention, in order to reduce the number of times the inlet valve **120** switches between the open and closed conditions, the closure of the valve is delayed in case the speed *SC* of the circulation pump **130** is lower than the target speed *TS* by a sufficiently large amount.

[0102] Figure 5 illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit **105** when the fill to speed routine **240** is being carried out according to an embodiment of the present invention.

[0103] According to an embodiment of the present invention, the fill to speed routine **240** may switch between two different states, and namely a so-called "valve open state" (block **502**) corresponding to an open condition of the inlet valve **120** for causing new washing fluid to be fed to the dishwasher **100** for being loaded in the tub **110** and a so-called "valve closed state" (block **504**) corresponding to a closed condition of the inlet valve **120** for preventing new washing fluid to be fed to the dishwasher **100**.

[0104] The initial state of the fill to speed routine **240** depends on the current state of the inlet valve **120**.

[0105] Starting from the valve closed state (block **504**), in which the inlet valve **120** is in the closed condition, according to an embodiment of the invention, if a starvation state of the circulation pump **130** is determined (block **505**), when the speed *SC* of the circulation pump **130** is equal to or lower than the target speed *TS* (block **506**), the control unit **105** causes the inlet valve **120** to switch to the open condition for causing new washing fluid to be fed in the tub **110** (block **507**). Then, the fill to speed routine **240** switches to the valve open state (going to block **502**).

[0106] According to an embodiment of the invention, if instead a saturation state of the circulation pump **130** is determined (block **508**), when the speed *SC* of the circulation pump **130** is equal to or higher than the target speed *TS* (block **509**), the fill to speed routine **240** terminates.

[0107] According to an embodiment of the present invention, when the fill to speed routine **240** is in the valve open state (block **502**), and a starvation state of the circulation pump **130** is determined (block **510**), when the speed *SC* of the circulation pump **130** is higher than the target speed *TS* (block **512**), the control unit **105** causes the inlet valve **120** to switch to the closed condition for preventing new washing fluid be fed to the dishwasher **100** (block **514**). Then the fill to speed routine **240** switches the valve closed state (going to block **504**).

[0108] According to an embodiment of the present invention, when the fill to speed routine **240** is in the valve open state (block **502**), and a saturation state of the circulation pump **130** is determined (block **516**), when the speed *SC* of the circulation pump **130** is equal to or higher

than the target speed *TS* (block **518**), the control unit **105** causes the inlet valve **120** to switch to the closed condition for preventing new washing fluid be fed to the dishwasher **100** (block **514**). Then, the fill to speed routine **240** switches to the valve closed state (going to block **504**).

[0109] According to an embodiment of the present invention, when the fill to speed routine **240** is in the valve open state (block **502**), and a saturation state of the circulation pump **130** is determined (block **516**), when the speed *SC* of the circulation pump **130** is lower than the target speed *TS* (block **520**), the control unit **105** checks (block **522**) if the speed *SC* is however close to (e.g., only slightly lower than) the target speed *TS*, or if said speed *SC* is still far from (e.g., substantially lower than) the target speed *TS*.

[0110] According to an embodiment of the present invention, if the difference between the target speed *TS* and the speed *SC* of the circulation pump **130** is not higher than a speed threshold *THC* (exit branch **N** of block **522**), the control unit **105** directly causes the inlet valve **120** to switch to the closed condition for preventing new washing fluid be fed to the dishwasher **100** (block **514**). Then, the fill to speed routine **240** switches to the valve closed state (going to block **504**).

[0111] According to an embodiment of the present invention, if the difference between the target speed *TS* and the speed *SC* of the circulation pump **130** is higher than a speed threshold *THC* (exit branch **Y** of block **522**), the control unit **105** causes a delayed switching of the inlet valve **120** to the closed condition. According to an embodiment of the invention, the control unit **105** causes the inlet valve **120** to switch to the closed position only after a delay interval *DIF* is expired.

[0112] According to an embodiment of the present invention, said speed threshold *THC* is higher than 100 RPM and lower than 300 RPM, for example is equal to 200 RPM.

[0113] According to an embodiment of the present invention, the duration of the delay interval *DIF* depends on the difference ΔF between the target speed *TS* and the speed *SC* of the circulation pump **130**.

[0114] According to an embodiment of the present invention, the control unit **105** set the delay interval *DIF* (block **524**) to a value that is proportional to the difference ΔF between the target speed *TS* and the speed *SC* of the circulation pump **130**. According to an embodiment of the present invention, the delay interval *DIF* is set to a maximum predetermined value *MDIF* if the difference ΔF is excessively large. For example, according to an embodiment of the present invention, the control unit **105** sets the delay interval *DIF* to the minimum value between:

- $\Delta F \cdot PF$, and
- *MDIF*,

wherein *PF* is a proportionality parameter.

[0115] For example, *MDIF* may be set to 10000 ms

and *PF* may be set to 20 ms.

[0116] According to an embodiment of the present invention, when the delay interval *DIF* is expired (block 526), the control unit 105 causes the inlet valve 120 to switch to the closed condition for preventing new washing fluid be fed to the dishwasher 100 (block 514). Then, the fill to speed routine 240 switches to the valve closed state (going to block 504).

[0117] By delaying the closure of the inlet valve 120 when the speed *SC* is still far from (e.g., substantially lower than) the target speed *TS*, an additional amount of washing fluid is fed into the tub 110, advantageously reducing the possibility that, once the inlet valve 120 is in the closed condition, the circulation pump 130 enters into the starvation state (with a consequent reopening of the inlet valve 120). In this way, undesired "bouncing" between the open and closed condition of the inlet valve 120 is advantageously reduced.

[0118] Thanks to the fill to speed routine 240 according to the embodiments of the invention, it is possible to efficiently control the inlet valve 120 to load in the tub 110 amounts of washing fluid dosed in such a way to allow a correct operation of the dishwasher 100 when the latter is operating with the circulation pump 130 at a circulation pump speed *SC* based on said target speed *TS*, without requiring the presence of a pressure sensor for the determination of the current level of washing fluid inside the tub 110.

[0119] According to an embodiment of the present invention, the controlled circulation routine 230 and the fill to speed routine 240 are two routines that can be expediently carried out by the control unit 105 concurrently, since each one of the two routines requires, among its inputs, something that can be output by the other routine.

[0120] Particularly, in order to be correctly executed, the controlled circulation routine 230 requires to receive the indication of the target speed *TS*, an indication of the operative state *PC* (starvation state or saturation state) of the circulation pump 130, and an indication of the condition *VC* (open condition or closed condition) of the inlet valve 120. Moreover, in order to be correctly execute, the fill to speed routine 240 requires to receive the indication of the target speed *TS*, the indication of the operative state *PC* of the circulation pump 130, and an indication of the current speed *SC* of the circulation pump 130.

[0121] By making reference to the schematic functional block of Figure 6, since the speed *SC* of the circulation pump 130 is set by the controlled circulation routine 230 (based on *TS*, *PC*, *VC*), and the condition *VC* of the inlet valve is set by the fill to speed routine 240 (based on *TS*, *PC*, *SC*), according to an embodiment of the present invention, the controlled circulation routine 230 and the fill to speed routine 240 may be advantageously executed concurrently, using the indication of the condition *VC* of the inlet valve 120 set by the fill to speed routine 240 as an input for the controlled circulation routine 230, and using the indication of the speed *SC* of the circulation

pump 130 set by the controlled circulation routine 230 as an input for the fill to speed routine 240.

[0122] According to an embodiment of the present invention, when the controlled circulation routine 230 and the fill to speed routine 240 are concurrently executed, each one of said routines may operate by using a respective different target speed *TS*.

[0123] According to an embodiment of the present invention, the control unit 105 may control the speed *SC* of the circulation pump 130 (by running the controlled circulation routine 230) based on:

- a first target speed *TS1*;
- the indication of the condition *VC* of the inlet valve 120;
- the indication of the operative state *PC* of the circulation pump 130.

[0124] According to an embodiment of the present invention, the control unit 105 may control the condition *VC* of the inlet valve 120 (by running the fill to speed routine 240) based on:

- a second target speed *TS2*;
- the indication of the speed *SC* of the circulation pump 130;
- the indication of the operative state *PC* of the circulation pump 130.

[0125] For example, if the first target speed *TS1* is set to a value higher than the value of the second target speed *TS2* (e.g., *TS1* is set to 2000 RPM, and *TS2* is set to 1800 RPM), as long as the current speed *SC* of the circulation pump 130 is equal to or lower than *TS2*, both the two routines are carried out by the control unit 105. When the speed *SC* of the circulation pump 130 is higher than *TS2*, the fill to speed routine 240 is prevented to cause the opening of the inlet valve 120.

Drain to speed routine 250

[0126] In general, according to an embodiment of the present invention, the drain to speed routine 250 provides for performing partial drains of washing fluid by causing the drain pump 160 to be activated to drain amounts of washing fluid out from the tub 110 (and from the dishwasher 100) when the speed *SC* of the circulation pump 130 is higher than or equal to the target speed *TS* if a saturation state of the circulation pump 130 is determined.

[0127] Figure 7 illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit 105 when the drain to speed routine 350 is being carried out according to an embodiment of the present invention.

[0128] According to an embodiment of the present invention, the drain to speed routine 250 may switch between two different states, and namely a so-called "drain

off state" (block **702**) corresponding to a deactivated condition of the drain pump **160** for preventing washing fluid in the tub **110** to be drained out from the dishwasher **100**, and a so-called "drain on state" (block **704**) corresponding to an activated condition of the drain pump **160** for causing washing fluid to be drained out from the tub **110**.

[0129] Starting from the drain off state (block **702**), in which the drain pump **160** is in the deactivated condition, according to an embodiment of the present invention, if a saturation state of the circulation pump **130** is determined (block **706**), when the speed *SC* of the circulation pump **130** is equal to or higher than the target speed *TS* (block **708**), the control unit **105** causes the drain pump **160** to switch to the activated condition (block **710**) for causing washing fluid to be drained out from the tub **110**. Then, the drain to speed routine **250** switches to the drain on state (going to block **704**).

[0130] According to an embodiment of the present invention, when the drain to speed routine **250** is in the drain off state (block **702**), with the drain pump **160** that is in the deactivated condition, if a starvation state of the circulation pump **130** is determined (block **712**), when the speed *SC* of the circulation pump **130** is lower than the target speed *TS* (block **714**), the drain to speed routine **250** terminates.

[0131] According to an embodiment of the present invention, when the drain to speed routine **250** is in the drain on state (block **704**), with the drain pump **160** that is in the activated condition, if a starvation state of the circulation pump **130** is determined (block **715**), the control unit **105** causes the drain pump **160** to switch to the deactivated condition (block **716**) for preventing washing fluid to be drained out from the tub **110**. Then, the drain to speed routine **250** switches to the drain off state (going to block **702**).

[0132] According to an embodiment of the present invention, when the drain to speed routine **250** is in the drain on state (block **704**), with the drain pump **160** that is in the activated condition, if a saturation state of the circulation pump **130** is determined (block **717**), when the speed *SC* of the circulation pump **130** is lower than the target speed *TS* (block **718**), the control unit **105** causes the drain pump **160** to switch to the deactivated condition (block **716**) for preventing washing fluid to be drained out from the tub **110**. Then, the drain to speed routine **250** switches to the drain off state (going to block **702**).

[0133] Thanks to the drain to speed routine **250** according to the embodiments of the invention it is therefore possible to carry out partial drains of washing fluid by efficiently control the drain of amounts of washing fluid from the tub **110** (and from the dishwasher **100**) dosed in such a way to allow a correct operation of the dishwasher **100** when the latter is operating with the circulation pump **130** at a circulation pump speed *SC* based on said target speed *TS*, without requiring the presence of a pressure sensor for the determination of the current level of washing fluid inside the tub **110**.

[0134] It is pointed out that since the drain to speed routine **250** according to the embodiments of the invention illustrated above requires that the circulation pump **130** and the drain pump **160** are driven concurrently, said routine can be implemented only in case the the circulation pump **130** and the drain pump **160** are driven by respective different and independent motor systems (*i.e.*, the motor systems **165** and **166**).

10 Drain to empty routine 270

[0135] In general, according to an embodiment of the present invention, the drain to empty routine **270** provides for activating the drain pump **160** for draining washing fluid from the tub **110** (and from the sump **124**) until an empty condition of the sump **124** is detected in which the sump **124** substantially does not contain washing fluid. The empty condition of the sump **124** is detected by controlling the circulation pump **130** to rotate in a second, backward, direction (opposite to the first, forward direction normally employed for circulating the washing fluid in the tub **110**, so that no circulation of washing fluid in the tub **110** occurs), collecting samples of an electromechanical parameter of the circulation pump **130** sensed by the pump sensor unit **190** during the rotation in the backward direction, and then by comparing said collected samples with a threshold *ETH*.

[0136] According to an embodiment of the present invention, said electromechanical parameter of the circulation pump **130** is an electric current drawn by the circulation pump **130**, a voltage across the circulation pump **130**, the power consumption of the circulation pump **130** and/or a torque of the circulation pump **130**.

[0137] According to an embodiment of the present invention, the control unit **105** is configured to calculate an energy value *EV* indicative of an electric energy consumed by the circulation pump **130** during the rotation in the backward direction based on the collected samples, and then by comparing said calculated energy value *EV* with the threshold *ETH*. If the energy value *EV* is higher than the threshold *ETH*, it means that there is still an amount of washing fluid in the tub **110** such to cause the circulation pump **130** to consume a non negligible amount of energy in order to be able to rotate.

[0138] Figure 8 illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit **105** when the drain to empty routine **270** is being carried out according to an embodiment of the present invention.

[0139] According to an embodiment of the present invention, the control unit **105** sets to zero an energy counter *EC* indicative of a number of times in a row the energy value *EV* has been determined to be lower than the threshold *ETH*, and set a minimum energy threshold *E_{min}* to a very large value (block **802**).

[0140] According to an embodiment of the present invention, the control unit **105** controls the drain pump **160** to switch to the activated condition for causing washing

fluid in the sump **124** to be drained from the dishwasher **100**, and controls the circulation pump **130** to rotate in the backward direction (block **804**).

[0141] According to an embodiment of the present invention, the control unit **105** collects a set of samples of an electromechanical parameter of the circulation pump **130** sensed by the pump sensor unit **190**, such as the electric current *I* drawn by the circulation pump **130** (similar considerations apply in case a different electromechanical parameter is used, such as the voltage, the power or the torque of the circulation pump **130**) and accordingly calculates a corresponding energy value *EV* (block **806**).

[0142] According to an embodiment of the present invention, the control unit **105** calculates the energy value *EV* by summing the samples of the collected set. However, similar considerations apply in case the energy value *EV* is calculated using the samples in a different way.

[0143] According to an embodiment of the present invention, the control unit **105** compares the calculated energy value *EV* with the threshold *ETH* (block **810**).

[0144] According to an embodiment of the present invention, if the calculated energy value *EV* is higher than the threshold *ETH* (exit branch **Y** of block **810**), it means that the washing tub **110**, and therefore the sump **124**, is still containing an amount of washing fluid such to cause the circulation pump **130** to consume a non negligible amount of energy in order to be able to rotate. In this case, according to an embodiment of the present invention, the control unit **105** reset the energy counter *EC* to zero (block **820**), and set the minimum energy threshold *Emin* to the minimum between the current value of the minimum energy threshold *Emin* and the last calculated energy value *EV* (block **822**). Then, according to an embodiment of the present invention, the control unit **105** causes the recirculation pump **130** to be turned off (block **823**), and, after a waiting interval, such as 5s, to be turned on again for rotating in the backward direction (going back to block **804**).

[0145] According to an embodiment of the present invention, if the calculated energy value *EV* is lower than the threshold *ETH* (exit branch **N** of block **810**), the control unit **105** increases (e.g., by one) the energy counter *EC* (block **824**), and then compares the just increased energy counter *EC* with an energy counter threshold *ECTH* (block **826**). According to an embodiment of the present invention, the energy counter threshold *ECTH* is equal to 2. However, similar considerations apply in case the energy counter threshold *ECTH* has a different value.

[0146] According to an embodiment of the present invention, if the energy counter *EC* is lower than the energy counter threshold *ECTH* (exit branch **N** of block **826**), the operations flow goes to block **822**.

[0147] According to an embodiment of the present invention, if the energy counter *EC* is higher than the energy counter threshold *ECTH* (exit branch **Y** of block **826**), it means that the energy value *EV* has been determined to be lower than the threshold *ETH* for a number of times

in a row sufficient to avoid incorrect determinations of empty conditions of the sump **124** due to spurious variations of the speed *SC* of the circulation pump **130** independent from the actual level of the washing fluid inside the sump **124**.

[0148] According to an embodiment of the present invention, if the energy counter *EC* is higher than the energy counter threshold *ECTH*, the control unit **105** carries out a stability check for determining if the current energy consumption of the circulation pump **130** is on a stable low value or not by comparing the last calculated energy value *EV* with the minimum energy threshold *Emin* (block **828**).

[0149] According to an embodiment of the present invention, if the last calculated energy value *EV* plus an energy hysteresis value *EH* is lower than the energy counter threshold *ECTH* (exit branch **N** of block **828**), it means that the current energy consumption of the circulation pump **130** is at a value that is not sufficiently low and stable to avoid incorrect determinations of empty conditions of the sump **124**, and therefore the operations flow goes to block **822**.

[0150] According to an embodiment of the present invention, if the last calculated energy value *EV* plus an energy hysteresis value *EH* is equal to or higher than the energy counter threshold *ECTH* (exit branch **Y** of block **828**), it means that a sufficient amount of washing fluid has been drained out, and the control unit **105** determines an empty condition of the sump **124**, and thus controls the drain pump **160** to switch to the deactivated condition (block **830**).

[0151] Thanks to the drain to empty routine **270** according to the embodiments of the invention it is therefore possible to efficiently empty the sump **124** (and therefore the tub **110**) and turning off the drain pump **160** when the empty condition of the sump **124** is determined, without requiring the presence of a pressure sensor for the determination of the current level of washing fluid inside the tub **110**.

[0152] It is pointed out that since the drain to empty routine **270** according to the embodiments of the invention illustrated above requires that the circulation pump **130** and the drain pump **160** are driven concurrently, said routine can be implemented only in case the the circulation pump **130** and the drain pump **160** are driven by respective different and independent motor systems (i.e., the motor systems **165** and **166**).

Fill to speed not empty routine 280

[0153] In general, according to an embodiment of the present invention, the fill to speed not empty routine **280** provides for controlling the circulation pump **130** to rotate in the backward direction. Then, the inlet valve **120** is caused to switch to the open condition for causing washing fluid be fed into the tub **110** (and therefore into the tub **124**) while the circulation pump **130** is rotating backward. Presence of washing fluid inside the sump is de-

terminated based on a comparison between an electric parameter of the circulation pump **130** during a first time period *TP1* (occurring before the opening of the inlet valve **120**) and the electric parameter of the circulation pump **130** during a second time period *TP2* (occurring after the opening of the inlet valve **120**). A filled condition of the sump **124** is determined if inside the sump **124** there is an amount of washing fluid that is sufficient to cause a sufficiently large increase of the electric parameter of the circulation pump **130** from the first time period *TP1* to the second time period *TP2*.

[0154] According to an embodiment of the present invention which will be described in detail in the following, said electric parameter of the circulation pump **130** is an electric current *I* drawn by the circulation pump **130**. In this way, a comparison is made between an electric current *I* drawn by the circulation pump **130** during the first time period *TP1* and an electric current *I* drawn by the circulation pump **130** during the second time period *TP2*. However, the concepts of the present invention can be applied to cases in which a different electric parameter of the circulation pump **130** is considered, such as a voltage developed across the circulation pump **130** or the power consumption of the circulation pump **130**.

[0155] Figure 9 illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit **105** when the fill to speed not empty routine **280** is being carried out according to an embodiment of the present invention.

[0156] According to an embodiment of the present invention, and starting from a condition in which the sump **124** is assumed to be empty, the control unit **105** controls the circulation pump **130** to rotate in the backward direction at a first reverse speed *CS1* (block **902**). For example, the first reverse speed *CS1* may be set to -1000 RPM (the minus sign shows that the circulation pump **130** is rotating in the backward direction, *i.e.*, a direction opposite to the first, forward direction normally employed for circulating the washing fluid in the tub **110**, so that no circulation of washing fluid in the tub **110** occurs).

[0157] According to an embodiment of the present invention, the control unit **105** waits until the electric current *I* drawn by the circulation pump **130** - sensed by the pump sensor unit **190** - reaches a stable value (block **904**), for example by observing the fluctuations of said current.

[0158] According to an embodiment of the present invention, the control unit **105** calculates an average current value *I_{AV}* corresponding to the average of the electric current *I* drawn by the the circulation pump **130** during a first time period *TP1* (block **906**).

[0159] At this point, according to an embodiment of the present invention, the control unit **105** causes the inlet valve **120** to switch to the open condition (block **910**), for causing washing fluid to be fed into the tub **110** (and therefore, into the sump **124**).

[0160] According to an embodiment of the present invention, the control unit **105** is configured to determine the presence of washing fluid inside the sump **124** (filled

condition) when the electric current *I* drawn by the circulation pump **130** - sensed by the pump sensor unit **190** - during a second time period *TP2* after the inlet valve **120** switched to the open condition is higher than the average current value *I_{AV}* by a first hysteresis threshold *ITH1* (block **920**). According to an embodiment of the present invention, the hysteresis threshold *ITH1* is set to a value higher than 1 mA and lower than 4 mA, such as for example 2 mA.

[0161] According to an embodiment of the present invention, the control unit **105** causes the inlet valve **120** to switch to the closed condition, and to cause the circulation pump **130** to stop (block **925**).

[0162] Thanks to the fill to speed not empty routine **280** according to the embodiments of the invention, it is therefore possible to efficiently assess if washing fluid has been correctly filled in the sump **124** without requiring the presence of a pressure sensor for the determination of the current level of washing fluid inside the tub **110**.

[0163] The fill to speed not empty routine **280** according to the embodiments of the invention described above is based on the assumption that the sump **124** is initially empty. In order to avoid incorrect results in case the sump **124** was already containing washing fluid at the beginning of the routine, for example because the average current value *I_{AV}* has a large value, according to an embodiment of the present invention, the fill to speed not empty routine **280** is modified to further provide for the following operations.

[0164] Returning back to block **910**, where the control unit **105** causes the inlet valve **120** to switch to the open condition, if the electric current *I* drawn by the circulation pump **130** during the second time period *TP2* after the inlet valve **120** switched to the open condition did not become higher than the average current value *I_{AV}* by the first hysteresis threshold *ITH1* (block **930**), the control unit **105** causes the circulation pump **130** to rotate in the backward direction at a second reverse speed *CS2* having an absolute value higher than an absolute value of said first reverse speed *CS* (block **940**). For example, the second reverse speed *CS2* may be set to -2000 RPM.

[0165] According to an embodiment of the present invention, the control unit **105** is configured to determine the presence of washing fluid inside the sump **124** (filled condition) when the electric current *I* drawn by the circulation pump **130** - sensed by the pump sensor unit **190** - during a third time period *TP3* after the second time period *TP2* is higher than the average current value *I_{AV}* by a second hysteresis threshold *ITH2* (block **942**). According to an embodiment of the present invention, the second hysteresis threshold *ITH2* is set to a value higher than the first hysteresis threshold *ITH1*. According to an embodiment of the present invention, the second hysteresis threshold *ITH2* is higher than 10 mA and lower than 20 mA, such as for example 15 mA.

[0166] According to an embodiment of the present invention, the control unit **105** is then configured to cause the inlet valve **120** to switch to the closed condition, and

to cause the circulation pump **130** to stop (block **944**).

[0167] It is pointed out that controlling the circulation pump **130** to rotate in the backward direction at a too large reverse speed, such as at the second reverse speed CS2, may cause problems in case a water softening agent regeneration procedure has been recently carried out by the water softening system **195** without having been followed by a complete drain operation. Indeed, in this case, brine comprising salt is still present in the sump **124**, and by running the circulation pump **130** to rotate in the backward direction at a too large reverse speed could cause salt being sprayed in the tub **110**, soiling the walls of the latter and the baskets **132**, **134**, **136**.

[0168] According to an embodiment of the present invention, this problem is solved by preventing the control unit **105** to cause the circulation pump **130** to rotate in the backward direction at the second reverse speed CS2 in case the water softening system **195** has been subjected to a water softening agent regeneration procedure and no drain of the washing fluid inside the sump **124** has been carried out after said water softening agent regeneration procedure.

[0169] Particularly, according to an embodiment of the present invention, after block **930**, the control unit **105** checks if the water softening system **195** has been subjected to a water softening agent regeneration procedure and no drain of the washing fluid inside the sump **124** has been carried out after said a water softening agent regeneration procedure (block **950**).

[0170] If no water softening agent regeneration procedure has been performed, or if after that a water softening agent regeneration procedure has been performed the washing fluid inside the sump **124** has been drained out through the drain outlet **162** (exit branch **N** of block **950**), the operations flow proceeds as already described above, with the control unit **105** that causes the circulation pump **130** to rotate in the backward direction at the second reverse speed CS2 (block **940**).

[0171] If instead the water softening system **195** has been subjected to a water softening agent regeneration procedure and no drain of the washing fluid inside the sump **124** has been carried out after said water softening agent regeneration procedure (exit branch **Y** of block **950**), according to an embodiment of the present invention, the control unit **105** causes the inlet valve **120** to switch to the closed condition, and cause the circulation pump **130** to stop (block **960**).

[0172] Then, according to an embodiment of the present invention, the washing fluid included in the sump **124** (comprising salt) is drained out from the dishwasher **100** (block **965**), for example using the previously described drain to empty routine **270**, and then the operation flows returns to block **902**.

Inlet valve checking routine 285

[0173] In general, according to an embodiment of the present invention, the inlet valve checking procedure **285**

provides for opening the inlet valve **120** to load washing fluid into the tub **110** while the circulation pump **130** is operated to reach a first target flow rate *TFR1*, and then closing the inlet valve **120** when a saturation state of the circulation pump **130** is determined with the circulation pump **130** that is operating at the first target flow rate *TFR1*. At this point, the circulation pump **130** is controlled to operate at a second flow rate *TFR2* higher than the first flow rate *TFR1*. If a starvation state of the circulation pump **130** is determined while the circulation pump **130** is operating at the second flow rate *TFR2*, the inlet valve **120** is determined to not be affected by leakages when in the closed condition.

[0174] Figure **10A** illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit **105** when the inlet valve checking routine **285** is being carried out according to an embodiment of the present invention.

[0175] According to an embodiment of the present invention, and starting from a condition in which the inlet valve **120** is in the closed condition, the control unit **105** controls the inlet valve to switch to the open condition for causing washing fluid to be fed into the tub **110** (block **1002**).

[0176] According to an embodiment of the present invention, while washing fluid is fed into the tub **110** through the inlet valve **122**, the control unit **105** controls the circulation pump **130** to operate for reaching a first target flow rate *TFR1* (block **1004**).

[0177] According to an embodiment of the present invention, the flow rate of the circulation pump **130** may be set by controlling the speed SC of the latter, and/or by selecting which spray devices **132**, **134**, **136** to connect (through the flow control device **140**) to the circulation pump **130**.

[0178] Particularly, if the speed SC of the circulation pump **130** is varied while maintaining a same spray condition SPC in which a same set of spray devices **132**, **134**, **136** is connected to the circulation pump **130**, the higher the speed SC of the circulation pump **130**, the higher the flow rate of the circulation pump **130**.

[0179] Moreover, if the speed SC of the circulation pump **130** is maintained to a same value, the flow rate of the circulation pump **130** can be varied by altering the spray condition SPC of the spray devices **132**, **134**, **136**. For example, the flow rate of the circulation pump **130** operating at a certain speed SC while connected to only the two spray devices **134**, **136** is lower than the flow rate of the circulation pump **130** operating at the same speed SC when connected to all the three spray devices **132**, **134**, **136**, since in the former spray condition SPC, only two spray devices **134**, **136** need to be fed by the circulation pump **130**, while in the latter spray condition SPC a higher number (3) of spray devices **132**, **134**, **136** need to be fed by the circulation pump **130**. Similarly, the flow rate of the circulation pump **130** operating at a certain speed SC while connected to only the spray device **136** is lower than the flow rate of the circulation pump **130**

operating at the same speed SC when connected to only the spray device **132**, since in the latter spray condition *SPC* the washing fluid pumped by the circulation pump **130** has to reach an higher altitude (to reach the spray device **132**) compared to the one corresponding to the former spray condition *SPC* (to reach the spray device **136**).

[0180] According to an embodiment of the present invention, the control unit **105** controls the inlet valve **120** to switch to the closed condition (block **1006**) when both the two following conditions are true:

- a saturation state of the circulation pump **130** is determined, and
- the circulation pump **130** is operating at (at least) the first target flow rate *TFR1*

[0181] In this way, the amount of washing fluid that has been loaded into the tub **110** with the operations corresponding to blocks **1002** - **1006** is sufficient to allow the circulation pump **130** to operate at the first target flow rate *TFR1* without causing a starvation state of the circulation pump **130**.

[0182] According to an embodiment of the present invention, the circulation pump **130** is operated by the control unit to reach the first target flow rate *TFR1* by varying the speed SC of the circulation pump **130** to reach a corresponding first target speed *TSC1*. Advantageously, according to an embodiment of the present invention, this is carried out by having the control unit **105** that controls the speed SC of the circulation pump **130** according to the previously described controlled circulation routine **230** based on a target speed equal to the first target speed *TSC1*.

[0183] According to an embodiment of the present invention, the amount of washing fluid fed into the tub **110** sufficient to allow the circulation pump **130** to operate at the first target flow rate *TFR1* without causing a starvation state of the circulation pump **130** corresponding to blocks **1004** and **1006** is set by having the control unit **105** that controls the inlet valve **120** according to the previously described fill to speed routine **240** based on a target speed equal to the first target speed *TSC1*. Therefore, according to an embodiment of the present invention, the control unit **105** is configured to control the inlet valve **120** to switch to the closed condition (block **1006**) when the two following conditions are both true:

- a saturated state of the circulation pump **130** is determined, and
- a current speed SC of the circulation pump **130** is substantially equal to a circulation pump current speed equal to the first target speed *TSC1* (e.g., when the current speed SC is equal to the first target speed *TSC1* $\pm 10\%$).

[0184] Moreover, since the fill to speed routine **240** according to the embodiments of the present invention pro-

vides that the inlet valve **120** is closed also before the speed SC reached the target speed if a starvation state of the circulation pump **130** is determined, intermediate closures and openings of the inlet valve **120** may occur after operations corresponding to block **1002** and before operations corresponding to block **1006**.

[0185] Particularly, according to an embodiment of the present invention, the control unit **105** is configured to:

- cause the inlet valve **120** to switch to the closed condition if a saturation state of the circulation pump **130** is determined while the current speed SC of the circulation pump **130** is lower than the first target speed *TSC1*;
- cause the inlet valve **120** to switch back to the open condition if a starvation state of the circulation pump **130** is determined while the current speed SC of the circulation pump **130** is lower than the first target speed *TSC1*.

[0186] According to an embodiment of the present invention, after that the inlet valve **120** switched to the closed condition when a saturated state of the circulation pump **130** is determined, and a current speed SC of the circulation pump **130** is (at least) equal to a circulation pump current speed equal to the first target speed *TSC1* (block **1006**), the control unit **105** causes the circulation pump **130** to operate at a second target flow rate *TFR2* higher than the first target flow rate *TFR1* (block **1010**). According to an embodiment of the present invention, the circulation pump **130** is controlled to operate at the second target flow rate *TFR2* for a corresponding time period, such as for example for about 45 seconds.

[0187] According to an embodiment of the present invention, the control unit **105** controls the circulation pump **130** to operate at the second target flow rate *TFR2* by causing the circulation pump **130** to increase its speed SC from the first target speed *TSC1* to a second target speed *TSC2* higher than the first target speed *TSC1*, and by keeping at the same time the spray devices **132**, **134**, **136** in a same spray condition *SPC*.

[0188] According to another embodiment of the present invention, the control unit **105** controls the circulation pump **130** to operate at the second target flow rate *TFR2* by maintaining the speed SC of the circulation pump **130** at the first target speed *TSC1* and by controlling at the same time the flow control device **140** to modify the spray condition *SPC* of the spray devices **132**, **134**, **136** with respect to the spray condition *SPC* employed during the execution of the operations corresponding to blocks **1002** - **1006**. For example, according to an embodiment of the present invention, the operations corresponding to blocks **1002** - **1006** may be carried out by having the flow control device **140** that connects the circulation pump **130** to two spray devices (e.g., the spray devices **134** and **136**), and the operations corresponding to block **1010** by having the flow control device **140** that connects the circulation pump **130** to all three spray de-

vices **132**, **134**, **136**.

[0189] The concepts of the present invention can be also applied in case the passage from the first target flow rate *TFR1* to the second target flow rate *TFR2* is accomplished by varying both the speed *SC* of the circulation pump **130** and the spray condition *SPC* of the spray devices **132**, **134**, **136**.

[0190] According to an embodiment of the present invention, if a starvation state of the circulation pump **130** is determined (block **1012**) while the circulation pump **130** is operating at the second target flow rate *TFR2* (for example, when the circulation pump **130** is operating at the second target speed *TSC2*), the control unit **105** is configured to determine that the inlet valve **120** is not affected by leakages when the latter is in the closed condition (block **1014**). Indeed, at the end of block **1006**, the inlet valve **120** has been closed in such a way that the total amount of washing fluid loaded into the tub **110** is just sufficient to allow the circulation pump **130** to operate at the first target flow rate *TFR1* without causing a starvation state of the circulation pump **130**. If no additional washing fluid amount is then fed into the tub **110** after the closure of the inlet valve **120** at block **1006**, when the circulation pump **130** is controlled to increase its flow rate to the second target flow rate *TFR2* (block **1010**), a starvation state determination is expected, since the amount of loaded washing fluid is insufficient for the requested increased second target flow rate *TFR2*.

[0191] According to an embodiment of the present invention, if no starvation state of the circulation pump **130** is determined (block **1016**) while the circulation pump **130** is operating at the second target flow rate *TFR2* (for example, a saturation state of the circulation pump **130** is still maintained after some time the circulation pump **130** is operating at the second target flow rate *TFR2*), the control unit **105** is configured to determine that the inlet valve **120** is affected by leakages when the latter is in the closed condition (block **1018**). Indeed, if the inlet valve **120** did not correctly close itself at block **1006**, and some washing fluid continue to leak into the tub **110** through the inlet valve **120** even after block **1006**, the amount of washing fluid inside the tub **110** increases, allowing thus the circulation pump **130** to operate at the second target flow *TFR2* without causing a starvation condition of the circulation pump **130**.

[0192] In this way, it is possible to efficiently determine possible fault conditions of the inlet valve **120** (causing undesired leakages into the tub **110** when the inlet valve **120** is in the closed condition) even if the dishwasher is lacking of a pressure sensor for the determination of the level of washing fluid inside the tub **110**.

[0193] According to an embodiment of the present invention, if the control unit **105** determined that the inlet valve **120** is affected by leakages when in the closed condition, the control unit is configured to generate a proper warning (block **1020**), for example through an acoustic message, a visual message on a display of the dishwasher, or a warning message sent (e.g., through

the Internet) to a smartphone of an user of the dishwasher **100**.

[0194] According to an embodiment of the present invention, if the inlet valve **120** is determined to be affected by leakages when in the closed condition, the control unit **105** stops the circulation pump **130** (block **1022**) and then drains the washing fluid out from the tub **110** by causing the drain pump **160** to switch to the activated condition for a predetermined time period *ITP* (block **1024**).

[0195] According to an embodiment of the present invention, at least the operations corresponding to blocks **1002** - **1010** can be reiterated at least once after the predetermined time period *ITP* is expired.

[0196] According to an embodiment of the present invention, the control unit **105** is configured to carry out the operations corresponding to block **1022** and **1024** after each reiteration of the operations corresponding to blocks **1002** - **1010**.

[0197] The inlet valve checking routine **285** according to the embodiments of the invention illustrated in **Figure 10A** does not provide for conditions in which the circulation pump **130** and the drain pump **160** are activated concurrently, and therefore it can be implemented both in the case in which the circulation pump **130** and the drain pump **160** are driven by respective different and independent motor systems (*i.e.*, the motor systems **165** and **166**), and in the case in which a single motor system is provided, configured to selectively drive the circulation pump **130** or the drain pump **160**.

[0198] **Figure 10B** illustrates in terms of functional blocks a flow chart depicting the operations carried out by the control unit **105** when the inlet valve checking routine **285** is being carried out according to another embodiment of the present invention, that can be implemented only in case the the circulation pump **130** and the drain pump **160** are driven by respective different and independent motor systems (*i.e.*, the motor systems **165** and **166**), and therefore they can be operated concurrently and independently. The operations of the inlet valve checking routine **285** according to the embodiment of the invention illustrated in **Figure 10B** that are equal to the ones of the inlet valve checking routine **285** according to the embodiment of the invention illustrated in **Figure 10A** will be identified with the same references, and their description will be omitted for the sake of conciseness.

[0199] The inlet valve checking routine **285** according to the embodiment of the invention illustrated in **Figure 10B** differs from the inlet valve checking routine **285** according to the embodiment of the invention illustrated in **Figure 10A** in that, after that no starvation state of the circulation pump **130** is determined while the circulation pump **130** is operating at the second target flow rate *TFR2* (block **1016**), the control unit **105** carries out a drain to speed routine **250** (block **1030**) for carry out a partial drain of washing fluid from the washing tub **110** based on the first target speed *TSC1*. Particularly, according to an embodiment of the present invention, the control unit **105** provides for causing the drain pump **160** to switch

from the deactivated condition to the activated condition and then for causing the drain pump **160** to switch from the activated condition to the deactivated condition when a starvation state of the circulation pump **130** is determined or when the following conditions are both true:

- a saturated state of the circulation pump **130** is determined, and
- the current speed SC of the circulation pump **130** is lower than the the first target speed TSC1.

[0200] According to an embodiment of the present invention, the control unit **105** measures then a time *IVT* spent by the drain to speed routine **250** for draining an amount of washing fluid sufficient to fulfill both the two conditions above (block **1040**).

[0201] Then, according to an embodiment of the present invention, the control unit **105** determines if the inlet valve **120** is affected by leakages when in the closed condition based on the measured time *IVT* (block **1050**). According to an embodiment of the present invention, if the measured time *IVT* is higher than a threshold *IVTH*, it means that an additional amount of washing fluid entered in the tub **110** through the inlet valve **120** even after that the inlet valve **120** switched to the closed condition (the increased amount of washing fluid causing an increased duration of the drain operation), and therefore the control unit **105** determines that the inlet valve **120** is affected by leakages when in the closed condition. In this case, according to an embodiment of the present invention, the control unit is configured to generate a proper warning (block **1060**), for example through an acoustic message, a visual message on a display of the dishwasher, or a warning message sent to a smartphone of an user of the dishwasher **100**.

[0202] According to an embodiment of the present invention, at least the operations corresponding to blocks **1002** - **1010** can be reiterated at least once before carrying out the drain to speed routine **250** at block **1030**.

[0203] According to an embodiment of the present invention, the control unit **105** is configured to carry out the operations corresponding to blocks **1030** and **1040** after each reiteration of the operations corresponding to blocks **1002** - **1010**.

Claims

1. Washing appliance (**100**) comprising:

- a tub (**110**) configured to house items to be washed;
- an inlet valve (**120**) operable to be selectively switched between an open condition for causing washing fluid to be loaded into the tub (**110**) and a closed condition for preventing washing fluid be fed to the appliance (**100**);
- a sump (**124**) in fluid communication with the

tub (**110**) for collecting washing fluid from the tub (**110**);

- a circulation pump (**130**) in fluid communication with the sump (**124**) and configured to circulate the washing fluid in the tub (**110**) during a washing cycle when the circulation pump (**130**) is controlled to rotate in a first direction;
- a control unit (**105**);

characterised in that

the control unit (**105**) is configured to control the load of washing fluid into the tub (**110**) by carrying out the following sequence of operations:

- control the circulation pump (**130**) to rotate in a second direction opposite to the first direction at a first speed;
- cause the inlet valve (**120**) to switch to the open condition;
- determine the presence of washing fluid inside the sump (**124**) based on a comparison between an electric parameter of the circulation pump (**130**) during a first time period before the inlet valve (**124**) switched to the open condition and said electric parameter of the circulation pump (**130**) during a second time period after the inlet valve switched to the open condition.

2. The washing appliance (**100**) of claim 1, wherein the control unit (**105**) is configured to:

- calculate an average of said electric parameter of the circulation pump (**130**) during the first time period, and
- determine the presence of washing fluid inside the sump (**124**) based on a comparison between said average and said electric parameter of the circulation pump (**130**) during the second time period.

3. The washing appliance (**100**) of claim 2, wherein the control unit (**105**) is configured to determine the presence of washing fluid inside the sump (**124**) if the electric parameter of the circulation pump (**130**) during the second time period is higher than said average by a first threshold.

4. The washing appliance (**100**) of claim 3, wherein the control unit (**105**) is configured so that, if the condition j) is true: j) the electric parameter of the circulation pump (**130**) during the second time period is not higher than said average by said first threshold, the control unit (**105**):

- controls the circulation pump (**130**) to rotate in said second direction at a second speed having an absolute value higher than an absolute value

- of said first speed;
 - determines that washing fluid was already present inside the sump (124) before the inlet valve (120) switched to the open condition based on a comparison between said average and the electric parameter of the circulation pump (130) during a third time period after the second time period.
5. The washing appliance (100) of claim 4, wherein the control unit (130) is configured to determine that washing fluid was already present inside the sump (124) before the inlet valve (120) switched to the open condition if, in addition to have the condition a) that is true, the electric parameter of the circulation pump (130) during the third time period is higher than said average by a second threshold higher than said first threshold.
6. The washing appliance (100) of claim 4 or 5, further comprising:
- a water softening system (195) configured to reduce hardness of water used for generating said washing fluid;
 - a drain pump (160) configured to be activated for causing washing fluid in the sump (124) to be drained from the washing appliance (100), wherein the control unit (105) is configured to carry out the following operations:
 - control the circulation pump (130) to rotate in said second direction at said second speed, and
 - determine that washing fluid was already present inside the sump (124) before the inlet valve (120) switched to the open condition based on a comparison between said average and the electric parameter of the circulation pump (130) during said third time period,
- if, in addition to have the condition j) that is true, at least one of the following two conditions k) and l) is true:
- k) said water softening system (195) has not been subjected to a regeneration procedure;
 - l) said drain pump (160) has been activated after that said water softening system has been subjected to a regeneration procedure.
7. The washing appliance (100) of any of claims 1 to 6, wherein the control unit (105) is further configured to cause the inlet valve (120) to switch to the closed condition if the control unit (105) has determined the presence of washing fluid inside the sump (124).
8. The washing appliance (100) of any of claims 1 to 7, wherein the control unit (105) is further configured to stop the circulation pump (130) if the control unit (105) has determined the presence of washing fluid inside the sump (124).
9. The washing appliance (100) of any of claims 1 to 8, wherein said electric parameter of the circulation pump (130) comprises:
- an electric current drawn by the circulation pump (130);
 - a voltage developed across the circulation pump (130);
 - an electric power consumed by the circulation pump (130).
10. The washing appliance (110) of any of claims 1 to 9, wherein the washing appliance (110) is a dishwasher comprising:
- at least one basket (112-116) provided in the tub (110) for accommodating the items to be washed;
 - a set of spray devices (132-136) for receiving washing fluid from the circulation pump (130) and for accordingly spray received washing fluid into the tub (110).
- ### Patentansprüche
1. Waschvorrichtung (100), umfassend:
- eine Wanne (110), die zur Aufnahme von zu waschenden Gegenständen ausgelegt ist;
 - ein Einlassventil (120), das dazu betreibbar ist, selektiv zwischen einem geöffneten Zustand zum Bewirken eines Ladens von Waschfluid in die Wanne (110) und einem geschlossenen Zustand zum Verhindern des Zuführens von Waschfluid zu der Vorrichtung (100) umgeschaltet zu werden;
 - einen Sumpf (124) in Fluidverbindung mit der Wanne (110) zum Auffangen von Waschfluid von der Wanne (110);
 - eine Umwälzpumpe (130), die in Fluidverbindung mit dem Sumpf (124) steht und dazu ausgelegt ist, das Waschfluid in der Wanne (110) während eines Waschzyklus umzuwälzen, wenn die Umwälzpumpe (130) derart gesteuert wird, dass sie sich in einer ersten Richtung dreht;
 - eine Steuereinheit (105); **dadurch gekennzeichnet, dass** die Steuereinheit (105) dazu ausgelegt ist, das Laden von Waschfluid in die Wanne (110) durch Ausführen der folgenden Abfolge von Operationen zu steuern:

- Steuern der Umwälzpumpe (130) derart, dass sie sich in einer zweiten Richtung entgegengesetzt zu der ersten Richtung mit einer ersten Geschwindigkeit dreht;
 - Bewirken, dass das Einlassventil (120) in den geöffneten Zustand umschaltet;
 - Bestimmen des Vorhandenseins von Waschfluid innerhalb des Sumpfes (124) basierend auf einem Vergleich zwischen einem elektrischen Parameter der Umwälzpumpe (130) während einer ersten Zeitspanne, bevor das Einlassventil (124) in den geöffneten Zustand umgeschaltet wurde, und dem elektrischen Parameter der Umwälzpumpe (130) während einer zweiten Zeitspanne, nachdem das Einlassventil in den geöffneten Zustand umgeschaltet wurde.
2. Waschvorrichtung (100) nach Anspruch 1, wobei die Steuereinheit (105) zu Folgendem ausgelegt ist:
- Berechnen eines Mittelwerts des elektrischen Parameters der Umwälzpumpe (130) während der ersten Zeitspanne, und
 - Bestimmen des Vorhandenseins von Waschfluid innerhalb des Sumpfes (124) basierend auf einem Vergleich zwischen dem Mittelwert und dem elektrischen Parameter der Umwälzpumpe (130) während der zweiten Zeitspanne.
3. Waschvorrichtung (100) nach Anspruch 2, wobei die Steuereinheit (105) dazu ausgelegt ist, das Vorhandensein von Waschfluid innerhalb des Sumpfes (124) zu bestimmen, wenn der elektrische Parameter der Umwälzpumpe (130) während der zweiten Zeitspanne um einen ersten Schwellenwert höher als der Mittelwert ist.
4. Waschvorrichtung (100) nach Anspruch 3, wobei die Steuereinheit (105) derart ausgelegt ist, dass, wenn die Bedingung j) wahr ist:
- j) der elektrische Parameter der Umwälzpumpe (130) ist während der zweiten Zeitspanne nicht um den ersten Schwellenwert höher als der Mittelwert, die Steuereinheit (105):
 - die Umwälzpumpe (130) derart steuert, dass sie sich in der zweiten Richtung mit einer zweiten Geschwindigkeit dreht, die einen Absolutwert aufweist, der höher als ein Absolutwert der ersten Geschwindigkeit ist;
 - basierend auf einem Vergleich zwischen dem Mittelwert und dem elektrischen Parameter der Umwälzpumpe (130) während einer dritten Zeitspanne nach der zweiten
- Zeitspanne bestimmt, dass sich bereits Waschfluid innerhalb des Sumpfes (124) befand, bevor das Einlassventil (120) in den geöffneten Zustand umschaltete.
5. Waschvorrichtung (100) nach Anspruch 4, wobei die Steuereinheit (130) dazu ausgelegt ist, zu bestimmen, dass Waschfluid bereits innerhalb des Sumpfes (124) vorhanden war, bevor das Einlassventil (120) in den offenen Zustand umschaltete, wenn zusätzlich zu der Bedingung a), die wahr ist, der elektrische Parameter der Umwälzpumpe (130) während der dritten Zeitspanne um einen zweiten Schwellenwert höher als der erste Mittelwert ist, der höher als der erste Schwellenwert ist.
6. Waschvorrichtung (100) nach Anspruch 4 oder 5, die ferner Folgendes umfasst:
- ein Wasserenthärtungssystem (195), das dazu ausgelegt ist, die Härte von Wasser, das zum Erzeugen des Waschfluids verwendet wird, zu reduzieren;
 - eine Ablasspumpe (160), die dazu ausgelegt ist, aktiviert zu werden, um zu bewirken, dass Waschfluid in dem Sumpf (124) aus der Waschvorrichtung (100) abgelassen wird, wobei die Steuereinheit (105) dazu ausgelegt ist, die folgenden Operationen auszuführen:
 - Steuern der Umwälzpumpe (130) derart, dass sie sich in der zweiten Richtung mit der zweiten Geschwindigkeit dreht, und
 - Bestimmen, dass sich bereits Waschfluid innerhalb des Sumpfes (124) befand, bevor das Einlassventil (120) in den geöffneten Zustand umschaltete, basierend auf einem Vergleich zwischen dem Mittelwert und dem elektrischen Parameter der Umwälzpumpe (130) während der dritten Zeitspanne,
- falls zusätzlich zu der Bedingung j), die wahr ist, mindestens eine der folgenden zwei Bedingungen k) und 1) wahr ist:
- k) das Wasserenthärtungssystem (195) wurde keinem Regenerationsvorgang unterzogen;
 - 1) die Ablasspumpe (160) wurde aktiviert, nachdem das Wasserenthärtungssystem einem Regenerationsvorgang unterzogen wurde.
7. Waschvorrichtung (100) nach einem der Ansprüche 1 bis 6, wobei die Steuereinheit (105) ferner dazu ausgelegt ist, zu bewirken, dass das Einlassventil (120) in den geschlossenen Zustand umschaltet, wenn die Steuereinheit (105) das Vorhandensein von Waschfluid innerhalb des Sumpfes (124) be-

stimmt hat.

8. Waschvorrichtung (100) nach einem der Ansprüche 1 bis 7, wobei die Steuereinheit (105) ferner dazu ausgelegt ist, die Umwälzpumpe (130) anzuhalten, wenn die Steuereinheit (105) das Vorhandensein von Waschfluid innerhalb des Sumpfes (124) bestimmt hat. 5
9. Waschvorrichtung (100) nach einem der Ansprüche 1 bis 8, wobei der elektrische Parameter der Umwälzpumpe (130) Folgendes umfasst: 10
 - einen elektrischen Strom, der von der Umwälzpumpe (130) gezogen wird; 15
 - eine Spannung, die über die Umwälzpumpe (130) entsteht;
 - eine elektrische Leistung, die von der Umwälzpumpe (130) verbraucht wird. 20
10. Waschvorrichtung (110) nach einem der Ansprüche 1 bis 9, wobei die Waschvorrichtung (110) eine Geschirrspülvorrichtung ist, die Folgendes umfasst: 25
 - mindestens einen Korb (112-116), der in der Wanne (110) zur Aufnahme der zu waschenden Gegenstände vorgesehen ist; 30
 - einen Satz von Sprühhvorrichtungen (132-136) zur Aufnahme von Waschfluid von der Umwälzpumpe (130) und zum entsprechenden Sprühen von aufgenommenem Waschfluid in die Wanne (110). 35

Revendications

1. Machine à laver (100), comprenant :

- une cuve (110) configurée pour recevoir des articles à laver ; 40
- une vanne d'admission (120) apte à être commutée sélectivement entre un état ouvert pour permettre le chargement de fluide de lavage dans la cuve (110) et un état fermé pour empêcher l'alimentation de la machine (100) en fluide de lavage ; 45
- un puisard (124) en communication fluïdique avec la cuve (110) pour récupérer le fluide de lavage provenant de la cuve (110) ;
- une pompe de circulation (130) en communication fluïdique avec le puisard (124) et configurée pour faire circuler le fluide de lavage dans la cuve (110) au cours d'un cycle de lavage lorsque la pompe de circulation (130) est commandée pour tourner dans un premier sens ; 50
- une unité de commande (105) ; **caractérisée en ce que** l'unité de commande (105) est configurée pour commander la charge de fluide de 55

lavage dans la cuve (110) en exécutant la séquence d'opérations suivantes :

- commander la pompe de circulation (130) pour la faire tourner dans un deuxième sens opposé au premier sens à une première vitesse ;
 - faire commuter la vanne d'admission (120) sur l'état ouvert ;
 - déterminer la présence de fluide de lavage à l'intérieur du puisard (124) sur la base d'une comparaison entre un paramètre électrique de la pompe de circulation (130) au cours d'un premier intervalle de temps avant que la vanne d'admission (124) commute sur l'état ouvert et ledit paramètre électrique de la pompe de circulation (130) au cours d'un deuxième intervalle de temps après que la vanne d'admission a commuté sur l'état ouvert.
2. Machine à laver (100) selon la revendication 1, l'unité de commande (105) étant configurée pour :
 - calculer une moyenne dudit paramètre électrique de la pompe de circulation (130) au cours du premier intervalle de temps, et
 - déterminer la présence de fluide de lavage à l'intérieur du puisard (124) sur la base d'une comparaison entre ladite moyenne et ledit paramètre électrique de la pompe de circulation (130) au cours du deuxième intervalle de temps.
 3. Machine à laver (100) selon la revendication 2, l'unité de commande (105) étant configurée pour déterminer la présence de fluide de lavage à l'intérieur du puisard (124) si le paramètre électrique de la pompe de circulation (130) au cours du deuxième intervalle de temps est supérieur d'un premier seuil à ladite moyenne. 35
 4. Machine à laver (100) selon la revendication 3, l'unité de commande (105) étant configurée de telle sorte que, si la condition j) est vérifiée :
 - j) le paramètre électrique de la pompe de circulation (130) au cours du deuxième intervalle de temps n'est pas supérieur dudit premier seuil à ladite moyenne, 40
 - l'unité de commande (105) :
 - commande la pompe de circulation (130) pour la faire tourner dans ledit deuxième sens à une deuxième vitesse dont la valeur absolue est supérieure à la valeur absolue de ladite première vitesse ;
 - détermine que du fluide de lavage était déjà présent à l'intérieur du puisard (124) 45

- avant que la vanne d'admission (120) commute sur l'état ouvert sur la base d'une comparaison entre ladite moyenne et le paramètre électrique de la pompe de circulation (130) au cours d'un troisième intervalle de temps qui suit le deuxième intervalle de temps.
5. Machine à laver (100) selon la revendication 4, l'unité de commande (130) étant configurée pour déterminer que du fluide de lavage était déjà présent à l'intérieur du puisard (124) avant que la vanne d'admission (120) commute sur l'état ouvert si, outre le fait que la condition a) est vérifiée, le paramètre électrique de la pompe de circulation (130) au cours du troisième intervalle de temps est supérieur d'un deuxième seuil supérieur audit premier seuil à ladite moyenne.
6. Machine à laver (100) selon la revendication 4 ou 5, comprenant en outre :
- un système adoucisseur d'eau (195) configuré pour réduire la dureté de l'eau utilisée pour générer ledit fluide de lavage ;
 - une pompe de vidange (160) configurée pour être activée pour provoquer la vidange du fluide de lavage dans le puisard (124) depuis la machine à laver (100), l'unité de commande (105) étant configurée pour exécuter les opérations suivantes :
 - commander la pompe de circulation (130) pour la faire tourner dans ledit deuxième sens à ladite deuxième vitesse, et
 - déterminer que du fluide de lavage était déjà présent à l'intérieur du puisard (124) avant que la vanne d'admission (120) commute sur l'état ouvert sur la base d'une comparaison entre ladite moyenne et le paramètre électrique de la pompe de circulation (130) au cours dudit troisième intervalle de temps,
- si, outre le fait que la condition j) est vérifiée, au moins une des deux conditions k) et l) suivantes est vérifiée :
- k) ledit système adoucisseur d'eau (195) n'a pas été soumis à une procédure de régénération ;
 - l) ladite pompe de vidange (160) a été activée après que ledit système adoucisseur d'eau a été soumis à une procédure de régénération.
7. Machine à laver (100) selon l'une quelconque des revendications 1 à 6, l'unité de commande (105) étant configurée en outre pour faire commuter la vanne d'admission (120) sur l'état fermé si l'unité de commande (105) a déterminé la présence de fluide de lavage à l'intérieur du puisard (124).
8. Machine à laver (100) selon l'une quelconque des revendications 1 à 7, l'unité de commande (105) étant configurée en outre pour arrêter la pompe de circulation (130) si l'unité de commande (105) a déterminé la présence de fluide de lavage à l'intérieur du puisard (124) .
9. Machine à laver (100) selon l'une quelconque des revendications 1 à 8, ledit paramètre électrique de la pompe de circulation (130) comprenant :
- un courant électrique appelé par la pompe de circulation (130) ;
 - une tension développée aux bornes de la pompe de circulation (130) ;
 - une puissance électrique consommée par la pompe de circulation (130).
10. Machine à laver (110) selon l'une quelconque des revendications 1 à 9, la machine à laver (110) étant un lave-vaisselle comprenant :
- au moins un panier (112-116) placé dans la cuve (110) pour accueillir les articles à laver ;
 - un ensemble de dispositifs de pulvérisation (132-136) destinés à recevoir du fluide de lavage en provenance de la pompe de circulation (130) et destinés à pulvériser en conséquence du fluide de lavage dans la cuve (110).

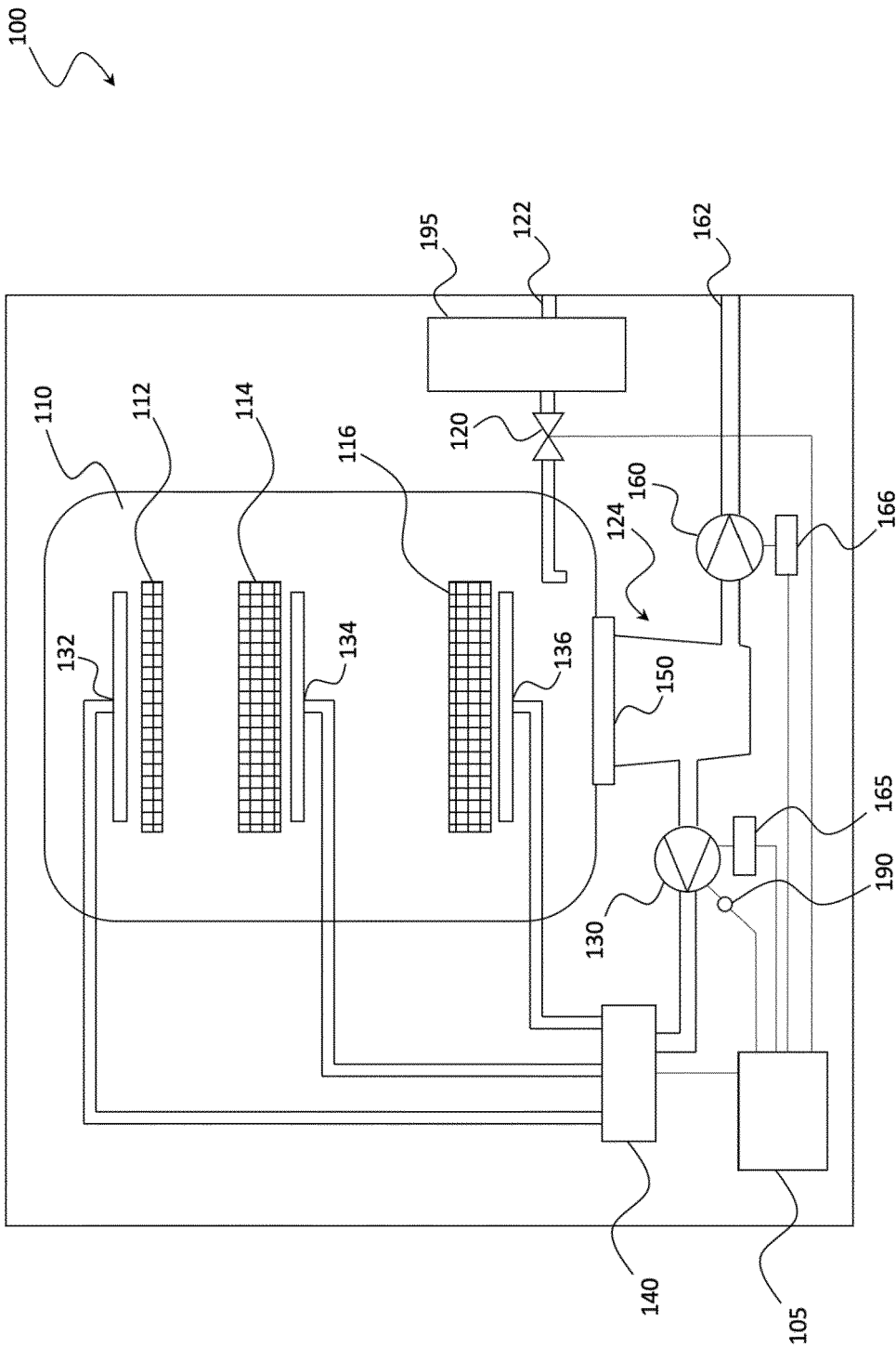


FIG.1

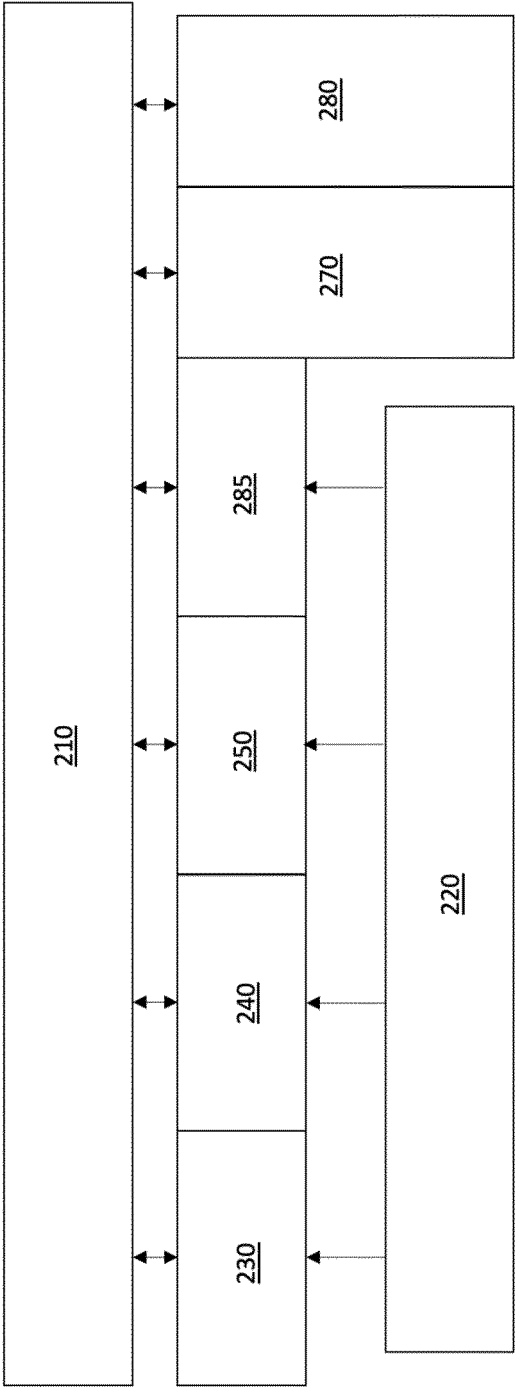


FIG.2

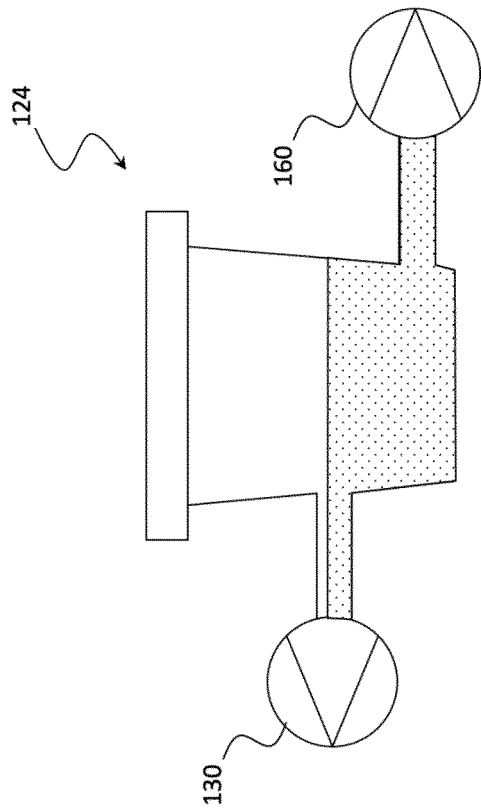


FIG. 3A

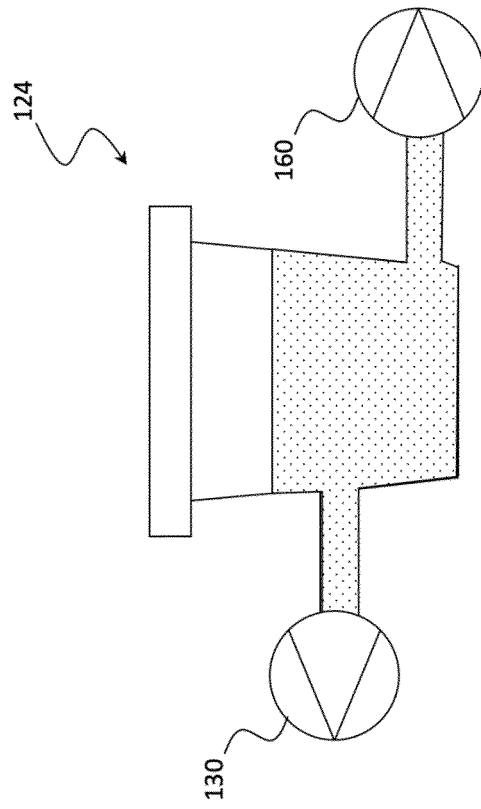


FIG. 3B

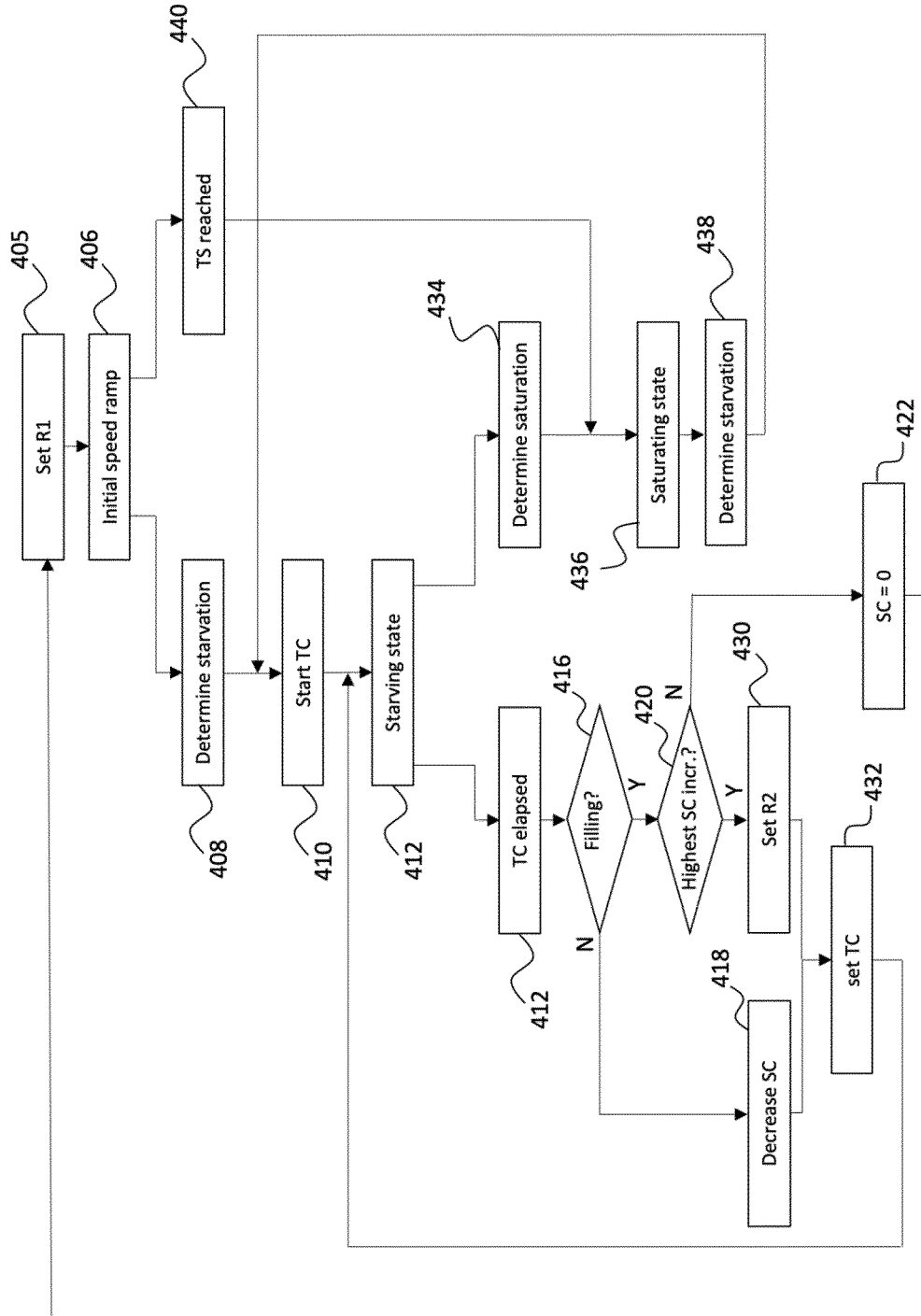


FIG. 4A

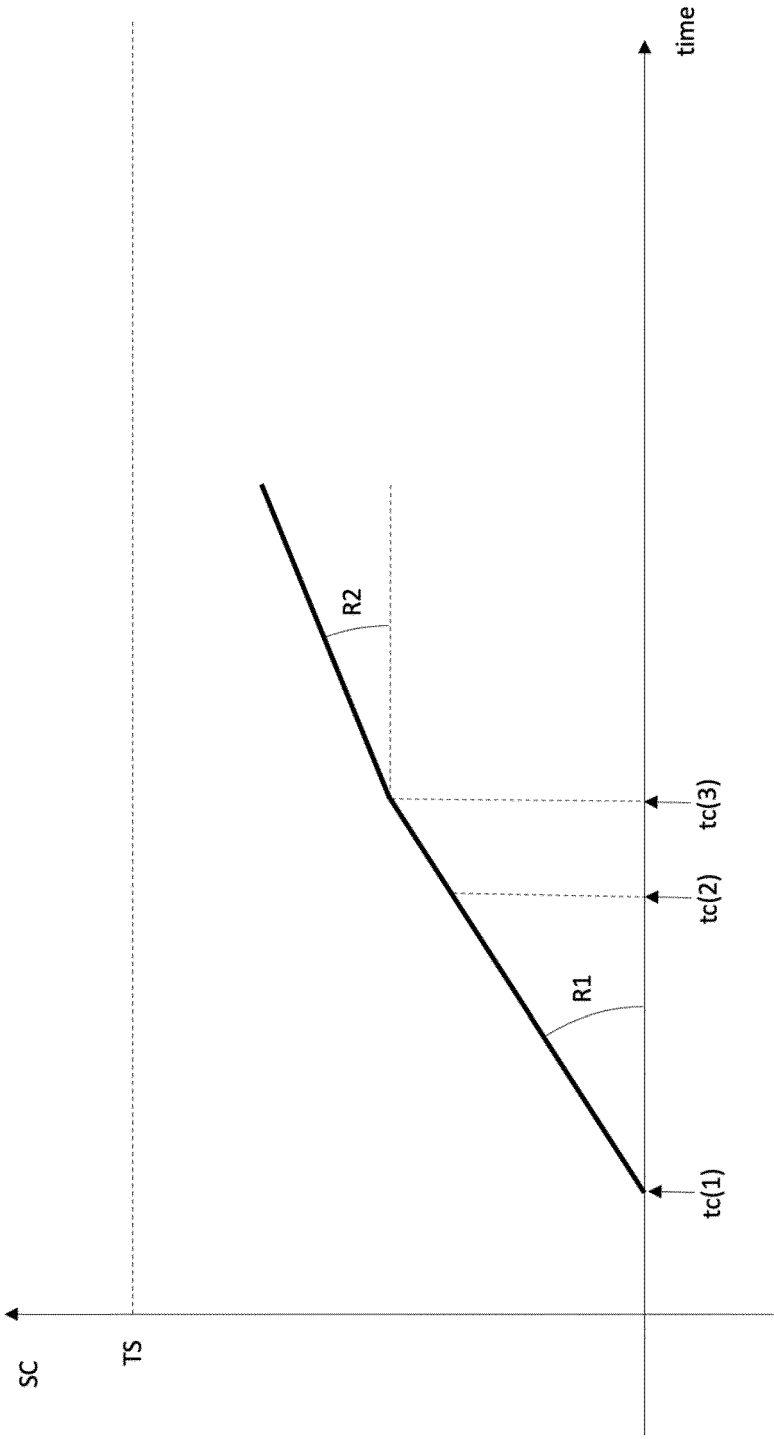


FIG.4B

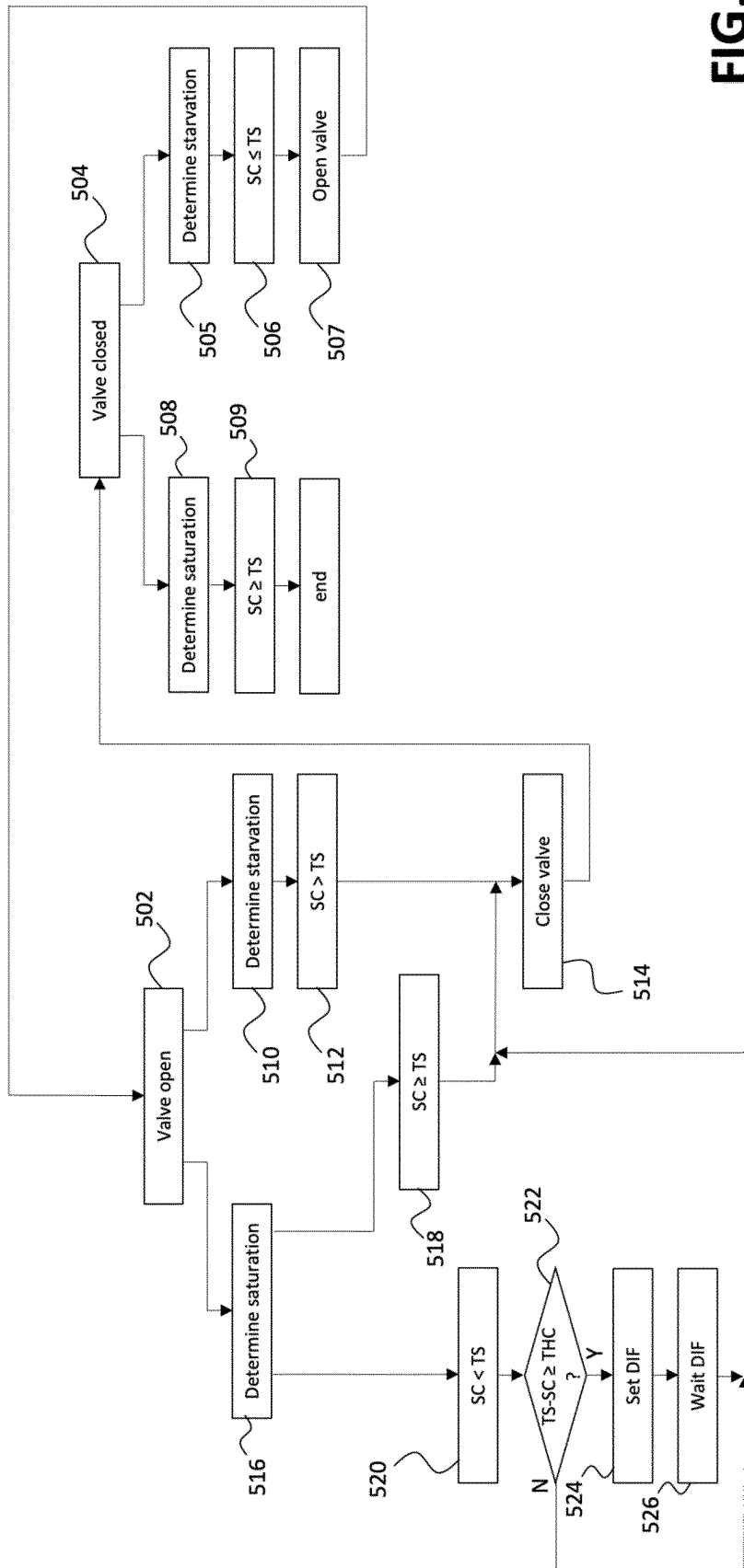


FIG. 5

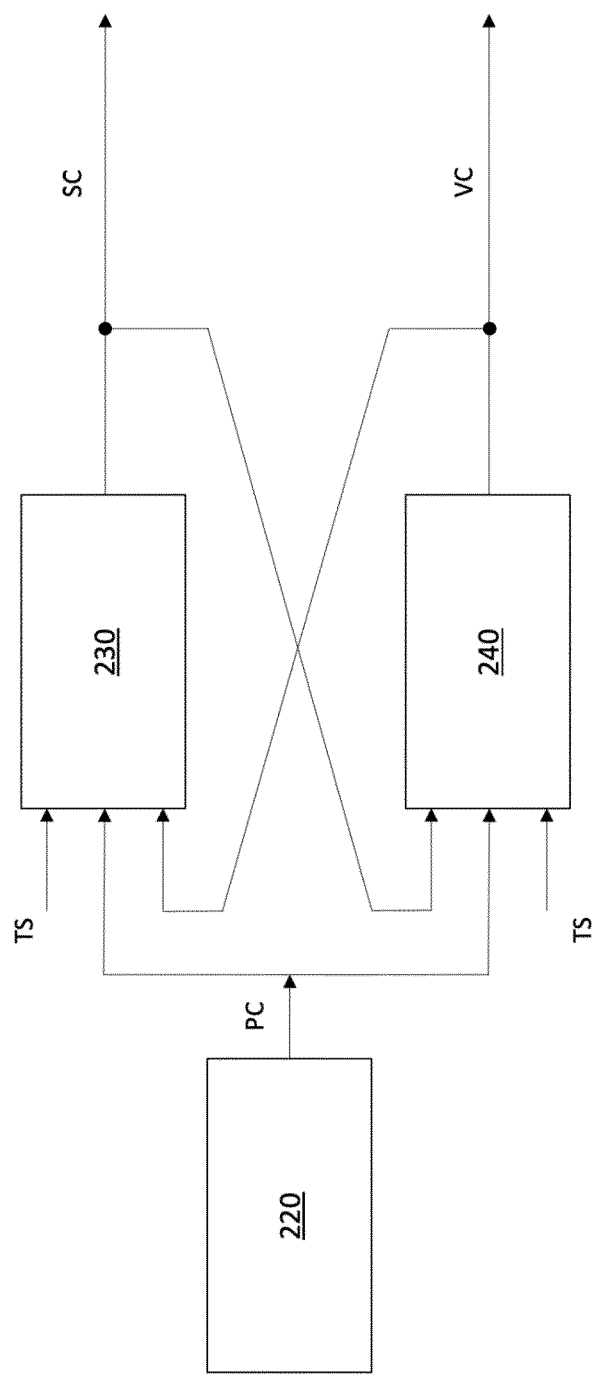
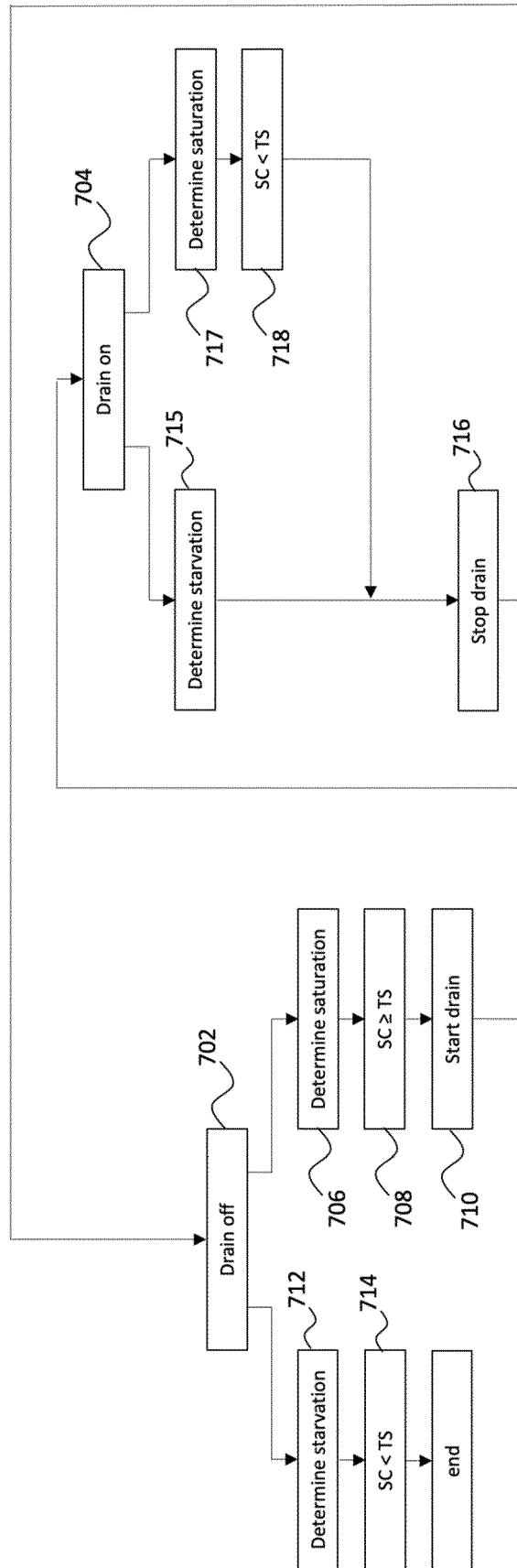


FIG.6

**FIG. 7**

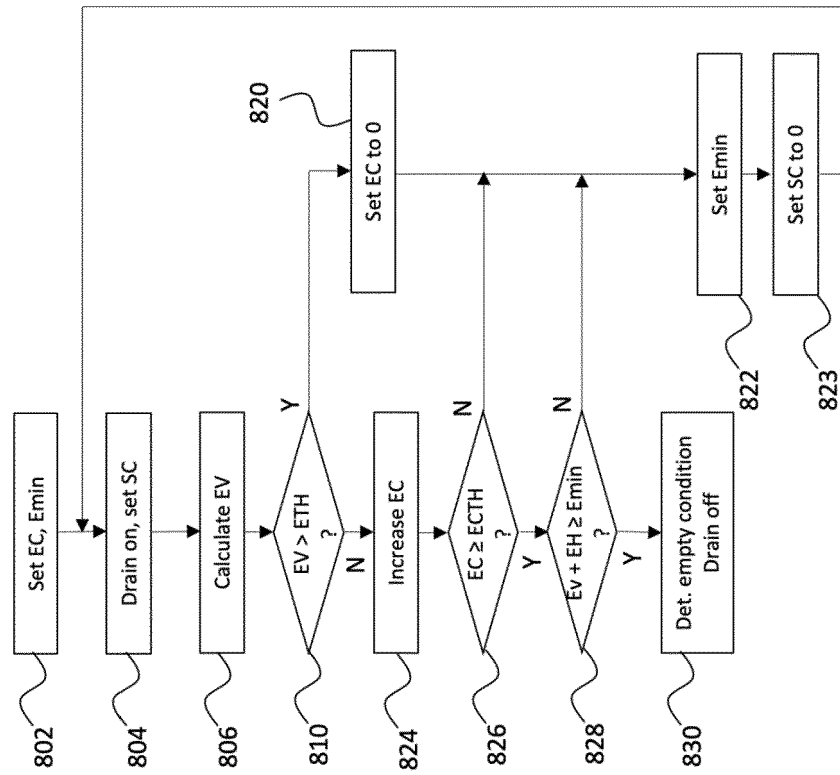
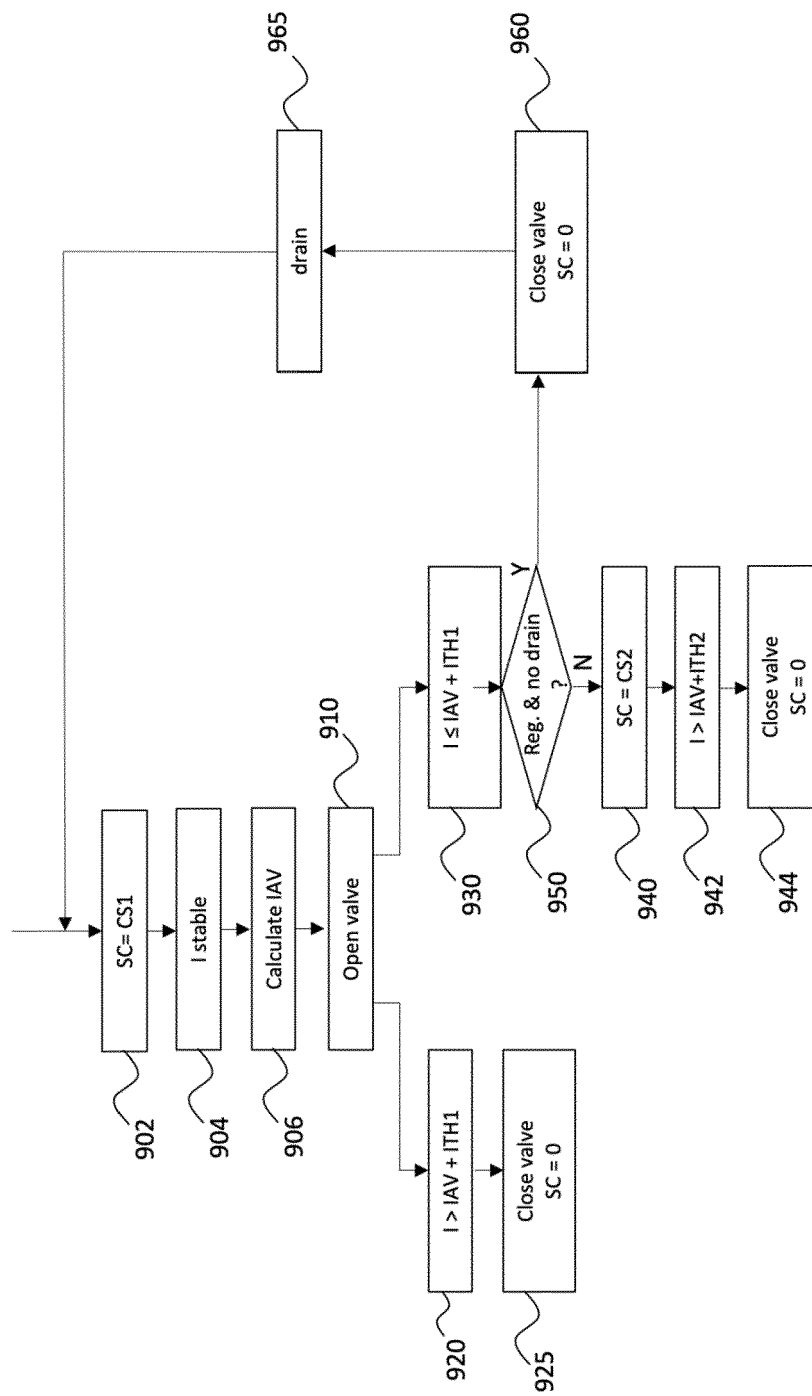


FIG. 8

**FIG.9**

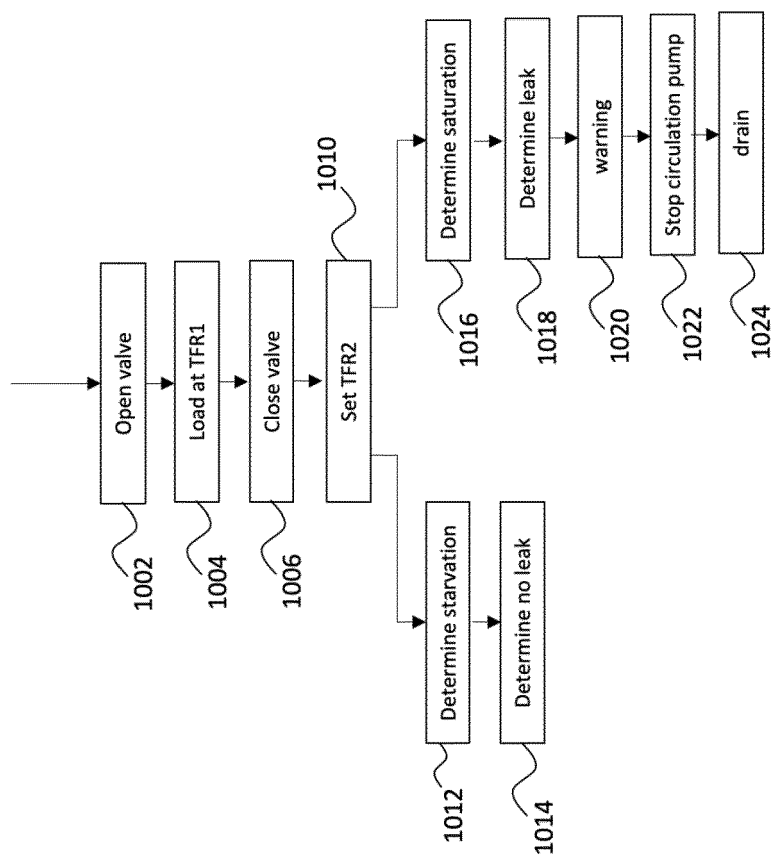


FIG.10A

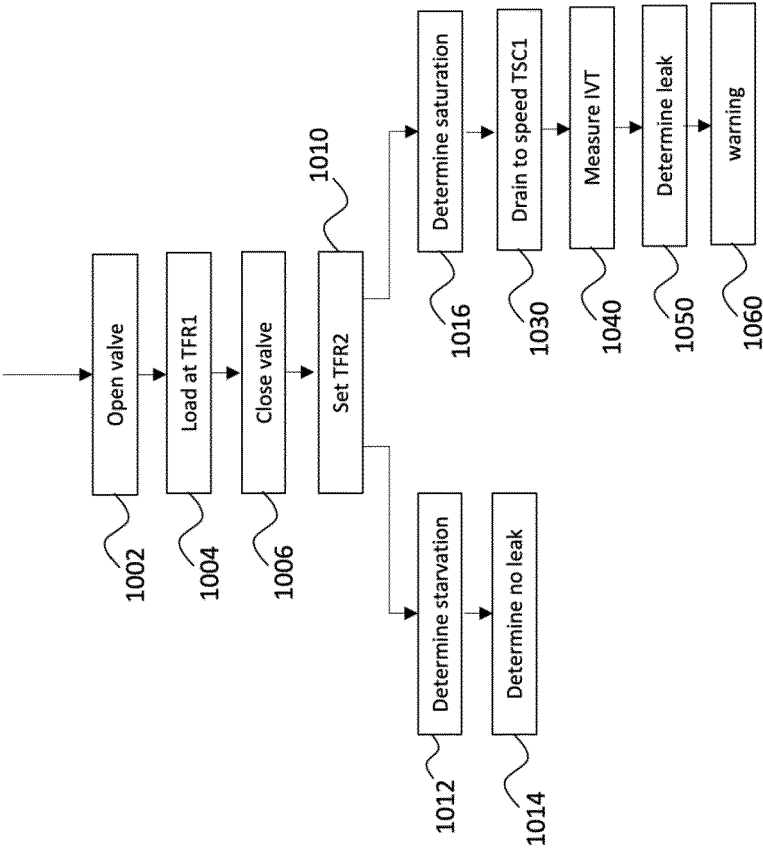


FIG.10B

REFERENCES CITED IN THE DESCRIPTION

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