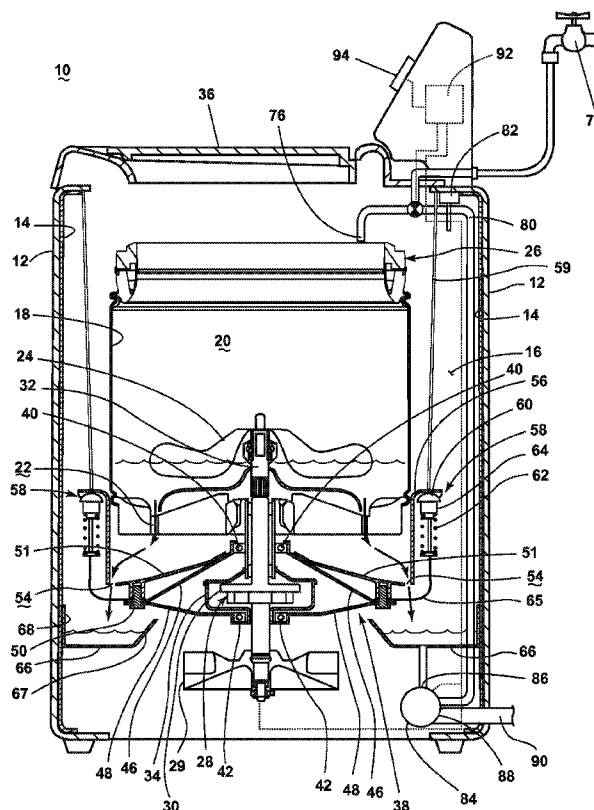




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ALEXANDER et al.(10) **Pub. No.: US 2015/0176166 A1**(43) **Pub. Date: Jun. 25, 2015**(54) **LAUNDRY TREATING APPLIANCE WITH A
STATIC TUB**(21) Appl. No.: **14/641,492**(71) Applicant: **WHIRLPOOL CORPORATION,**
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CPC **D06F 17/06** (2013.01); **D06F 39/08**
(2013.01); **D06F 39/085** (2013.01)(57) **ABSTRACT**

A method of controlling a laundry treating appliance having a rotatable wash basket defining a treating chamber for receiving laundry items for treatment according to an automatic cycle of operation, the method comprising supplying liquid to the wash basket, draining liquid from the wash basket by gravity, and filling the wash basket to a predetermined fill level based on an amount of laundry, a type of laundry, a selected cycle of operation, or combinations thereof.

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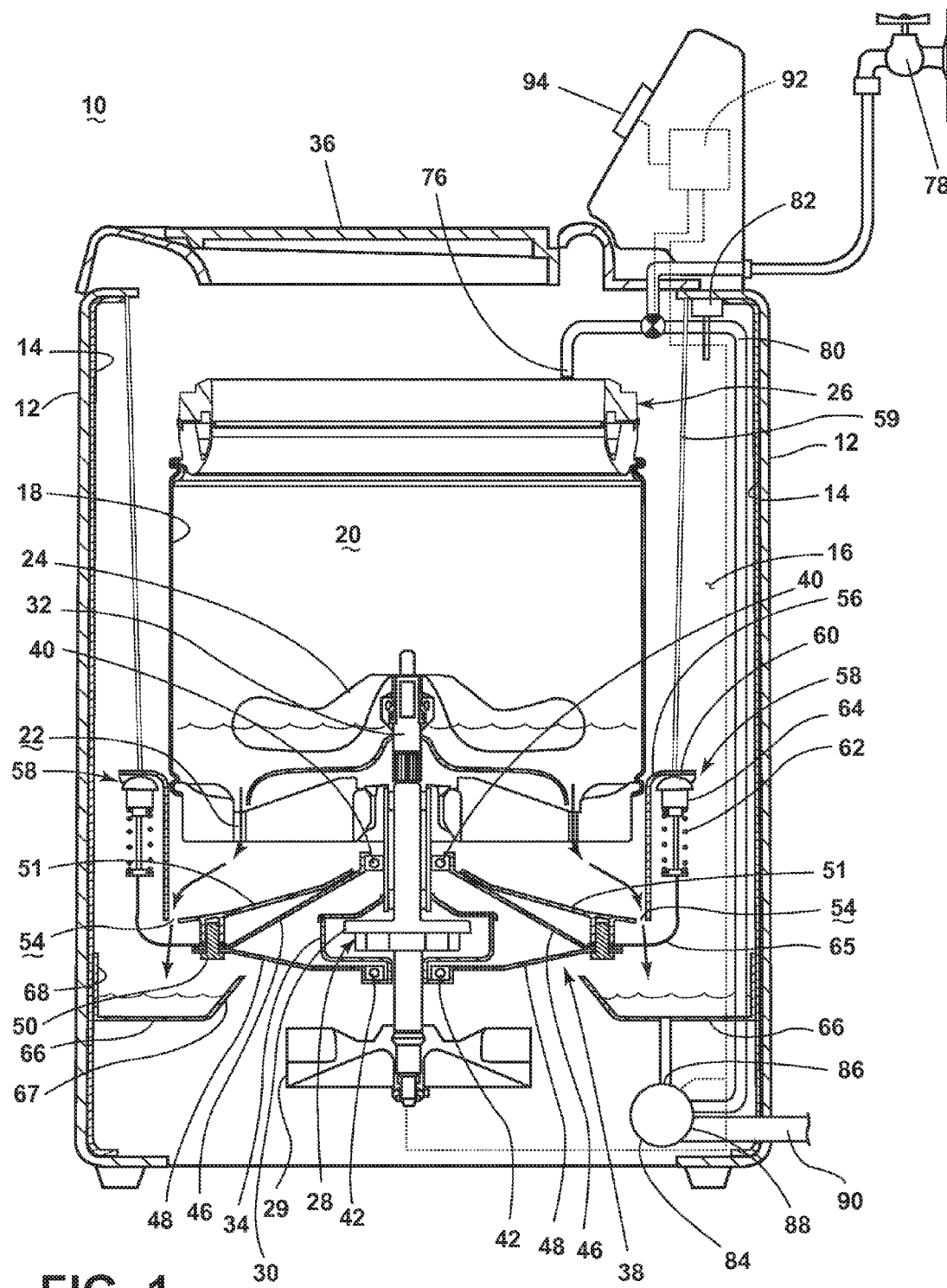


FIG. 1

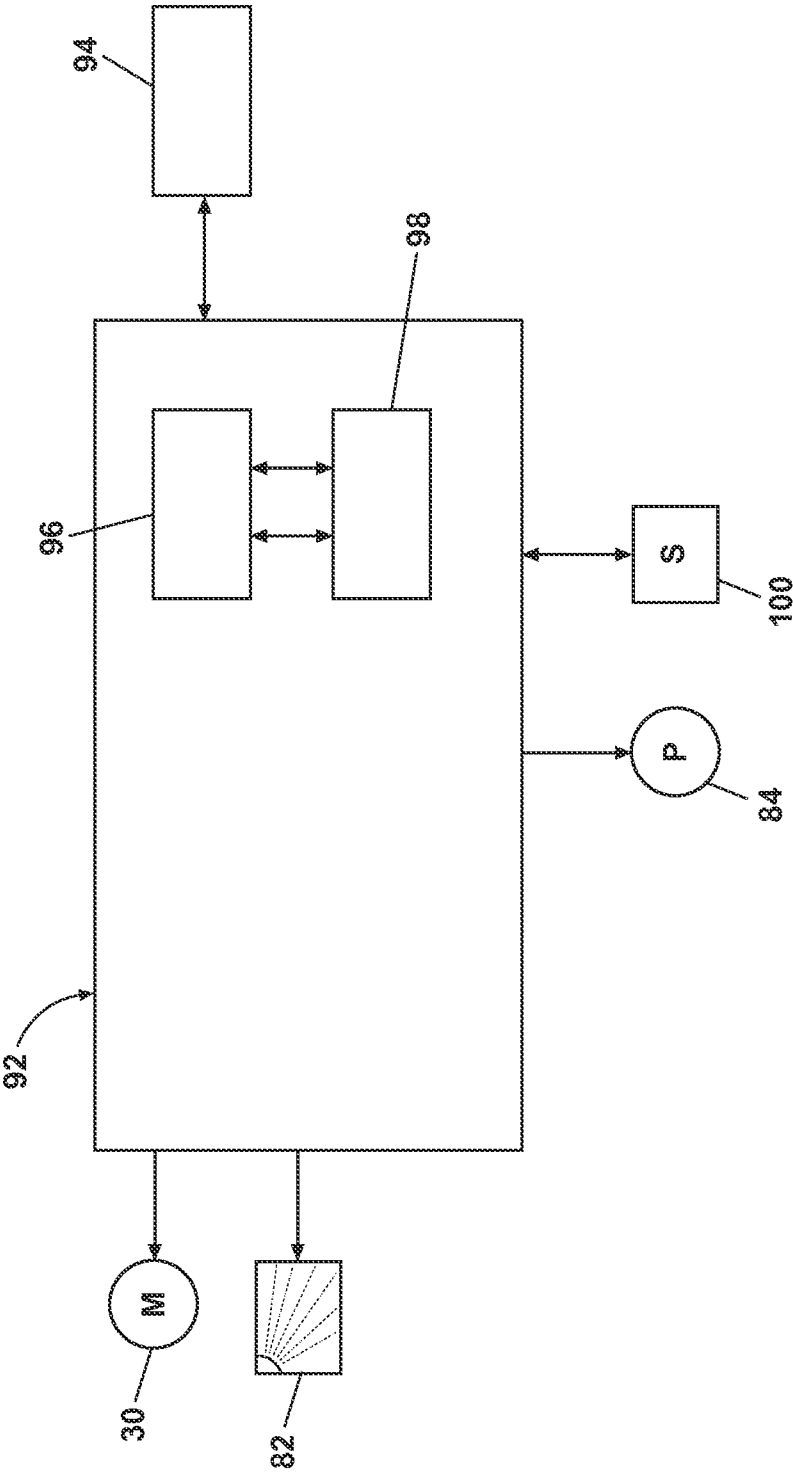
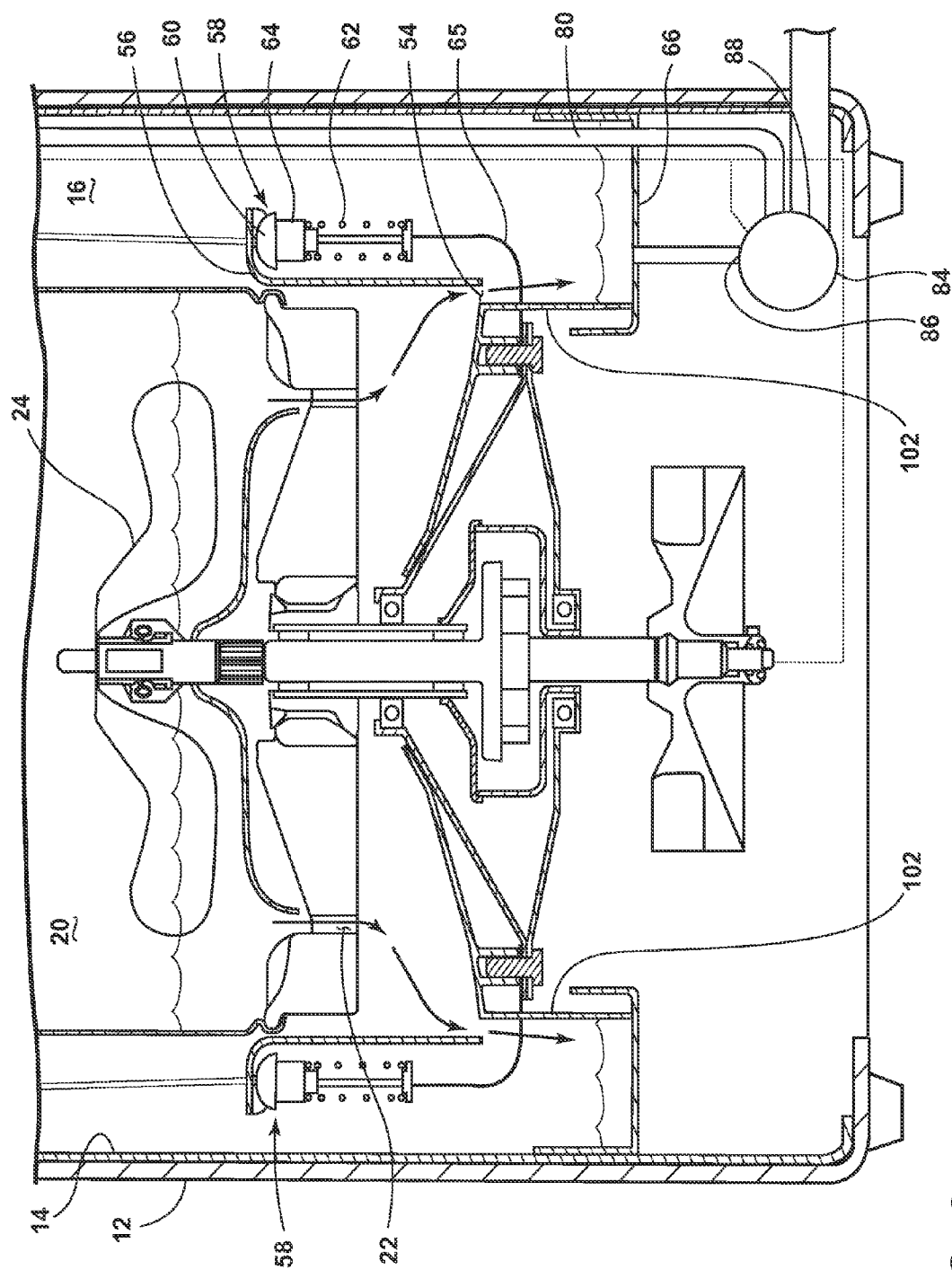
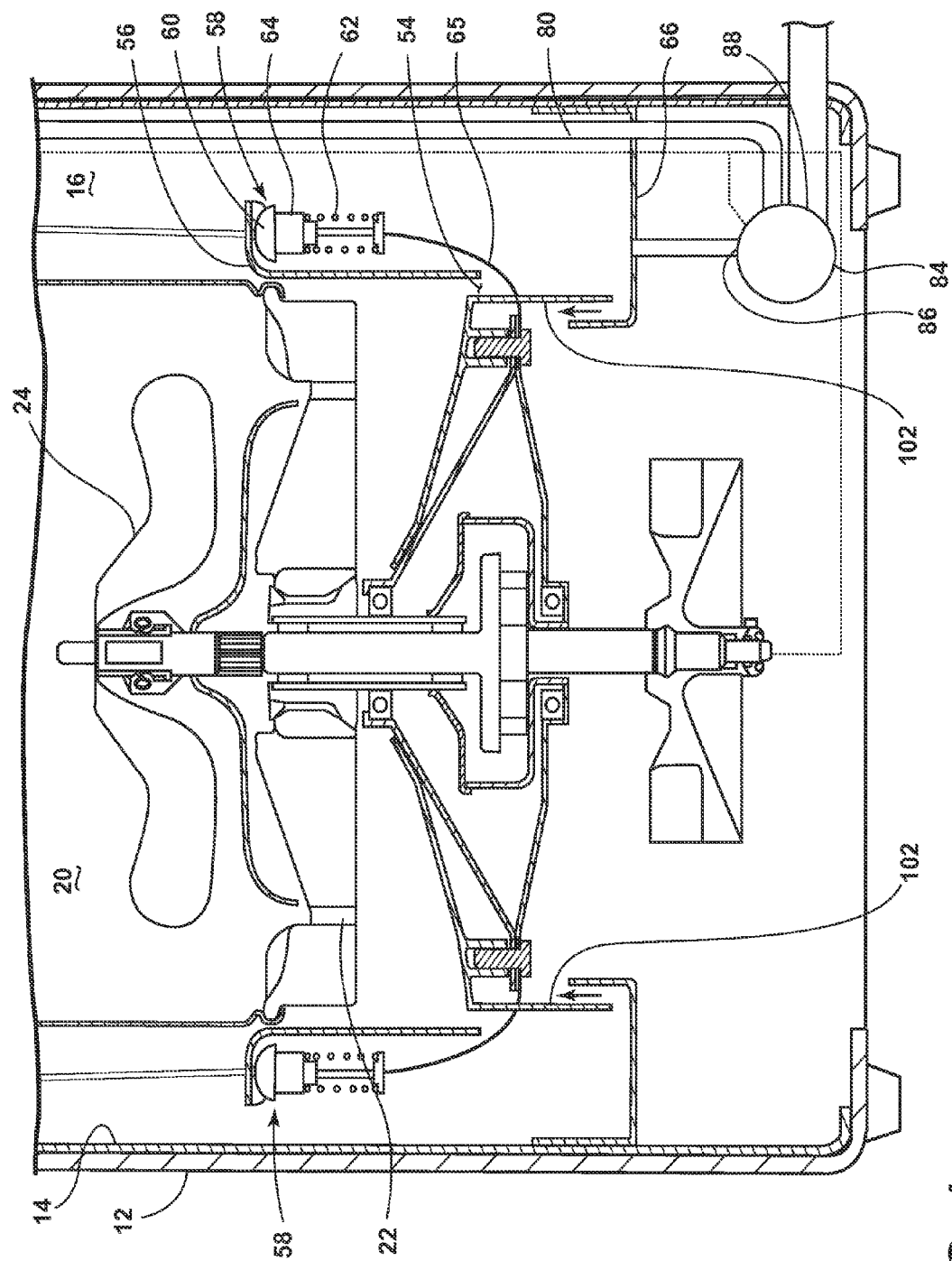


FIG. 2





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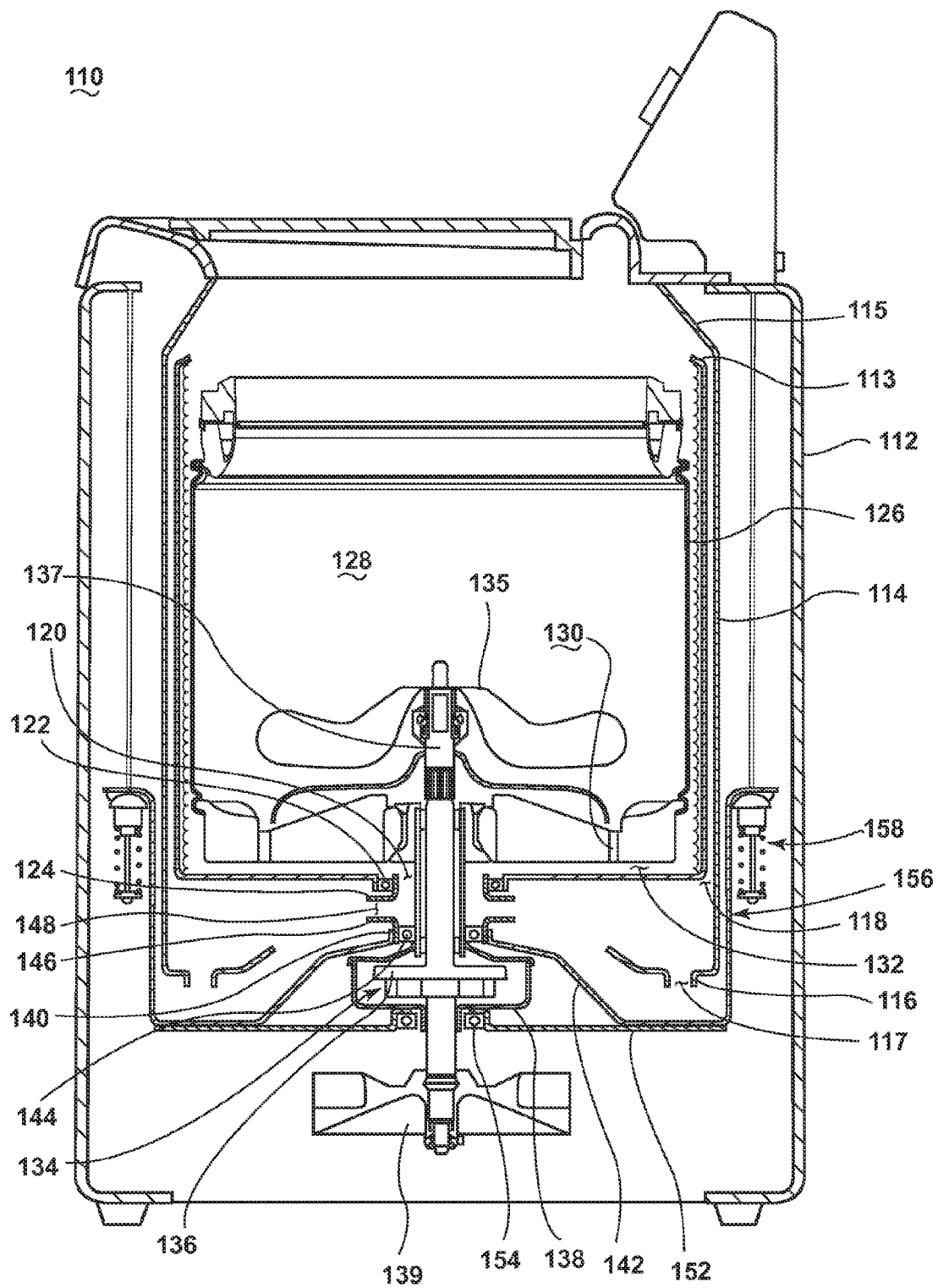


FIG. 5

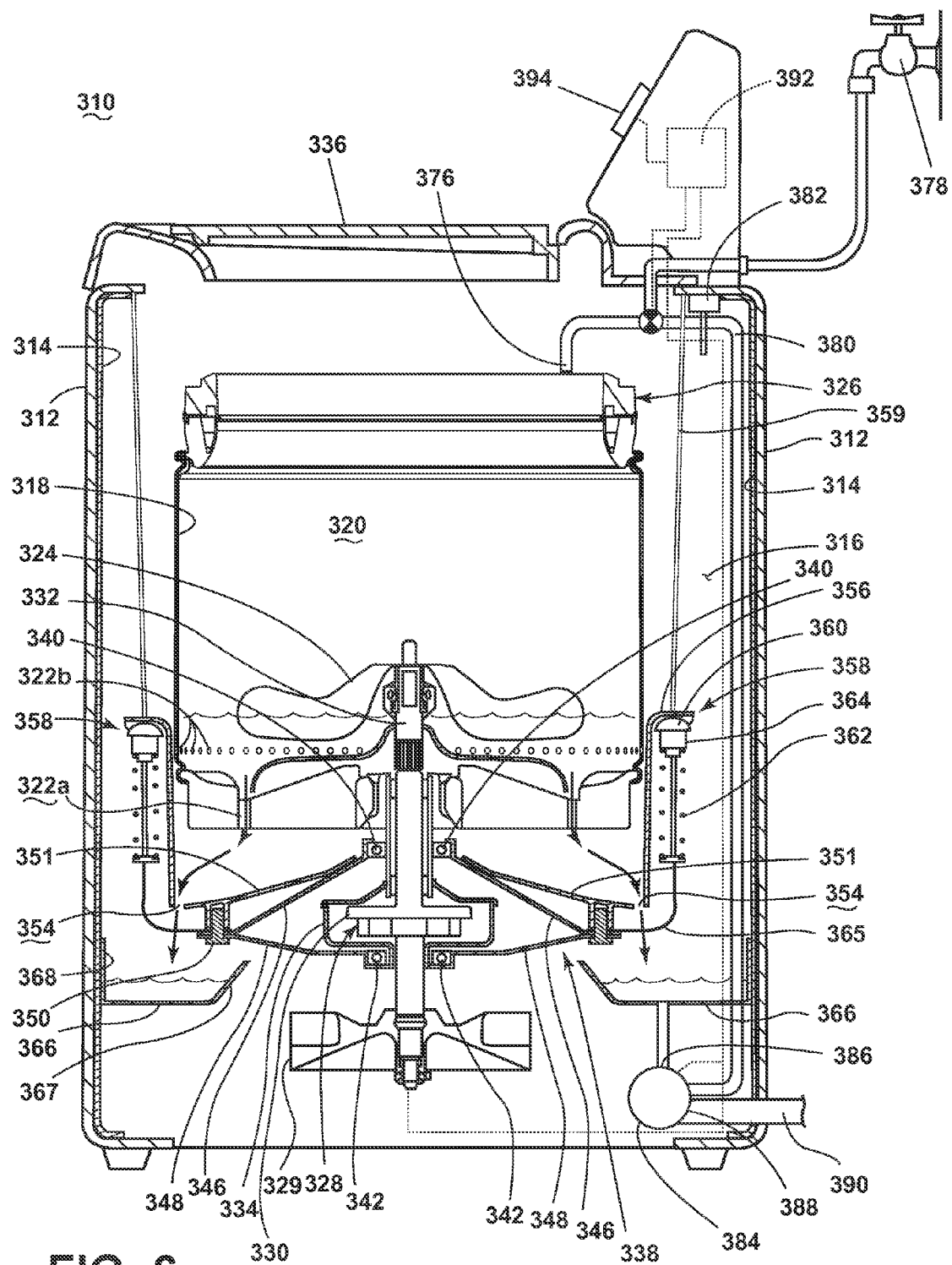
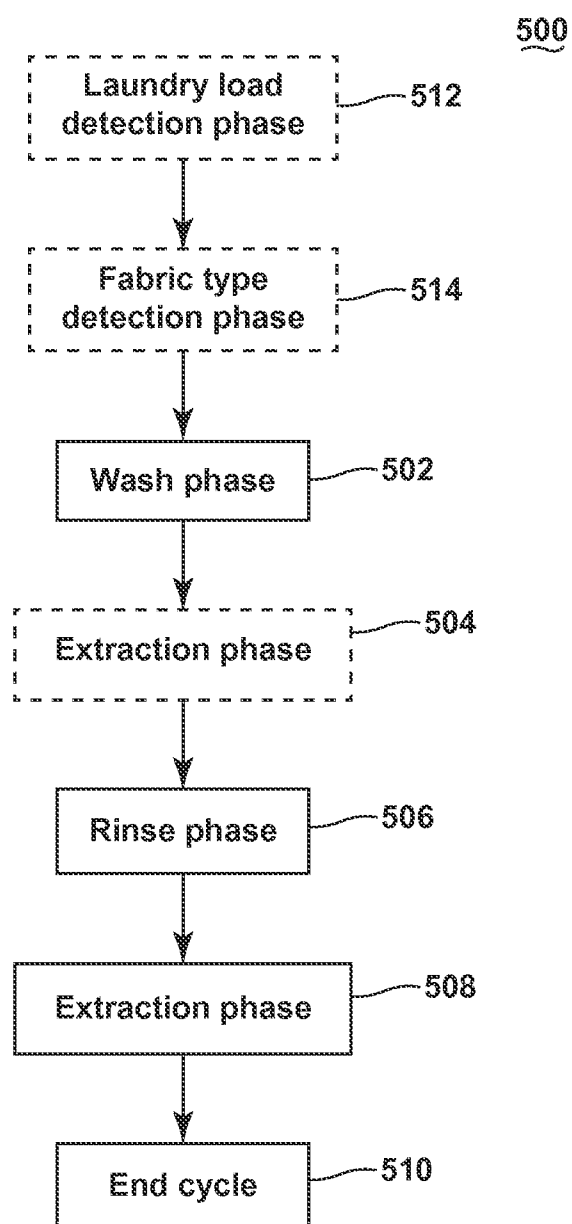


FIG. 6

**FIG. 7**

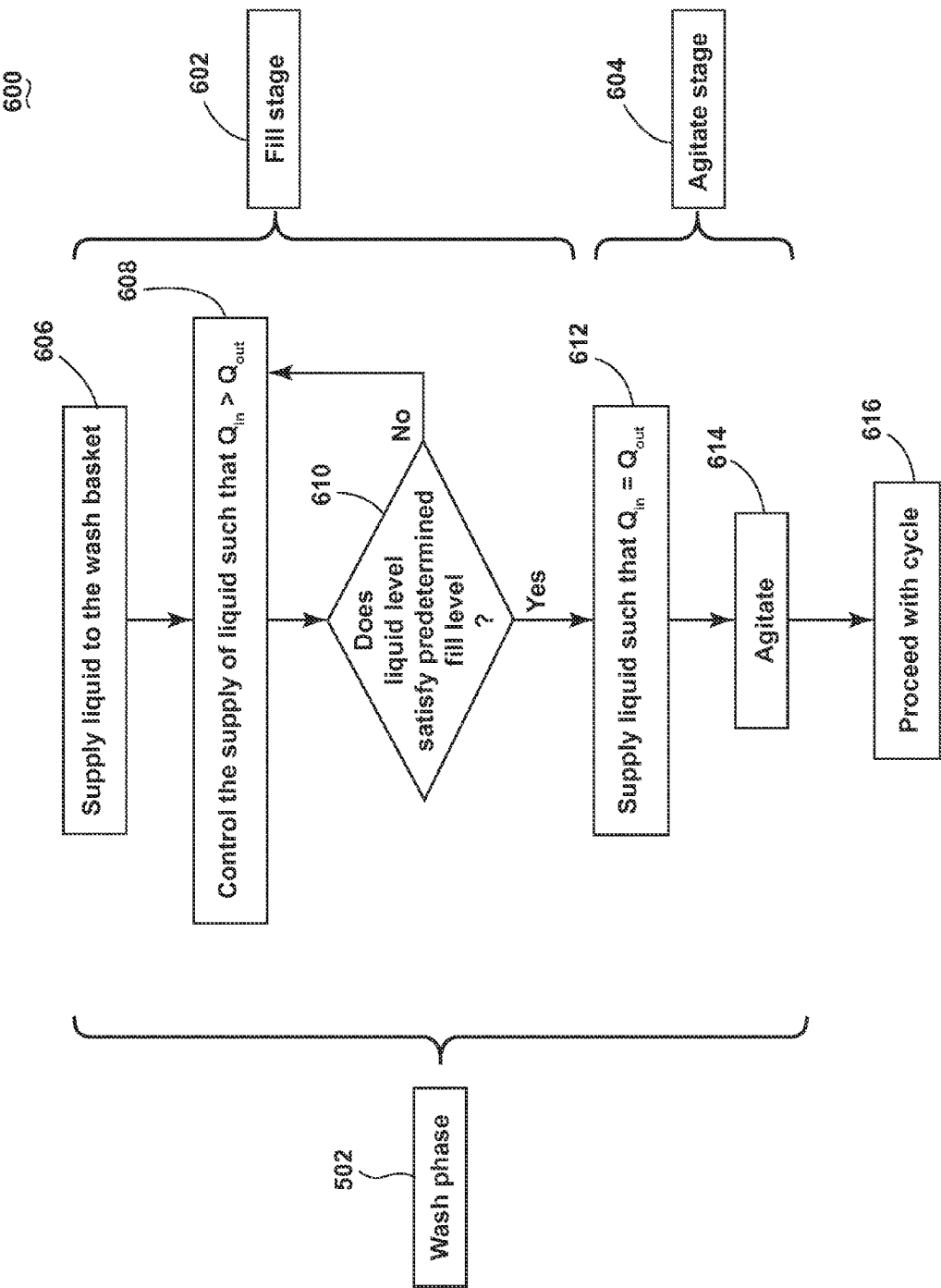


FIG. 8

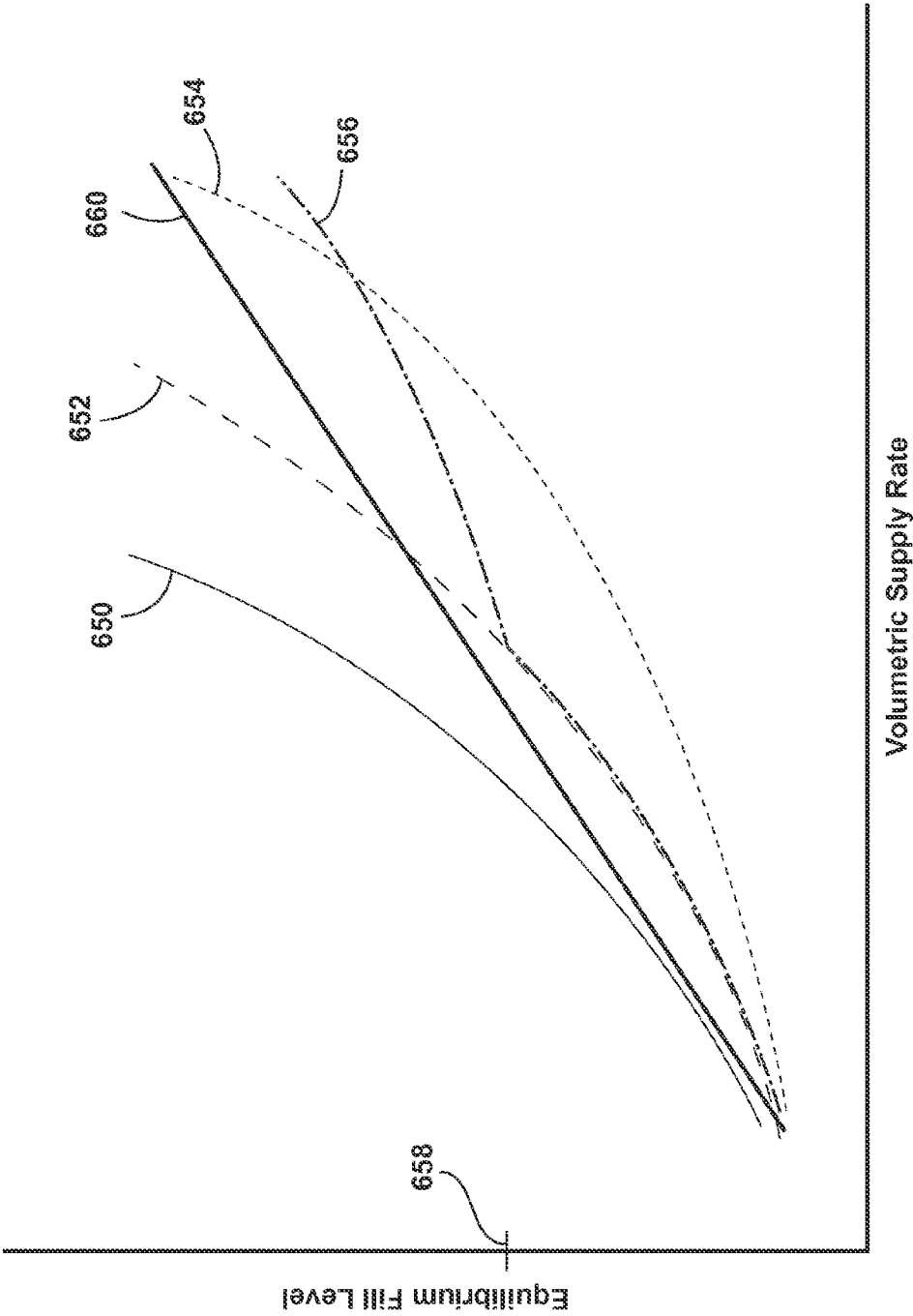


FIG. 9

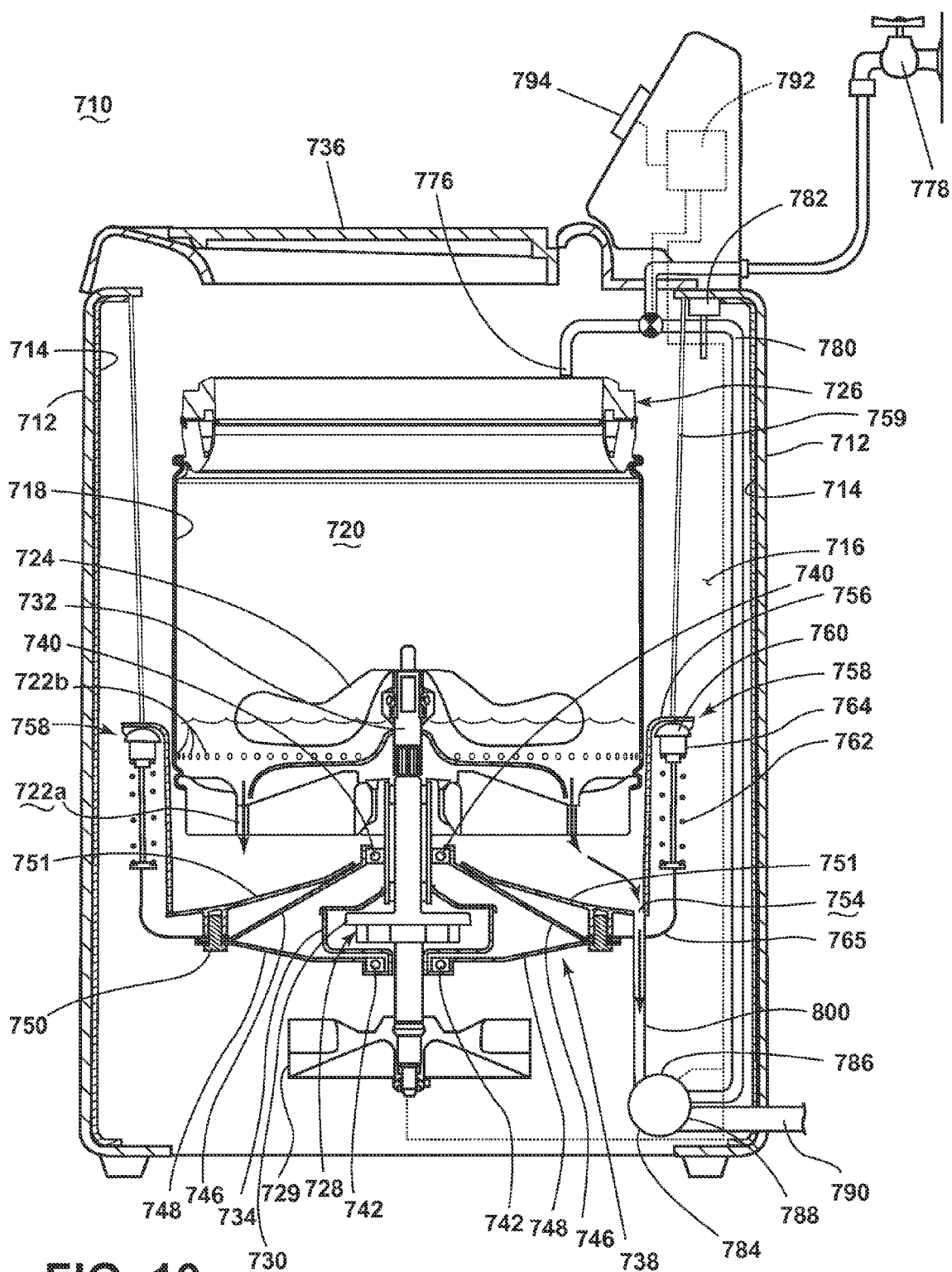


FIG. 10

LAUNDRY TREATING APPLIANCE WITH A STATIC TUB

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 13/970,733, filed Aug. 20, 2013, which is incorporated herein by reference in its entirety. This application is also related to U.S. patent application Ser. No. 14/156,928, filed Jan. 16, 2014, which is also a continuation-in-part of U.S. patent application Ser. No. 13/970,733, filed Aug. 20, 2013, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] Laundry treating appliances, such as vertical washing machines, typically include a cabinet, a tub in the interior of the cabinet, and a rotatable wash basket mounted in the tub that receives laundry for treatment according to a cycle of operation. The tub may suspend from the cabinet, and may be supported by one or more suspension systems.

[0003] During the operation of the vertical washing machine with the suspended tub, the laundry load may be limited by the wash basket size, which is limited by the adjacent suspending tub. In case the laundry is non-uniformly distributed in the wash basket, an unbalance during the rotation of the wash basket may cause it to deviate off an anticipated rotational orbit, and in extreme cases, induce collisions between the wash pedestal basket and the adjacent tub such that spin extraction efficiency may be limited. Prior solutions have focused on predicting imbalances, altering the rotation, and applying rebalancers or counterbalancers.

BRIEF DESCRIPTION

[0004] A method of controlling a laundry treating appliance having a rotatable wash basket defining a treating chamber for receiving laundry items for treatment according to an automatic cycle of operation, the method comprising supplying liquid to the wash basket at a predetermined volumetric supply rate, draining liquid from the wash basket by gravity at a predetermined volumetric drain rate, and filling the wash basket to a predetermined fill level based on an amount of laundry, a type of laundry, a selected cycle of operation, or combinations thereof, wherein the predetermined volumetric supply rate is controlled based on the predetermined volumetric drain rate to control an amount of liquid in the wash basket according to the automatic cycle of operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] In the drawings:

[0006] FIG. 1 is a schematic cross-sectional view of a laundry treating appliance with a static wash tub during a wash phase according to a first embodiment of the invention.

[0007] FIG. 2 is a schematic view of a controller of the laundry treating appliance of FIG. 1.

[0008] FIG. 3 is an enlarged schematic cross-sectional view of a laundry treating appliance with a static wash tub during a wash phase according to a second embodiment of the invention.

[0009] FIG. 4 is an enlarged schematic cross-sectional view of the laundry treating appliance with the static wash tub of FIG. 3 during a spin phase according to a third embodiment of the invention.

[0010] FIG. 5 is a schematic cross-sectional view of a laundry treating appliance with a static wash tub during a wash phase according to a fourth embodiment of the invention.

[0011] FIG. 6 is a schematic cross-sectional view of a laundry treating appliance with a static wash tub according to an embodiment of the invention.

[0012] FIG. 7 is flow chart illustrating a cycle of operation according to an embodiment of the invention.

[0013] FIG. 8 is a flow chart illustrating a wash phase according to an embodiment of the invention.

[0014] FIG. 9 is graph illustrating an equilibrium fill level as a function of volumetric supply rate according to an embodiment of the invention.

[0015] FIG. 10 is a schematic cross-sectional view of a laundry treating appliance with a static wash tub according to an embodiment of the invention.

DETAILED DESCRIPTION

[0016] Referring now to the drawings, FIG. 1 is a schematic view of an exemplary laundry treating appliance 10 in the form of a washing machine according to a first embodiment of the invention. While the laundry treating appliance 10 is illustrated as a vertical axis, top-fill washing machine, the invention may have applicability in other laundry treating appliances, such as a horizontal axis washing machine, a combination laundry treating appliance and dryer, an extractor, a non-aqueous laundry treating appliance, and a tumbling or stationary refreshing/revitalizing machine, for example.

[0017] The washing machine 10 may include a cabinet or housing 12, and a static wash tub 14 which is in fixed position with respect to the cabinet 12. In one example, as illustrated in FIG. 1, the static wash tub 14 may be integrated to the cabinet 12, and define an interior 16 of the washing machine 10. By “static wash tub,” it is not necessarily meant that the tub is fixedly integrated to the cabinet 12. Alternately, the tub 14 may be referred to as the static wash tub as long as the tub 14 is in a fixed position with respect to the cabinet 12. For example, the static wash tub may be spaced from the cabinet 12 by a predetermined distance.

[0018] A drum or wash basket 18 may be located within and rotatable relative to the interior 16 of the tub 14 and may define a laundry treating chamber 20 for receiving a laundry load. The wash basket 18 may include one or more drain holes 22 formed on the base portion of the wash basket 18 to discharge the liquid from the wash basket 18 through one or more drain holes 22. An agitator or clothes mover 24 may be located within the laundry treating chamber 20 and rotatable relative to and/or with the wash basket 18. For example, the agitator 24 may be commonly oscillated or rotated about its axis of rotation during a cycle of operation in order to provide movement to the fabric load contained within the laundry treating chamber 20. A balance ring 26 may be coupled to a top portion of the wash basket 18 for eliminating unbalance from the rotation of laundry items that are non-uniformly distributed in the wash basket 18.

[0019] An electrical motor assembly 28 may be provided to drive the wash basket 18 and/or the agitator 24. The electrical motor assembly 28 may be fixedly positioned on a pedestal 29, and may include a motor 30, a shaft 32, and a motor housing 34 for accommodating the motor 30. The electrical motor assembly 28 may be operably connected to the wash basket 18 and/or the agitator 24. For example, the shaft 32 may be rotatably coupled to the agitator 24.

[0020] The top of the cabinet 12 may include a selectively openable lid 36 to provide access into the laundry treating chamber 20 through the open top of the wash basket 18.

[0021] A liquid trap system may be provided to the interior 16 of the washing machine 10 for controlling the flow of liquid such as water or a combination of water and one or more treating chemistries from impinging into the electrical motor assembly 28. A closure system 38 may be provided to the interior 16 of the washing machine 10 for controlling the flow of liquid from the wash basket 18 to the exterior to the closure system 38. As illustrated in FIG. 1, the closure system 38 may be positioned under the wash basket 18, that is, between the motor assembly 28 and the static wash tub 14, to receive the liquid from the wash basket 18.

[0022] A first seal 40 may be positioned above the motor assembly 28, and a second seal 42 may be positioned below the motor assembly 28. The first and second seals 40, 42 may be in the form of a seal bearing or stationary seal, and prevent the liquid from the static wash tub 14 from impinging into the motor assembly 28.

[0023] One or more boots may be provided for attenuating the vibration generated from the operation of the rotatable wash basket 18. As illustrated in FIG. 1, one end portion of a first boot 46 may downwardly extend from the first seal 40 to form a slanted plane. One end portion of a second boot 48 may be coupled to and extend from the second seal 42 to form an upwardly slanted plane. The other end portions of the first and second boots 46, 48 may be coupled to a seal 50 such as a labyrinth seal.

[0024] The closure system 38 may also include a closure 51 extending from the first seal 40 for coupling with the labyrinth seal 50. The closure 51 may be positioned above the first and second boots 46, 48. The closure 51 may include one or more drain ports 54 formed at lower and/or periphery portion of the closure 51. The other end portion 56 of the closure 51 may extend upwardly and may be coupled to a suspension system 58.

[0025] A plurality of suspension systems 58 may be provided in the interior 16 of the washing machine 10 for damping the vibrations generated during the rotational movement of the wash basket 18. The suspension system 58 may include a rod 59, cap 60, elastic spring 62, and a damper 64. The suspension system 58 may be operably coupled to the cabinet 12 via the rod 59. An elastic element 65 may downwardly extend from the damper 64 to operably couple the suspension system 58 to one of the first and second boots 46, 48 via the seal 50 for damping the vibrations from the first and second boots 46, 48. The elastic element 65 may be made of metallic material, and may be in the form of a rod, plate, spring or the like.

[0026] A sump 66 may be fixedly positioned in the lower portion of the cabinet 12. As illustrated in FIG. 1, the sump 66 may be in the form of a catch basin having walls for accommodating a predetermined amount of wash liquid draining from the wash basket 18. The sump 66 may be positioned underneath the closure system 38, and the position of the sump 66 may be determined such that the sump 66 may receive the liquid flowing downwardly by gravity through the drain ports 54. The sump 66 may include first and second walls 67, 68, with the second wall 68 sealably coupled to the static wash tub 14 for preventing the leak of wash liquid and/or vapour through the gap between the second wall 68 and the static wash tub 14. While the sump 66 may be located within the interior of the cabinet 12, it may be understood that

positioning the sump 66 exterior of the cabinet 12 may also be possible in another embodiment.

[0027] The sump 66 may be provided with a liquid level sensor for determining the liquid level in the catch basin 66. The sump 66 may also be provided with a turbidity sensor for determining the turbidity of the wash liquid received in the sump 66.

[0028] A spraying system may be provided to supply the liquid, such as water or a combination of water and one or more treating chemistries into the open top of the wash basket 18. The spraying system may be configured to recirculate wash liquid from the sump 66, and spray it onto the laundry via a recirculation conduit 80 and a sprayer 76. The nature of the spraying system is not germane to the invention, and thus any suitable spraying system may be used with the washing machine 10.

[0029] A dispensing system may be provided to the washing machine 10 for supplying treating chemistry to the treating chamber 20 according to a cycle of operation. The dispensing system may include a detergent dispenser 82 which may be a single use dispenser, a bulk dispenser or a combination of a single and bulk dispenser. As illustrated in FIG. 1, the detergent dispenser 82 may be positioned within the static wash tub 14, and may be disposed vertically above the sump 66 for providing one or more treating chemistries to the sump 66 by gravity according to a cycle of operation. The detergent dispenser 82 may include a conduit with a predetermined dimension for guiding the supply of one or more treating chemistries to the sump 66. The treating chemistries may be in the form of at least one of liquid, powder, pod, compressed puck, or combination thereof.

[0030] The treating chemistries may be provided without being mixed with wash liquid from the recirculation conduit 80 or water from the household water supply 78. In another embodiment, the detergent dispenser 82 may be operably configured to dispense a treating chemistry mixed with water supplied from the household water supply 78 through the sprayer 76. The sprayer 76 may be configured to dispense the treating chemistry into the treating chamber 20 in a desired pattern and under a desired amount of pressure. For example, the sprayer 76 may be configured to dispense a flow or stream of treating chemistry into the tub 14 by gravity, i.e. a non-pressurized stream.

[0031] Non-limiting examples of suitable dispensers are disclosed in U.S. Pub. No. 2010/0000022 to Hendrickson et al., filed Jul. 1, 2008, which issued as U.S. Pat. No. 8,196,441, on Jun. 12, 2012, entitled "Household Cleaning Appliance with a Dispensing System Operable Between a Single Use Dispensing System and a Bulk Dispensing System;" U.S. Pub. No. 2010/0000024 to Hendrickson et al., filed Jul. 1, 2008, which issued as U.S. Pat. No. 8,388,695, on Mar. 5, 2013, entitled "Apparatus and Method for Controlling Laundering Cycle by Sensing Wash Aid Concentration;" U.S. Pub. No. 2010/0000573 to Hendrickson et al., filed Jul. 1, 2008, which issued as U.S. Pat. No. 8,397,328, on Mar. 19, 2013, entitled "Apparatus and Method for Controlling Concentration of Wash Aid in Wash Liquid;" U.S. Pub. No. 2010/0000581 to Doyle et al., filed Jul. 1, 2008, which issued as U.S. Pat. No. 8,813,526, on Aug. 26, 2014, entitled "Water Flow Paths in a Household Cleaning Appliance with Single Use and Bulk Dispensing;" U.S. Pub. No. 2010/0000264 to Luckman et al., filed Jul. 1, 2008, entitled "Method for Converting a Household Cleaning Appliance with a Non-Bulk Dispensing System to a Household Cleaning Appliance with

a Bulk Dispensing System,” U.S. Pub. No. 2010/0000586 to Hendrickson, filed Jun. 23, 2009, which issued as U.S. Pat. No. 8,397,544, on Mar. 19, 2013, entitled “Household Cleaning Appliance with a Single Water Flow Path for Both Non-Bulk and Bulk Dispensing,” and application Ser. No. 13/093,132, filed Apr. 25, 2011, which issued as U.S. Pat. No. 8,438,881, on May 14, 2013, entitled “Method and Apparatus for Dispensing Treating Chemistry in a Laundry Treating Appliance,” which are herein incorporated by reference in full.

[0032] Non-limiting examples of treating chemistries that may be dispensed by the dispensing system during a cycle of operation include one or more of the following: water, surfactants, enzymes, fragrances, stiffness/sizing agents, wrinkle releasers/reducers, softeners, antistatic or electrostatic agents, stain repellants, water repellants, energy reduction/extraction aids, antibacterial agents, medicinal agents, vitamins, moisturizers, shrinkage inhibitors, dye transfer inhibitors, color fidelity agents, and combinations thereof.

[0033] A recirculation and drain system may be provided to the laundry treating appliance **10** for recirculating liquid within and/or draining liquid from the laundry treating appliance **10**. A pump **84** may be housed below the closure system **38**. The pump **84** may have an inlet **86** fluidly coupled to the sump **66** and an outlet **88** configured to fluidly couple to a recirculation conduit **80** and a drain conduit **90**. It is understood that the pump **84** may be configured to switch the pumping direction by operating the motor coupled to the pump **84** in the reverse direction.

[0034] Alternatively, two separate pumps, such as a recirculation pump and a drain pump, may be used instead of the single pump as previously described, in which case, at least one of the recirculation pump or the drain pump may be fluidly coupled to a drain conduit **90** for flushing the liquid out of the washing machine **10** according to a treating cycle of operation. It is understood that the recirculation pump, similar to the pump **84**, may be configured to switch the pumping direction by operating the motor in the reverse direction.

[0035] Additionally, the spraying system, the dispensing system, and recirculation and drain system may differ from the configuration shown in FIG. 1, such as by inclusion of other valves, conduits, treating chemistry dispensers, sensors and the like, to control the flow of liquid through the washing machine **10** and for the introduction of more than one type of treating chemistries.

[0036] As used herein, the term “wash liquid” refers to water or a combination of water and one or more treating chemistries such as those capable of generating suds. The terms “rinse liquid” and “rinse water” are interchangeable and refer to water supplied from the household water supply **78** that has not been mixed with a treating chemistries prior to being applied to the laundry.

[0037] The washing machine **10** also includes a control system for controlling the operation of the washing machine **10** to implement one or more cycles of operation. The control system may include a controller **92** and a user interface **94** that is operably coupled with the controller **92**. The user interface **94** may include one or more knobs, dials, switches, displays, touch screens and the like for communicating with the user, such as to receive input and provide output. The user may enter different types of information including, without limitation, cycle selection and cycle parameters, such as cycle options.

[0038] The controller **92** may include the machine controller and any additional controllers provided for controlling any

of the components of the washing machine **10**. For example, the controller **92** may include the machine controller and a motor controller. Many known types of controllers may be used for the controller **92**. The specific type of controller is not germane to the invention. It is contemplated that the controller **92** is a microprocessor-based controller that implements control software and sends/receives one or more electrical signals to/from each of the various working components to effect the control software. As an example, proportional control (P), proportional integral control (PI), and proportional derivative control (PD), or a combination thereof, a proportional integral derivative control (PID control), may be used to control the various components.

[0039] As illustrated in FIG. 2, the controller **92** may be provided with a memory **96** and a central processing unit (CPU) **98**. The memory **96** may be used for storing the control software that is executed by the CPU **98** in implementing a cycle of operation using the washing machine **10** and any additional software. Examples, without limitation, of cycles of operation include: wash, heavy duty wash, delicate wash, quick wash, pre-wash, refresh, rinse only, and timed wash. A common wash cycle includes a wash phase, a rinse phase, and a spin extraction phase. Other phases for cycles of operation include, but are not limited to, intermediate extraction phases, such as between the wash and rinse phases, and a pre-wash phase preceding the wash phase, and some cycles of operation include only a select one or more of these exemplary phases.

[0040] The memory **96** may also be used to store information, such as a database or table, and to store data received from one or more components of the washing machine **10** that may be communicably coupled with the controller **92**. The database or table may be used to store the various operating parameters for the one or more cycles of operation, including factory default values for the operating parameters and any adjustments to them by the control system or by user input.

[0041] The controller **92** may be operably coupled with one or more components of the washing machine **10** for communicating with and controlling the operation of the component to complete a cycle of operation. For example, the controller **92** may be operably coupled with the motor **30**, the pump **84**, and the detergent dispenser **82** to control the operation of these and other components to implement one or more of the cycles of operation.

[0042] The controller **92** may also be coupled with one or more sensors **100** provided in one or more of the systems of the washing machine **10** to receive input from the sensors, which are known in the art and not shown for simplicity. Non-limiting examples of sensors **100** that may be communicably coupled with the controller **92** include: a treating chamber temperature sensor, a moisture sensor, a weight sensor, a chemical sensor, a position sensor, a motor torque sensor, the liquid level sensor, and the turbidity sensor, which may be used to determine a variety of system and liquid characteristics. For example, when the turbidity of one of the wash liquid or rinse liquid in the wash basket **18** or the sump **66** satisfies a predetermined threshold, the wash liquid or rinse liquid may be drained by the activation of the pump **84**, and fresh water may be supplied to the wash basket **18** from the household water supply **78**.

[0043] Typically, a vertical axis washing machine having a tub suspended from a cabinet, and a rotatable wash basket disposed in the tub, may have multiple performance limitations. For example, the size of the wash basket and corre-

sponding capacity of laundry load may be limited by the position of the suspended tub in the vicinity of the rotatable wash basket and one or more suspension systems exterior of the suspended tub in the cabinet. In another example, the spin speed for the wash basket during a rinse phase may not be maintained at a very high speed due to the potential collision between the wash basket and the suspended tub from an unbalance associated with non-uniformly distributed laundry load in the wash basket. In yet another example, the treating efficiency of laundry items is known to be limited due to discrete steps comprising water supply, agitation, rinsing, compared to out of water wash where wash liquid is continuously supplied to the laundry load for continuously treating laundry items.

[0044] The operation of the washing machine 10 with the static wash tub 14 may be different from the operation of a typical vertical axis washing machine having a suspending tub. It is assumed that laundry items may be received in the wash basket 18 prior to or during a cycle of treating operation.

[0045] When the wash phase in the wash cycle begins, water may be provided from the household water supply 78. The water may percolate through the laundry items in the wash basket 18, and drain downwardly by gravity through the drain holes 22. The agitator 24 may rotate in at least one of the clockwise or counter clockwise directions for engaging the laundry with the agitator 24 at a predetermined speed according to a cycle of operation. The drain holes 22 may be configured to open, therefore the water may drain through the drain holes 22 when the basket 18 is either in a stationary mode or rotates according to a cycle of operation. Once passing through the drain holes 22, the water may be received downwardly by the surface of the closure 51 until the water is received in the sump 66 through one or more drain ports 54.

[0046] The level of wash liquid in the sump 66 may be determined by the amount of water initially provided from the household water supply 78 to the treating chamber 20 of the wash basket 18. Therefore water may be supplied to the wash basket 18 until the water level in the sump 66 satisfies a predetermined threshold. For example, an output from the water level sensor may be monitored to determine when the water supply to the wash basket 18 needs to be stopped.

[0047] The water received in the sump 66 may be provided with one or more treating chemistries supplied from the detergent dispenser 82 to the interior of the sump 66, and the water and one or more treating chemistries may be physically and/or chemically mixed to each other to form wash liquid. The wash liquid may subsequently be supplied to the inlet 86 of the pump 84 for recirculation through the recirculation conduit 80 back to the laundry items in the wash basket 18. The wash liquid, now a mixture of water and one or more treating chemistries may be percolated through the laundry items in the wash basket 18 while the agitator 24 rotates according to a cycle of operation.

[0048] It may be noted that, during the wash phase, the wash liquid may be continuously recirculated from the wash basket 18, through drain holes 22 of the wash basket 18, drain ports 54 of the closure 51, pump 84, recirculation conduit 80, and then back to the wash basket 18. It may also be noted that treating laundry based on the continuous or semi-continuous percolation of wash liquid may be effective in improving the treating performance of laundry item, compared to a traditional treating step comprising discrete steps of water supply, agitation, and rinsing.

[0049] When the wash phase is complete, the wash liquid received in the sump 66 may be drained out of the washing machine 10 by activating the pump 84 in the drain mode. In another embodiment where two separate pumps are operable, the drain pump may be activated to drain wash liquid out of the washing machine 10. Prior to the activation of the pump 70 for draining the wash liquid, the liquid level of the catch basin 66 may be monitored by the water level sensor, and the activation of the pump 84 for draining wash liquid may continue until wash liquid level satisfies a predetermined threshold range.

[0050] The wash phase may be followed by the rinse phase. During the rinse phase, water may be provided to the laundry items in the wash basket 18 through the sprayer 76. Similar to the wash phase, the water supplied from the household water supply 78 may be percolated through the laundry items while the laundry items are agitated by the agitator 24 according to a cycle of operation. During the rinse phase, the water may continuously drain out of the wash basket 18 through one or more drain holes 22, pass through one or more drain ports 54, and then recirculated back to the wash basket via the recirculation conduit 80 by the pump 70. One or more treating chemistries for rinse phase may be provided to the catch basin 66 prior to the onset of or during the rinse phase.

[0051] Referring to FIG. 3, a schematic cross-sectional view of a laundry treating appliance with a static wash tub according to a second embodiment of the invention is illustrated, wherein the laundry treating appliance is in the wash phase.

[0052] The primary difference between the first embodiment in FIG. 1 and second embodiment in FIG. 3 may be a flange 102 mounted to the closure 51. As illustrated, the flange 102 may be coupled to a low end portion of the closure 51 such that the flange 102 may extend downwardly from the low end portion of the closure 51 until one end portion of the flange 102 contacts the bottom of the sump 66 during the wash phase.

[0053] The flange 102 may be configured to form a seal when the flange 102 contacts the bottom of the sump 66. As a result, the flange 102 may act as a trap for confining the wash liquid and/or vapour inside the interior 16 of the static wash tub 14. For example, the flange 102 may form a trap seal with the bottom of the catch basin 66 for blocking the wash liquid and/or vapour escaping from the sump 66 and interior 16 of the static wash tub 14. Confining wash liquid and/or vapour inside the static wash tub 14 may prevent the impingement of wash liquid and/or vapour into other parts of the laundry treating appliance. In one example, the motor assembly 28 may be protected from any impingements of wash liquid and/or vapour that may adversely affect the operation of the motor assembly 28 while wash liquid recirculates through the pump 84 and recirculation conduit 80 back to the treating chamber 20.

[0054] FIG. 4 is a schematic cross-sectional view of the laundry treating appliance of FIG. 3 according to a third embodiment of the invention, where the laundry treating appliance in FIG. 4 is in a spin extraction phase. When the wash phase is complete, the wash liquid may be drained out of the sump 66, followed by the spin extraction phase where the wash basket 18 rotates at a high spin speed.

[0055] It is understood that, during the high speed spin extraction phase, the wash basket 18 may be subject to a translational and/or vertical movement from any unbalance of non-uniformly distributed laundry items in the wash basket

18. The translational and/or vertical movement of the wash basket **18** may be transmitted to other coupled components in the form of vibration. In one example, vibration may transmit to the closure system **38**, the flange **102**, the elastic element **65**, and the suspension system **58**.

[0056] The suspension system **58** may move horizontally and/or vertically for damping out the vibrations of the wash basket **18** during the spin extraction phase. In one example, during the vibration damping, the elastic spring **62** of the suspension system **58** may be compressed for damping out the vibrations, which may lift up the elastic element **65** in an upward direction. As a result, the closure **51** and first/second boots **46**, **48**, which are coupled to the elastic element **65**, and the flange **102**, which is coupled to the closure **51**, may be also lifted up during the vibration damping.

[0057] Lifting up the flange **102** during the high speed rinse phase may disengage the flange **102** from the bottom of the sump **66**, and the vibrations transmitted from the wash basket **18** may not be transferred to the sump **66**, as illustrated in FIG. **4**. When the spin extraction phase is complete, the elastic spring **62** may be extended back to its original length, and the flange **102** may move downwardly until the flange **102** contact the bottom of the sump **66**.

[0058] FIG. **5** is a schematic cross-sectional view of a laundry treating appliance **110** with a static wash tub **114** during the wash phase according to a fifth embodiment of the invention. The laundry treating appliance **110** may be different from a laundry treating appliance **10** in FIG. **1** in that the laundry treating appliance **110** includes a rotatable tub **113** between a wash basket **126** and a static wash tub **114**.

[0059] As illustrated, the laundry treating appliance **110** comprises a cabinet **112**, and a static wash tub **114** which may be spaced from the cabinet **112** by a predetermined distance. First end portion **115** of the static wash tub **114** may be coupled to the cabinet **112**, while the second end portion **116** may extend downwardly to form a drain opening **117**. A rotatable tub **113** may be located within and rotatable relative to the interior **118** defined by the static wash tub **114**. The rotatable tub **113** may be in the form of a cylinder with a closed bottom, and may include an opening **120** at the centre of the closed bottom. The rotatable tub **113** may be rotatably coupled to a first seal **122**, which may be in the form of a seal bearing. A first outlet portion **124** may extend from the first seal **122**.

[0060] A rotatable drum or wash basket **126** may be located within the rotatable tub **113** for defining a laundry treating chamber **128** for receiving a laundry load. The wash basket **126** may be configured to rotate at a predetermined speed according to a cycle of operation. It is understood that the wash basket **126** and rotatable tub **113** may be configured to rotate at the same time. It is also noted that the wash basket **126** and rotatable tub **113** may rotate substantially at identical speed relative to each other. The wash basket **126** may include one or more drain holes **130** formed on the base portion of the wash basket **126**, and one or more drain holes **130** may be fluidly coupled to the space **132** formed by the exterior of the wash basket **126** and the inner wall of the rotatable tub **113**.

[0061] An electrical motor assembly **134** may be provided to drive the wash basket **126**, rotatable tub **113**, or an agitator **135** according to a cycle of operation. The electrical motor assembly **134** may include a motor **136**, a shaft **137**, and a motor housing **138** for accommodating the motor **136**. The electrical motor assembly **134** may be positioned on the pedestal **139**.

[0062] One or more boots may be provided to the laundry treating appliance for attenuating the vibration generated from the operation of the rotatable wash basket **126** and/or preventing wash liquid impinging into the motor assembly **134**. First end portion **140** of a first boot **142** may extend from a second seal **144**. A second outlet portion **146** may extend from the first end portion **140** of the first boot **142**, with the second outlet portion **146** combined with the first outlet portion **124** to form an outlet **148**.

[0063] The outlet **148** may be coupled to a recirculation conduit and pump (not shown) for recirculating wash liquid back to the treating chamber or draining wash liquid out of the laundry treating appliance **110**.

[0064] A second boot **152** may extend from a third seal **154** in a horizontal direction until the second boot **152** may be coupled to the first boot **142** to form a closure **156**. The closure **156** may be coupled to a suspension system **158**, which may be operably coupled to the cabinet **112** for damping out the vibration from the movement of the wash basket **126** and/or the rotatable tub **113**.

[0065] Other components and sensors such as the electric motor assembly, the spraying system, the dispensing system, the recirculation and drain system, the controller are well known, and may not be described in detail unless otherwise necessary hereof.

[0066] In operation, during a wash phase, wash liquid may be provided to the treating chamber **128** of the wash basket **126**, percolate through the laundry items in the wash basket **126**, and drain downwardly through the drain holes **130**. Wash liquid may be further removed from the laundry items in the spin extraction phase by rotating the wash basket **126** at a predetermined speed. When the wash basket **126** rotates, the rotatable tub **113** may also rotate at a substantially identical speed with the wash basket **126**. While the wash basket **126** and rotatable tub **113** rotate, wash liquid may be extracted from laundry items through the drain holes **130** along the inner wall of the rotatable tub **113** by a centrifugal force to form a wash liquid layer along the height of the rotatable tub **113**.

[0067] The distribution of the wash liquid layer on the inner wall of the rotatable tub **113** may vary with treating parameters. In one example, the drain holes **130** of the wash basket **126** may be configured to control the flow direction and magnitude of wash liquid extracted from drain holes **130** in the wash basket **126**. For example, by controlling the location and angle of the drain holes **130** relative to the rotational axis of the wash basket **126**, the wash liquid may be distributed such that the amount of wash liquid may substantially compensate for the unbalance from laundry items to spin the wash basket **126** at its maximum spin speed.

[0068] When the wash basket **126** is stationary, centrifugal force on the wash liquid may not be effective any more. Wash liquid may flow down to the lower portion of the rotatable tub **113** to be collected, and may be drained through the opening **120** to the outlet **148**, where the wash liquid may be recirculated to the wash basket **126** via the recirculation conduit and pump (not shown). Alternately wash liquid may be drained out of the laundry treating appliance by the pump by switching the pumping direction of the pump.

[0069] During the spin extraction phase, the wash liquid may spill out of the top of the rotatable tub **113**. The spilled wash liquid may be confined to the interior **118** by the static wash tub **114**. In one example, the spilled wash liquid may flow down the space formed between the rotatable tub **113**

and the static wash tub 114, and may be collected at the drain opening 117, where the wash liquid may be either recirculated or drained.

[0070] FIG. 6 illustrates a schematic of a vertical axis washing machine 310 that is similar to the washing machine 10 of FIG. 1 except for the configuration of the wash basket 318. Therefore, elements in the washing machine 310 similar to those of washing machine 10 are labelled with the prefix 300. Only those elements necessary for a complete understanding of the embodiments of the invention are illustrated and it will be understood that the clothes washer 310 may include additional elements traditionally found in a clothes washer without deviating from the scope of the invention.

[0071] Still referring to FIG. 6, the washing machine 310 may include a structural support system comprising a cabinet 312 which defines a housing within which a laundry holding system resides, and a static wash tub 314 which is in fixed position with respect to the cabinet 312. In one example, as illustrated in FIG. 6, the static wash tub 314 may be integrated to the cabinet 312, and define an interior 316 of the washing machine 310. By “static wash tub,” it is not necessarily meant that the tub is fixedly integrated to the cabinet 312. Alternatively, the tub 314 may be referred to as the static wash tub as long as the tub 314 is in a fixed position with respect to the cabinet 312. For example, the static wash tub may be spaced from the cabinet 312 by a predetermined distance. The cabinet 312 may be a housing having a chassis and/or a frame, defining an interior enclosing components typically found in a conventional washing machine, such as motors, pumps, fluid lines, controls, sensors, transducers, and the like. Such components will not be described further herein except as necessary for a complete understanding of the invention.

[0072] The wash basket 318 may include a first set of drain holes 322a provided in the base, also referred to as the end wall, of the wash basket 318 and a second set of drain holes 322b provided in the side wall of the wash basket 318 to naturally drain liquid from the interior of the wash basket 318 by gravity (meaning without the use of a pump). The first and second set of drain holes 322a and 322b may have the same or different volumetric drain rates providing the wash basket 318 with a volumetric drain rate Q_{out} for the liquid that drains from the wash basket 318. The liquid drained from the wash basket 318 through the first and/or second set of drain holes 322a and 322b may pass through the drain ports 354 in the closure 351 to the catch basin 366. Liquid collected in the catch basin 366 may be pumped through the drain conduit 390 to drain the liquid from the machine or pumped through the recirculation conduit 380 and supplied to the treating chamber 320 by the pump 384.

[0073] The washing machine 310 may also be configured to supply liquid to the treating chamber 320 at a predetermined volumetric supply rate Q . The volumetric supply rate Q_{in} is based on the total amount of liquid provided to the treating chamber 320 over time, including liquid that is recirculated from the catch basin 366 and/or liquid provided from the household water supply 378. The rate at which liquid is supplied to the treating chamber 320 through the recirculation system and/or the household water supply 378 may be controlled in any number of ways to supply the liquid at the predetermined volumetric supply rate Q_{in} .

[0074] For example, the pump 384 may be a variable flow rate pump such that pump 384 may be controlled to recirculate liquid to the treating chamber 320 at the predetermined volumetric supply rate Q_{in} . While only a single pump 384 is

illustrated, it will be understood that the washing machine 310 may include any number of pumps supplying recirculated liquid to the treating chamber 320, in which case, each pump may be controlled such that the total flow rate of liquid supplied to the treating chamber 320 satisfies the predetermined volumetric supply rate Q_{in} . For example, the washing machine 310 may be provided with multiple recirculation pumps, each recirculation pump configured to pump liquid at a different volumetric supply rate than the others. The multiple recirculation pumps may be operated such that the total flow rate of liquid supplied to the treating chamber 320 by the recirculation pumps satisfies the predetermined volumetric supply rate Q_{in} . The pump 384 may be operated to supply liquid to the wash basket 318 as a continuous supply of liquid at a predetermined volumetric supply rate Q_{in} or the pump 384 may supply liquid as multiple, discrete supplies of liquid such that the rate of supply of liquid over a predetermined period of time satisfies the predetermined volumetric supply rate Q_{in} .

[0075] Additionally, or alternatively, to a variable flow rate pump, the recirculation system may be provided with one or more valves or variable flow rate sprayers to control the supply of liquid to the treating chamber 320 such that liquid is supplied at the predetermined volumetric supply rate Q_{in} . For example, the recirculation conduit 380 may be provided with a valve 400 that is operably coupled with the controller 392 such that the valve 400 may be controlled to supply liquid to the treating chamber 320 through the recirculation conduit 380 at the predetermined volumetric supply rate Q_{in} . In another example, the flow rate of water supplied from the household water supply 378 may be controlled using either the valve 400 or an additional valve (not shown).

[0076] In yet another example, the sprayer 376 may be a variable flow rate sprayer operably coupled with the controller 392 such that the sprayer 376 may be controlled to supply liquid to the treating chamber 320 through the recirculation conduit 380 at the predetermined volumetric supply rate Q_{in} . One or more sprayers 376 may be provided such that the total flow rate of liquid supplied to the treating chamber 320 through the sprayers 376 satisfies the predetermined volumetric supply rate Q_{in} .

[0077] The previously described washing machine 310 may be used to implement one or more embodiments of the invention for implementing an automatic cycle of operation in a washing machine in which the wash basket is not encompassed by a liquid holding tub having walls coextensive with the walls of the wash basket. The embodiments of the invention provide a method to control the liquid level within just the wash basket itself in a manner that does not require filling a coextensive liquid tub to the same fill level, as occurs in a traditional washing machine. The volumetric supply rate Q_{in} relative to the volumetric drain rate Q_{out} of the wash basket may be controlled to control the supply of liquid such that liquid can accumulate within the wash basket, be maintained at a constant liquid level, or drain from the wash basket as needed according to the selected cycle of operation.

[0078] Generally, cleaning of laundry items is dependent on a variety of factors, one of which includes how the laundry items move within the wash liquid. One variable that effects how the laundry items move within the wash liquid is the fill level of liquid within which the laundry is treated. Both the amount and type of laundry may affect the behavior of the laundry for a given fill level. If too little liquid is present, the laundry may aggregate and not move well within the liquid. If

too much liquid is present, the load may float, which may affect the ability of the agitator to move the laundry within the liquid as desired.

[0079] In a traditional washing machine in which the wash basket is encompassed within a rotatable liquid holding tub in which the tub walls are coextensive with the wash basket walls, the tub can be supplied with liquid up to the desired fill level and the apertures within the wash basket allow the liquid to fill the wash basket to the same fill level. In washing machines in which the wash basket is not encompassed by a liquid holding tub, such as illustrated in FIG. 6, the desired fill level within the wash basket cannot be obtained simply by filling the tub to the desired fill level in the same manner as in a traditional washing machine. The embodiments of the invention provide a method to control the liquid level within just the wash basket itself based on controlling the volumetric supply rate Q_{in} relative to the volumetric drain rate Q_{out} of the wash basket as needed according to the selected cycle of operation.

[0080] Referring now to FIG. 7, an exemplary method for treating laundry according to a wash cycle **500** is illustrated. While the methods are described with respect to the washing machine **310** of FIG. 6, it will be understood that the methods may be implemented with any of the washing machines **10**, **110**, or **710** described herein. In addition, it will be understood that the sequence of steps depicted is for illustrative purposes only, and is not meant to limit any of the methods described herein in any way as it is understood that the steps may proceed in a different logical order, additional or intervening steps may be included, or described steps may be divided into multiple steps, without detracting from the invention.

[0081] The wash cycle **500** starts with assuming that the user has placed one or more laundry items for treatment within the treating chamber **320** and selected a cycle of operation through the user interface **394**. The wash cycle **500** may be implemented during any portion of a cycle of operation or may be implemented as a separate cycle of operation. For example, the wash cycle **500** may be implemented as part of a cycle of operation that includes a pre-treatment or pre-soak phase and/or may be implemented as an independent cycle.

[0082] The wash cycle **500** may begin with a wash phase at **502** that includes washing the laundry with a detergent-based laundry composition. The wash phase at **502** may be followed by an optional extraction phase **504** in which liquid is removed from the wash basket **318**. The optional extraction phase **504** may include spinning the laundry at high speeds to remove extraneous liquid from the laundry. Alternatively, the optional extraction phase **504** may include a pause in the supply of liquid to the wash basket **318** while the wash basket **318** is stationary or rotating to allow liquid to drain from the wash basket **318** by gravity. At rinse phase **506**, the laundry load may be treated with water from the household water supply **378** that optionally may include one or more treating chemistries, a non-limiting example of which includes a fabric softener. The rinse phase **506** may be followed by an extraction phase at **508**, which may include spinning the laundry at high speeds to remove extraneous liquid from the laundry load prior to ending the cycle at **510**.

[0083] The wash cycle **500** may also include an optional laundry load detection phase **512**. The amount of laundry may be determined at **512** according to any suitable method for determining the amount of laundry prior to the addition of liquid to the laundry treating chamber. One example of a

suitable method for automatically determining the amount of laundry prior to the application of liquid may include using a load amount sensor coupled with the wash basket **318** or the suspension system **358**. Non-limiting examples of load amount sensors for determining the amount of laundry may include load volume, pressure, IR or optical based sensors, or force transducers which may include, for example, load cells and strain gauges.

[0084] Another example of a suitable method may include rotating the wash basket **318** with the motor **330** and using feedback from the motor or one or more sensors associated with the motor **330** or the wash basket **318** to determine the amount of laundry. One example of determining the amount of laundry by rotating the wash basket **318** with laundry therein is disclosed in U.S. Pub. No. 2011/0247148 to Chanda et al., filed Apr. 12, 2011, entitled "Laundry Treating Appliance with Load Amount Detection," which is herein incorporated by reference in full. Additional exemplary methods include U.S. Pat. No. 8,176,798 to Ashrafzadeh et al., issued May 15, 2012, entitled "Method and Apparatus for Determining Laundry Load", U.S. Pat. No. 8,381,569 to Lilie et al., issued Feb. 26, 2013, entitled "Method and Apparatus for Determining Load Amount in a Laundry Treating Appliance," U.S. Pat. No. 8,166,590 to Ashrafzadeh et al., issued May 1, 2012, entitled "Method and Apparatus for Determining Laundry Load Size," and U.S. Pat. No. 8,215,134 to Ashrafzadeh et al., issued Jul. 10, 2012, entitled "Method and Apparatus for Determining Laundry Load Size," all of which are herein incorporated by reference in full. Alternatively, the laundry load may be determined automatically by the controller **392** based on user input through the user interface **394**.

[0085] The amount of laundry may be qualitative or quantitative and may be determined based on user input through the user interface **394** or automatically by the washing machine **310**, as described above. For example, a qualitative determination of the laundry amount may include determining whether the laundry is a small, medium or large load. A quantitative determination may include determining a weight or volume of the laundry within the treating chamber **320**. The manner in which the amount of laundry is determined is not germane to the embodiments of the invention.

[0086] The type of laundry may also optionally be determined manually based on user input through the user interface **394** or automatically by the washing machine **310**. Non-limiting examples of types of laundry include cotton, silk, polyester, delicates, permanent press and heavy duty. In one example, the controller **392** may determine the type of laundry based on the cycle of operation selected by the user and optionally one or more settings of the cycle of operation selected by the user. Alternatively, one or more sensors may be used to determine the type of laundry. The manner in which the type of laundry is determined is not germane to the embodiments of the invention.

[0087] FIG. 8 illustrates a method **600** for controlling the liquid level within just the wash basket itself based on controlling the volumetric supply rate Q_{in} relative to the volumetric drain rate Q_{out} of the wash basket during a wash phase **502** of a selected cycle of operation. For the purposes of discussion, the wash phase **502** may be considered as having two stages, a fill stage **602** in which liquid is supplied to the wash basket **318** to increase the amount of liquid in the wash basket **318** to satisfy a predetermined liquid fill level, and an agitate stage **604** in which mechanical energy is supplied to the laundry to facilitate treating the laundry during the wash

phase 502 to remove soils and stains from the laundry. Satisfying the predetermined liquid fill level may include comparing a determined liquid fill level to a predetermined reference value that may be a range of reference values, an upper threshold or a lower threshold stored in the memory of the controller 392. The term “satisfies” the threshold is used herein to mean that the variation satisfies the predetermined threshold, such as being equal to, less than, or greater than the threshold value. It will be understood that such a determination may easily be altered to be satisfied by a positive/negative comparison or a true/false comparison. For example, a less than threshold value can easily be satisfied by applying a greater than test when the data is numerically inverted. Typically, at the beginning of a wash phase there will be little to no liquid within the wash basket 318 and thus the wash phase 502 will begin with a fill stage 602 in which liquid is supplied to the wash basket 318 to increase the amount of liquid within the wash basket 318. However, if the amount of liquid is determined to satisfy or exceed the predetermined liquid fill level, the fill stage 602 may include decreasing the amount of liquid within the wash basket 318 as described below, without deviating from the scope of the invention.

[0088] The wash phase 502 may begin with supplying liquid to the wash basket 318. Supplying liquid to the wash basket 318 may include supplying liquid directly to the wash basket from the household water supply 378 and/or supplying liquid collected in the catch basin 366 through the recirculation conduit 380. The liquid supplied to the wash basket 318 may include a treating chemistry supplied by the detergent dispenser 382 through the dispensing system during at least a portion of the supply of liquid at 606. At 608, the supply of liquid may be controlled such that the volumetric supply rate Q_{in} is greater than the volumetric drain rate Q_{out} for at least a portion of the supply of the liquid to the wash basket at 608.

[0089] At 610, it may be determined whether the liquid level inside the wash basket 318 satisfies a predetermined fill level. The predetermined fill level may be determined based on the amount and/or type of laundry and/or the selected cycle of operation. In one example, the fill level may correspond to a predetermined liquid-to-laundry ratio (e.g. kilograms of liquid per kilogram of laundry). If the liquid level does not satisfy the predetermined fill level, then the method may return to 608 and continue to supply liquid to the wash basket 318. If the liquid level does satisfy the predetermined fill level, then the method may continue to supply liquid to the wash basket 318 such that the volumetric supply rate Q_{in} is generally equal to the volumetric drain rate Q_{out} at 612 to maintain the liquid level at the desired fill level for a predetermined period of time. The determination at 610 may be repeated intermittently at predetermined intervals or continuously until it is determined that the liquid fill level is satisfied.

[0090] During the agitate stage 604 of the wash phase 502, liquid may continue to be supplied to the wash basket 318 to maintain the liquid level at or near the predetermined fill level. Maintaining the liquid level may include intermittently or continuously supplying liquid to the wash basket 318 such that the volumetric supply rate Q_{in} is generally equal to the volumetric drain rate Q_{out} to maintain the liquid level at the fill level according to the cycle of operation. The liquid may be fresh liquid from the household water supply 378 and/or recirculated liquid from the catch basin 366. The recirculated liquid carrying a treating chemistry may be recirculated onto the laundry in the wash basket 318 to facilitate treating the laundry with the treating chemistry. It will be understood that

the liquid level inside the wash basket 318 may vary throughout the wash phase 502 and that maintaining the liquid level at the predetermined fill level includes maintaining the liquid level within a predetermined range of fill levels above and below the predetermined fill level.

[0091] At 614, mechanical energy may be supplied to the laundry to facilitate the removal of soils and stains from the laundry. Applying mechanical energy may include activating the clothes mover 324, rotating the wash basket 318 and/or recirculating liquid onto the laundry. At the conclusion of the wash phase 502, the method may proceed at 616 to the next phase of the wash cycle 500.

[0092] The manner in which the liquid is initially supplied to the system at 606 may vary depending on the configuration of the washing machine 310. In one scenario, water from the household water supply 378 may be supplied to the catch basin 366 to dilute treating chemistry supplied to the catch basin 366 to form a wash liquid and then the wash liquid may be supplied to the laundry through the recirculation conduit 380 to treat the laundry. Water may continue to be supplied to the catch basin 366 as needed in order to continue circulating liquid such that the volumetric supply rate Q_{in} is greater than the volumetric drain rate Q_{out} to increase the liquid level in the wash basket 318. Alternatively, water from the household water supply 378 may be supplied directly to the wash basket 318. Water that drains into the catch basin 366 may be recirculated back into the wash basket 318 during and/or after the supply of water from the household water supply 378 begins to increase the liquid level in the wash basket 318.

[0093] The total amount of water in the system is equal to the amount of water within the wash basket 318 and the amount of water stored in the catch basin 366 and recirculation system. Water from the household water supply 378 may be supplied intermittently or continuously until the fill level in the wash basket 318 is satisfied at 610. Water from the household water supply 378 may also be added as needed after the fill level is satisfied to keep the liquid level within the catch basin 366 from falling below a predetermined liquid level to avoid running the pump 384 dry and to provide enough liquid to continue recirculating liquid such that the volumetric supply rate Q_{in} is generally equal to the volumetric drain rate Q_{out} to maintain the liquid level in the wash basket 318 at 612.

[0094] The volumetric drain rate Q_{out} relates to the rate at which liquid naturally drains by gravity from the wash basket 318 through the drain holes 322a, b. The volumetric supply rate Q_{in} may be controlled at 608 based on the known volumetric drain rate Q_{out} to supply liquid to the wash basket 318 at a greater volumetric rate than the liquid is draining from the wash basket 318 such that the liquid may accumulate within the wash basket 318 to a predetermined fill level. The rate at which liquid is supplied to the wash basket 318 through the recirculation system and/or the household water supply 378 may be controlled in any manner, as described above, to supply the liquid at the predetermined volumetric supply rate Q_{in} .

[0095] The controller 392 may be pre-programmed with a control program that includes one or more algorithms or databases relating the volumetric supply rate Q_{in} with a predetermined fill level based on the known volumetric drain rate Q_{out} for the system. The volumetric drain rate Q_{out} may be determined for a given wash basket configuration and is related to constant variables, such as the configuration of the drain holes in the wash basket 318, including shape, size, amount, and location, and the size of the wash basket 318, as

well as non-constant variables, such as the amount and type of laundry in the wash basket 318 and the speed at which the wash basket 318 is rotating. In one example, for a given wash basket size and drain hole configuration, the controller 392 may be provided with a database of volumetric supply rates Q_{in} based on load amount to reach the predetermined fill level. In another example, the controller 392 may be provided with an algorithm based on the predetermined volumetric drain rate Q_{out} and input variables such as load amount, load type, and/or the selected cycle of operation may be provided as inputs to the algorithm to determine the rate at which to supply liquid to the wash basket 318 to reach the predetermined fill level. The volumetric supply rate Q_{in} may also be determined such that the predetermined fill level is satisfied within a predetermined period of time.

[0096] The determination of when the liquid level satisfies the predetermined fill level at 610 may be based on sensor data or on empirical data. One or more liquid level sensors, non-limiting examples of which include optical sensors or pressure sensors, may be used to determine when the liquid level in the wash basket 318 satisfies the predetermined fill level. Alternatively, the predetermined fill level may be determined to be satisfied by the controller 392 using pre-programmed algorithms or stored databases relating the predetermined fill level to one or more characteristics of the system. For example, a predetermined volume of liquid may be supplied to the washing machine 310 based on the load amount and/or type and recirculated to the wash basket 318 and the fill level may be determined to be satisfied after a predetermined period of time has passed according to a pre-programmed algorithm provided to the controller 392.

[0097] Controlling the supply of liquid at 612 such that the volumetric supply rate Q_{in} is generally equal to the volumetric drain rate Q_{out} in order to maintain the liquid level at the predetermined fill level may be based on sensor data or on empirical data. For example, the washing machine 310 may be provided with a flow rate sensor that determines the rate at which the liquid is draining from the wash basket 318 and liquid may be supplied to the wash basket 318 by the pump 384 or the controllable valve 400, for example, at a flow rate generally equal to the rate at which the liquid is draining from the wash basket 318. Alternatively, the controller 392 may be pre-programmed with one or more algorithms or a stored databases relating the predetermined fill level with a volumetric supply rate Q_{in} that will maintain the fill level.

[0098] FIG. 9 demonstrates the relationship between an equilibrium fill level for a given wash basket and the volumetric supply rate. The graphs in FIG. 9 are based on the assumption that the drain rate is proportional to the square root of the fill level within the wash basket and that at equilibrium, the volumetric supply rate Q_{in} is generally equal to the volumetric drain rate Q_{out} . The graphs in FIG. 9 are provided for the purposes of discussion only and not necessarily representative of real data. Graphs 650, 652, and 654 illustrate the relationship between the volumetric supply rate Q_{in} and the equilibrium fill level for a wash basket configuration in which the base includes a set of drain holes and a single row of drain holes is provided in the side wall of the wash basket. As the number of holes in the side wall increases, the volumetric supply rate required to reach a given equilibrium fill level also increase.

[0099] Graph 656 represents a scenario in which the configuration of drain holes is similar to the configuration represented by graph 652 except for that the basket includes an

additional second row of drain holes provided in the side wall of the basket. As illustrated in FIG. 9, when the fill level reaches a predetermined fill level 658 within the wash basket that corresponds to the second row of drain holes, the relationship between the volumetric supply rate Q_{in} and the equilibrium fill level changes. As illustrated by graph 660, the configuration of drain holes within the wash basket can be varied to provide a linear relationship between the volumetric supply rate Q_{in} and the equilibrium fill level. The data represented in FIG. 9 demonstrates that the relationship between the volumetric supply rate Q_{in} and the equilibrium fill level for a given washing machine configuration can be determined and used to provide a data table or pre-programmed control algorithm to the controller 392 for use by the washing machine 310 in maintaining the liquid level in the wash basket 318 at the predetermined fill level.

[0100] While the method 600 is described in the context of the wash phase 502, it will be understood that the method 600 may be used during any phase of a cycle of operation in which it is desired to fill the wash basket to a predetermined fill level. For example, the method 600 may be used in a pre-treatment phase or a rinse phase in which it is desired to fill the wash basket to a predetermined fill level with a treating liquid having one or more treating chemistries, non-limiting examples of which include a stain pre-treater, dye transfer inhibitor, and water repellent chemistry.

[0101] Referring again to FIG. 7, following the wash phase 502, an optional extraction phase 504 may be implemented to drain liquid from the wash basket 318 prior to supplying rinse liquid to the wash basket 318 in the rinse phase 506. The extraction phase 504 may include stopping the supply of liquid to the wash basket 318 and allowing the liquid to drain through the drain holes 322a, b while the wash basket 318 is stationary or rotating. In one example, the wash basket 318 may be rotated at high spin speeds to facilitate removal of liquid from the laundry by centrifugal force, as is known in the art.

[0102] While the extraction phase 504 is illustrated as a separate phase from the wash phase 502, the extraction phase 504 may also overlap with the end of the wash phase 502. For example, towards the end of the agitate stage 604 of the method 600, the rate at which liquid is supplied to the wash basket 318 may be decreased or stopped such that the volumetric supply rate Q_{in} is less than the volumetric drain rate Q_{out} . When the volumetric supply rate Q_{in} is less than the volumetric drain rate Q_{out} , the liquid level in the wash basket 318 will decrease because liquid is draining from the wash basket 318 at a faster rate than it is being supplied. The extraction phase 508 may be implemented in a similar manner to drain liquid from the wash basket 318 and to extract liquid from the laundry.

[0103] Liquid may be supplied to the wash basket 318 during the rinse phase 506 such that the volumetric supply rate Q_{in} is less than the volumetric drain rate Q_{out} to keep too much liquid from accumulating within the wash basket 318. The volumetric supply rate Q_{in} may be selected to allow rinse liquid to percolate through the laundry to rinse away soils and stains that have been lifted from the laundry items during the wash phase 502.

[0104] FIG. 10 illustrates a schematic of a vertical axis washing machine 710 that is similar to the washing machine 310 of FIG. 6 except for the connection between the pump 784 and the closure 751. Therefore, elements in the washing machine 710 similar to those of washing machine 310 are

labelled with the prefix **700**. Only those elements necessary for a complete understanding of the embodiments of the invention are illustrated and it will be understood that the clothes washer **710** may include additional elements traditionally found in a clothes washer without deviating from the scope of the invention.

[0105] As illustrated in FIG. **10**, the pump **784** may be coupled directly with the closure **751** through a conduit **800**. Liquid may drain from the wash basket **718** through the drain holes **722a, b** in a manner similar to that described above for the washing machine **310** of FIG. **6**. Liquid drained from the wash basket **718** may collect in the closure **751** and be pumped to either the recirculation conduit **780** or the drain conduit **790** through the drain port **754** and conduit **800**. While only a single drain port **754** is illustrated, the closure **751** may be provided with multiple drain ports **754** fluidly coupled with the pump **784** through one or more conduits **800** to pump liquid from the closure **751**. The conduit **800** may be a flexible conduit to accommodate movement of the closure **751** relative to the pump **784** during operation of the washing machine **710**. In this manner, the washing machine **710** may be provided with a single structure that performs the functions of the closure **51, 151, 351** and catch basin/sump **66, 166, 366**. When a single structure is used, the closure **751** may also be referred to as the catch basin/sump.

[0106] The methods described herein may be used with any of the washing machines **10, 110, 310**, and **710** to control the volumetric supply rate Q_{in} of liquid supplied to the wash basket relative to the volumetric drain rate Q_{out} of liquid draining from the wash basket such that liquid can accumulate within the wash basket, be maintained at a constant liquid level, or drain from the wash basket as needed according to the selected cycle of operation. The embodiments of the invention provide a method to control the liquid level within just the wash basket itself in a manner that does not require filling a coextensive liquid tub to the same fill level, as occurs in a traditional washing machine.

[0107] In some static-tub washing machines, a hole-less wash basket is used. Liquid is removed from the holeless wash basket by spinning the wash basket such that the liquid travels up the sides of the wash basket and spills out over the top of the wash basket or through holes located near the top of the wash basket. However, in this type of wash basket, heavy soils can be difficult to remove and thus may accumulate in the bottom of the wash basket. In addition, spinning a wash basket with a large amount of liquid therein can lead to an unstable dynamic condition which can extend cycle time and potentially result in undesirable movement and noise from the wash basket. Furthermore, extracting liquid from the laundry by having the liquid move up the sides of the wash basket can result in higher remaining moisture content in the laundry, which may lead to longer drying times.

[0108] The wash basket **18, 118, 318**, and **718** described herein includes drain holes in the end and side walls of the wash basket, allowing heavy soils to drain out of the wash basket. In addition, liquid can be drained from the wash basket without spinning the wash basket at high speeds, thus minimizing the potential for an unstable dynamic condition that can occur when a wash basket with a large amount of liquid therein is rotated at higher speeds.

[0109] The previously described washing machines **10** and **110** with the static wash tub may be used to implement one or more embodiments of the invention. The embodiment of the invention may be used in increasing the size of the wash

basket and correspondingly the treating capacity of laundry items by eliminating the clearance between the wash basket and the suspending tub. The embodiments of the invention may also be used to control the operation of the washing machines **10, 110** to improve the treating efficiency of the laundry items during the wash cycle by continuously or semi-continuously percolating the wash liquid through the laundry items in the wash basket. The embodiments of this invention may also be used in attaining the maximum rotational speed of the wash basket for high dehydration efficiency and/or eliminating the mechanical contact between the basket and tub during the dehydrating step. The embodiments of this invention may also be used in designing the washing machine **110** to which any balancing system is not provided by means of the rotatable tub that may rotate at substantially identical speeds with the wash basket. The embodiments of this invention may further be used in blocking the wash liquid and/or vapor escaping from the interior of the static wash tub such that mechanical parts such as the motor assembly, may not be impinged by the wash liquid and/or vapor.

[0110] To the extent not already described, the different features and structures of the various embodiments may be used in combination with each other as desired. That one feature may not be illustrated in all of the embodiments is not meant to be construed that it may not be, but is done for brevity of description. Thus, the various features of the different embodiments may be mixed and matched as desired to form new embodiments, whether or not the new embodiments are expressly described. All combinations or permutations of features described herein are covered by this disclosure. The primary differences between the exemplary embodiments relate to the location of the static wash tub relative to the cabinet, presence of a rotatable tub, numbers and location of drain holes in the basket, the coupling of first and second boots to the seal bearings, the location and number of suspension system, the location and configuration of the catch basin and pump, and these features may be combined in any suitable manner to modify the above embodiments and create new embodiments. As examples, the detergent dispenser may be provided with one or more conduits for providing one or more treating chemistries to the catch basin. The seal may not be limited to the labyrinth seal, and may include any mechanical seals providing seals preventing leakage. It is also noted that the rotatable tub may be provided to the washing machine with a closure system having the sump provided with the flange. In addition, the methods **500** and **600** may be used with any of the washing machines **10, 110, 310**, and **710**.

[0111] While the invention has been specifically described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not of limitation. Reasonable variation and modification are possible within the scope of the forgoing disclosure and drawings without departing from the spirit of the invention which is defined in the appended claims.

What is claimed is:

1. A laundry treating appliance for treating laundry items according to an automatic cycle of operation comprising:
 - a cabinet defining an interior;
 - a wash basket mounted within the cabinet for rotation about a vertical axis and defining a treating chamber for receiving laundry items for treatment;

a plurality of drain holes, provided in the wash basket, and configured to drain liquid supplied to the wash basket at a predetermined volumetric drain rate;
 a motor located within the cabinet drivingly coupled to the wash basket for rotating the wash basket;
 a catch basin coupled with the cabinet for accommodating liquid draining from the wash basket through the plurality of drain holes; and
 a recirculation pump configured to supply liquid from the catch basin to the wash basket at a predetermined volumetric supply rate;
 wherein the predetermined volumetric supply rate is controlled based on the predetermined volumetric drain rate to control an amount of liquid in the wash basket according to the automatic cycle of operation.

2. The laundry treating appliance of claim 1 wherein the predetermined volumetric supply rate is greater than the predetermined volumetric drain rate such that liquid supplied to the wash basket accumulates within the wash basket to a predetermined fill level to treat laundry items according to the automatic cycle of operation.

3. The laundry treating appliance of claim 1 wherein the predetermined volumetric supply rate is the same as the predetermined volumetric drain rate to maintain a liquid level in the wash basket at a predetermined fill level to treat laundry items according to the automatic cycle of operation.

4. The laundry treating appliance of claim 1 wherein the predetermined volumetric drain rate is based on at least one of an amount of the drain holes, a shape of the drain holes, at least one dimension of the drain holes, or a location of the drain holes.

5. The laundry treating appliance of claim 1 wherein the wash basket comprises an end wall and at least one side wall extending from the end wall to define the treating chamber and wherein at least a portion of the plurality of drain holes are provided in the end wall of the wash basket.

6. The laundry treating appliance of claim 1 wherein the predetermined fill level is based on an amount of laundry, a type of laundry, a selected cycle of operation, or a combination thereof.

7. The laundry treating appliance of claim 1 wherein the predetermined fill level satisfies a predetermined liquid-to-laundry ratio.

8. The laundry treating appliance of claim 1 wherein the recirculation pump is operated to supply liquid to the wash basket at least one of as a continuous supply or in multiple discrete supplies.

9. The laundry treating appliance of claim 1, further comprising a valve coupled with the recirculation pump through a liquid supply conduit to supply liquid to the wash basket, and wherein the valve is operated to supply the liquid to the wash basket at the predetermined volumetric supply rate.

10. A method of controlling a laundry treating appliance having a rotatable wash basket defining a treating chamber for receiving laundry items for treatment according to an automatic cycle of operation, the method comprising:

supplying liquid to the wash basket at a predetermined volumetric supply rate;

draining liquid from the wash basket by gravity at a predetermined volumetric drain rate; and

filling the wash basket to a predetermined fill level based on an amount of laundry, a type of laundry, a selected cycle of operation, or combinations thereof;

wherein the predetermined volumetric supply rate is controlled based on the predetermined volumetric drain rate to control an amount of liquid in the wash basket according to the automatic cycle of operation.

11. The method of claim 10 wherein the predetermined volumetric supply rate is greater than the predetermined volumetric drain rate such that liquid supplied to the wash basket accumulates within the wash basket to a predetermined fill level to treat laundry items according to the automatic cycle of operation.

12. The method of claim 10 wherein the predetermined volumetric supply rate is the same as the predetermined volumetric drain rate to maintain a liquid level in the wash basket at a predetermined fill level to treat laundry items according to the automatic cycle of operation.

13. The method of claim 10 wherein the wash basket comprises a plurality of drain holes configured to drain liquid supplied to the wash basket, and wherein the predetermined volumetric drain rate is based on at least one of an amount of the drain holes, a shape of the drain holes, at least one dimension of the drain holes, a location of the drain holes or combinations thereof.

14. The method of claim 13 wherein the wash basket comprises an end wall and at least one side wall extending from the end wall to define the treating chamber and wherein the drain holes are provided in the end wall of the wash basket.

15. The method of claim 10 wherein the predetermined fill level is based on an amount of laundry, a type of laundry, a selected cycle of operation, or a combination thereof.

16. The method of claim 10 wherein the predetermined fill level satisfies a predetermined liquid-to-laundry ratio.

17. The method of claim 10 wherein the supplying liquid to the wash basket comprises at least one of a continuous supply of liquid or multiple discrete supplies of liquid.

18. The method of claim 10 wherein the supplying the liquid comprises supplying the liquid through a liquid supply conduit and a valve, and further comprising operating the valve at the predetermined volumetric supply rate to supply the liquid to the wash basket.

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