(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 September 2010 (16.09.2010)

PCT

(10) International Publication Number
WO 2010/103521 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/IL2010/000204

(22) International Filing Date:
10 March 2010 (10.03.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/159,819 13 March 2009 (13.03.2009) US

(72) Inventor; and
(71) Applicant : KOCHAVI, Avner [IL/IL]; 28/22 Oranim St., 18362 Afula (IL).

(74) Agent: ZOHAR ELIEZRI INTELLECTUAL PROPERTY PATENT ATTORNEYS AND LAW OFFICE; 8 Nachalat Yitzchak St., 67448 Tel Aviv (IL).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) **Title**: WATER DISTRIBUTION SYSTEM AND METHOD

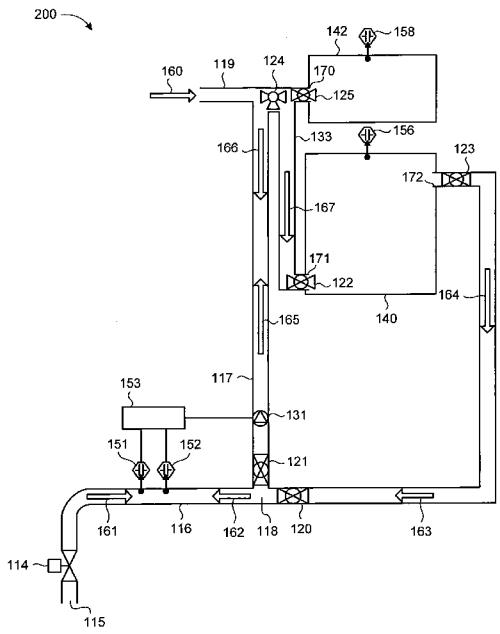


FIG. 2

(57) **Abstract**: Water distribution system, including at least a hot water piping, a diverting piping, an air-water exchanger and a hot water source. The hot water piping provides hot water to a user at a point-of-use through a faucet. The air water exchanger selectively removes retained water retained in a hot water piping portion, into the diverting piping, when at least one activation criteria is met, while admitting air into the hot water piping portion through the faucet to replace the displaced retained water. The air water exchanger ceases operation when at least one deactivation criteria is met, after which the hot water piping portion is refilled with hot water from the hot water source.

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WATER DISTRIBUTION SYSTEM AND METHOD

FIELD OF THE DISCLOSED TECHNIQUE

The disclosed technique relates to hydraulic systems and methods, and more specifically to the heating and cooling of water in a water distribution system.

BACKGROUND OF THE DISCLOSED TECHNIQUE

Typical domestic and industrial water distribution systems include separate hot piping and cold piping for delivering hot and cold water to respective hot and cold points-of-use, or alternatively to a common point-of-use, via a faucet. Standing water along the hot piping gradually cools down due to the lower temperature of the surroundings. As a consequence, the water that exits the hot piping might be significantly lower than the desired temperature for washing or other uses. Normally, to obtain hot water at the desired temperature, the water remaining in the hot piping must go to waste in order for hot water to reach the faucet. Generally, between initiating a request for hot water until its subsequent supply, hot water contained in the hot piping that has cooled down is flushed out of the piping and into the sink until the incoming hot water becomes warm enough for use.

US 4,606,325 to Lujan Jr., entitled "Multi-controlled water conservation system for hot water lines with low pressure utilization

disable", is directed to a water conservation system that recirculates cooled hot water back to a water heater from remote hot water locations. The water conservation system includes manual, timer based and thermostat based controls, and further includes a controller gated by a water pressure switch to prevent system operation when the water pressure from the main water supply is too low.

US 4,628,902 to Comber, entitled "Hot water distribution system", is directed to a system that circulates cooled water to a hot water tank through a return pipe forming a closed loop with the hot water supply pipe. A one-way check valve prevents the dispensing of the lower temperature water from the return pipe.

US 4,700,884 to Barrett et al, entitled "Dispensing system", is directed to a system for dispensing liquid at a desired temperature. The system includes a mechanism for diverting cooled water to a recovery means until the temperature reaches the desired temperature selected by the operator.

US 4,936,289 to Peterson, entitled "Usage responsive hot water recirculation system", discloses an energy conservation apparatus for controlling a hot water distribution system. The hot water distribution system includes a flow sensor installed in the cold water line to the water heater, which detects water usage and indicates when to turn on a recirculating pump. The system further includes mechanisms for preventing activation during very short usages or if the distribution system

is already hot, for operating a pump for a preset minimum duration, and for monitoring leakage and sensor problems.

US 5,009,572 to Imhoff et al., entitled "Water conservation device", discloses a device that can be installed in conjunction with existing plumbing systems and fixtures. When the water temperature drops below a set temperature on the thermostat, cooled water in hot water pipes is pumped into a cold water line via a pump and a solenoid valve. When water reaches a set temperature, the pump and the solenoid valve are deactivated, and a light provides an indication thereof.

US 5,042,524 to Lund, entitled "Demand recovery hot water system", discloses a system that provides intermittent circulation of hot water from a hot water source to a plumbing fixture and back. The system may include a transfer tank with a moveable piston separating the tank into two compartments. Water is displaced from the first compartment into the hot water source while water flows into the second compartment from a conduit, and water is displaced from the second compartment into the conduit while water flows into the first compartment from the hot water source.

US 5,105,846 to Britt, entitled "Water conserving purge system for hot water lines", is directed to a water conservation system where a purge line connects a hot water line with a cold water line adjacent to a hot water outlet valve. A pump is actuated to withdraw a slug of cooled water from the hot water line and transfer it to the cold water line. Hot

water from a water heater flows in to replace the withdrawn water. The system further includes a timer that can control the duration of the pumping operation.

US 5,339,859 to Bowman, entitled "Water conservation system", discloses a system that directs unheated water in a hot water line to a storage tank. The stored water is subsequently introduced into and mixed with incoming cold water from a main supply. Heated water lines are maintained at a pressure greater than unheated water lines.

US 5,603,344 to Hall Jr., entitled "Apparatus for recovering and saving chilled water in hot water lines having adjustable thermostatic control", is directed to a water saving device that utilizes a hydraulically powered pump to pump a portion of cool water from a hot water pipe to a cold water pipe, until the water in the hot water pipe reaches a desired temperature. The pump is powered by allowing some of the water from the hot water pipe to escape from the hot water tap.

US 6,039,067 to Houlihan, entitled "Selectable control energy and water conservation system", is directed to a water and energy conservation system. The system includes a flow control valve that may be positioned in a water saver mode, a use mode or an energy saver mode. In the water saver mode, a pump draws out water from a hot water distribution conduit to the hot water supply and hot water is pumped in. In the use mode, cold water pressure is directed to the hot water supply. In the energy saver mode, hot water is forced towards an open hot water

outlet under cold water supply pressure, so that all the hot water delivered to the distribution conduit is utilized.

US 6,161,567 to Ziehm, entitled "Single chamber water circulator", is directed to a water circulation device that can be installed in a water supply pipe leading only to a water heater, leaving cold water pipes untouched. The device utilizes the convective forces produced by the cooling of warm water in a return line, resulting in an upward flow of hot water in a distribution line from the heater, and a downward flow of cooler water in a return line.

US 6,895,985 to Popper et al., entitled "Smart device and system for improved domestic use and saving of water", discloses a system for providing a user with water at a desired temperature. The system includes a smart water delivery device (e.g., a smart faucet) coupled to the hot and cold water pipes. The water delivery device includes a circulation mechanism that circulates water from the hot water pipe to the cold water pipe. Water in the hot water pipe having a temperature lower than the desired temperature is transferred to the cold water pipe through the water delivery device, bringing the water temperature at the outlet of the water delivery device to the desired temperature.

SUMMARY OF THE DISCLOSED TECHNIQUE

In accordance with one aspect of the disclosed technique, there is thus provided a water distribution system that includes a hot water piping, a diverting piping connected to the hot water piping at a diverting junction, an air-water exchanger situated in the diverting piping, and a hot water source connected to the hot water piping. The hot water piping provides hot water to a point-of-use through a faucet. When at least one activation criteria is met, the air-water exchanger removes retained water retained in a portion of the hot water piping, while admitting air into the hot water piping portion through the faucet to replace the displaced retained water. The air-water exchanger ceases operation when at least one deactivation criteria is met. Subsequently, the hot water piping portion is refilled with hot water from the hot water source, and the hot water is delivered to the user at the point-of-use. The activation criteria may include: when the faucet is turned on to a hot water setting, when the detected temperature of the water in the hot water piping portion is below an activation-temperature-threshold, when the detected water flow in the hot water piping portion is above an activation-flow-threshold, when a predetermined time interval has elapsed since water was removed from the hot water piping portion, when an aperture is open for admitting ambient air into the hot water piping portion, and/or when an activation command is provided to the air-water exchanger. Correspondingly, the deactivation criteria may include: when the faucet is turned off, when the

detected temperature of the water in the hot water piping portion is above a deactivation-temperature-threshold, when the detected water flow in the hot water piping portion is below a deactivation-flow-threshold, when a predetermined time interval has elapsed since the air-water exchanger was activated, when no aperture is open for admitting ambient air into the hot water piping portion, and/or when a deactivation command is provided to the air-water exchanger. The retained water may be diverted along the diverting piping to a water storage unit, such as a hot water tank or an expansion tank. The water distribution system may admit cooled water to the hot water piping portion via the diverting piping, in order to reduce the temperature of the water in the hot water piping portion to below a maximum temperature threshold. The water distribution system may include a unit, situated at the faucet outlet of a mixer faucet, for preventing cold water from a cold water piping from entering the hot water piping portion when the air-water exchanger is activated and the faucet is turned on to an intermediate setting. The unit includes a diaphragm between the cold water piping and the hot water piping, where the diaphragm is configured to selectively shift between a first position that allows water to flow from the cold water piping toward the faucet outlet, and a second position that prevents water from flowing from the cold water piping toward the faucet outlet. The water distribution system may include a backflow prevention unit for preventing water from being drawn back into the faucet toward the hot water piping, while enabling ambient air to enter the faucet.

The water distribution system may include a module situated at the end of the hot water piping at the faucet outlet, for ensuring that the retained water is removed when necessary, regardless of whether the air-water exchanger was recently activated, and avoiding unnecessary removal of the retained water. The module includes a washer with a first opening and a second opening. The first opening substantially closes when the ambient temperature is above a temperature threshold level, such as by use of a bimetallic strip, and the second opening includes a valve that allows water to flow from the hot water piping to the faucet outlet while preventing water flow from the faucet outlet toward the hot water piping.

In accordance with another aspect of the disclosed technique, there is thus provided a water distribution method. The water distribution method includes the procedure of selectively removing retained water retained in a portion of a hot water piping of a water distribution system, with an air-water exchanger, into a diverting piping, when at least one activation criteria is met. The water distribution method further includes the procedure of admitting air into the hot water piping portion through a faucet, to replace the retained water while the retained water is being removed. The water distribution method further includes the procedure of ceasing removal of the retained water from the hot water piping portion when at least one deactivation criteria is met. The water distribution method further includes the procedure of refilling the hot water piping portion with hot water from a hot water source, and providing the hot water

to a user at a point-of-use. The water distribution method may further include the procedures of measuring the temperature of water in the hot water piping with a temperature sensor, and detecting the presence of water in the hot water piping with a flow sensor. The activation criteria may include: when the faucet is turned on to a hot water setting, when the detected temperature of the water in the hot water piping portion is below an activation-temperature-threshold, when the detected water flow in the hot water piping portion is above an activation-flow-threshold, when a predetermined time interval has elapsed since water was removed from the hot water piping portion, when an aperture is open for admitting ambient air into the hot water piping portion, and/or when an activation command is provided to the air-water exchanger. Correspondingly, the deactivation criteria may include: when the faucet is turned off, when the detected temperature of the water in the hot water piping portion is above a deactivation-temperature-threshold, when the detected water flow in the hot water piping portion is below a deactivation-flow-threshold, when a predetermined time interval has elapsed since the air-water exchanger was activated, when no aperture is open for admitting ambient air into the hot water piping portion, and/or when a deactivation command is provided to the air-water exchanger. The retained water may be diverted along the diverting piping to a water storage unit, such as a hot water tank or an expansion tank. The water distribution method may further include the procedure of admitting cooled water to the hot water piping portion via the

diverting piping, to reduce the temperature of water in the hot water piping portion to below a maximum-temperature-threshold. The water distribution method may further include the procedure of preventing cold water from a cold water piping from entering the hot water piping portion, when the air-water exchanger is activated and the faucet is a mixer faucet that is turned on to an intermediate setting, with a unit situated at the faucet outlet. The water distribution method may further include the procedure of preventing water from being drawn back into the faucet, while enabling ambient air to enter the faucet, with a backflow prevention unit. The water distribution method may further include the procedure of ensuring that the retained water is removed when necessary, regardless of whether the air-water exchanger was recently activated, and avoiding unnecessary removal of the retained water, with a module situated at the end of the hot water piping at the faucet outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosed technique will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Figure 1A is a schematic illustration of the configuration a water distribution system where a diverting pump is in operation, operative in accordance with an embodiment of the disclosed technique;

Figure 1B is a schematic illustration of the configuration of a water distribution system where a diverting pump is not in operation, operative in accordance with an embodiment of the disclosed technique;

Figure 2 is a schematic illustration of the configuration of a water distribution system, constructed and operative in accordance with another embodiment of the disclosed technique;

Figure 3A is a schematic illustration of a unit for preventing cold water from entering the hot water piping when pumping retained water, constructed and operative in accordance with an embodiment of the disclosed technique;

Figure 3B is a schematic illustration of the installation of the unit of Figure 3A in a mixer faucet, in accordance with an embodiment of the disclosed technique;

Figure 3C is an exploded view of the unit of Figure 3A with a first exemplary configuration, in an opened state and a closed state,

constructed and operative in accordance with an embodiment of the disclosed technique;

Figure 3D is an exploded view of the unit of Figure 3A with a second exemplary configuration, in an opened state and a closed state, constructed and operative in accordance with another embodiment of the disclosed technique;

Figure 4A is a schematic illustration of a water distribution system having multiple faucets, constructed and operative in accordance with a further embodiment of the disclosed technique

Figure 4B is a schematic illustration of a module for ensuring the pumping and diverting of cooled water at the outlet of a faucet when necessary, while avoiding the unnecessary pumping and diverting of hot water at the faucet outlet, constructed and operative in accordance with an embodiment of the disclosed technique; and

Figure 5 is a flow diagram of a water distribution method, operative in accordance with an embodiment of the disclosed technique.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The disclosed technique provides a novel water-saving water distribution system and method that ensures that hot water is delivered immediately to a user. When hot water is requested by turning on a faucet to a hot water setting, an air-water exchanger removes cooled water in the hot water piping portion adjacent to the system outlet, and replaces the displaced water with air from outside the faucet. The removed water may be conveyed to a water storage unit, for subsequent reuse. After the cooled water is removed, the hot water piping portion is refilled with hot water, which is then supplied at the faucet outlet.

Reference is now made to Figures 1A and 1B. Figure 1A is a schematic illustration of the configuration of a water distribution system, generally referenced 100, where a diverting pump is in operation, operative in accordance with an embodiment of the disclosed technique. Figure 1B is a schematic illustration of the configuration of water distribution system 100, where the diverting pump is not in operation, operative in accordance with an embodiment of the disclosed technique. System 100 includes a hot water piping 116 for providing hot water from a hot water source to a point-of-use 115 via a faucet 114. System 100 further includes a cold water piping (not shown) for providing cold (i.e., unheated) water to point-of-use 115. System 100 further includes a diverting piping 117, which is connected to hot water piping 116 at diverting junction 118 upstream of point-of-use 115. System 100 further

includes a diverting pump 131, valves 120 and 121, a check valve 133, a temperature sensor 151 and a flow sensor 152. Diverting pump 131 is situated in diverting piping 117. Valve 120 is situated in hot water piping 116 upstream of diverting junction 118, towards the hot water source. Valve 121 is situated in diverting piping 117 upstream of diverting junction 118. Check valve 133 is situated between faucet 114 and point-of-use 115. Temperature sensor 151 and flow sensor 152 are situated within an evacuation length of hot water piping 116, upstream of faucet 114.

Diverting pump 131 is selectively operative for drawing at least some of the retained water in hot water piping 116 into diverting piping 117, while passively replacing the displaced water with air, introducing the air into an evacuation length of hot water piping 116. Valves 120 and 121 regulate the flow of water through hot water piping 116. Immediately before operating diverting pump 131, valve 120 is closed, and valve 121 is opened. Once all the water has been removed from the evacuation length, valve 121 is closed, and valve 120 is opened, allowing hot water to refill the evacuation length. Check valve 133 ensures that no water enters hot water piping 116 when diverting pump 131 is operating (e.g., if faucet 114 is turned on). Flow sensor 152 is operative to detect the presence of water in hot water piping 116. Temperature sensor 151 is operative to measure the water temperature in hot water piping 116.

Referring to Figure 1A, to initiate the hot water distribution process, faucet 114 is turned on to a hot water setting and then

temperature sensor 151 measures the temperature of the water in hot water piping 116. If the measured temperature is below an activation-temperature-threshold, then valve 120 is closed, valve 121 is opened, and diverting pump 131 is activated to remove retained water from an evacuation length of hot water piping 116 into diverting piping 117. Meanwhile, air is admitted into hot water piping 116 through faucet 114 to replace the removed water, as shown by the arrows in Figure 1A. Flow sensor 152 measures the flow of water in hot water piping 116. Referring to Figure 1B, when flow sensor 152 indicates that there is no flow, valve 121 is closed, diverting pump 131 is deactivated, and valve 120 is opened, to allow hot water from the hot water source to refill hot water piping 116.

In general, diverting pump 131 may be activated whenever hot water is required (e.g., when faucet 114 is turned on at a hot water setting), whenever the temperature of the water in hot water piping 116 drops below an activation-temperature-threshold, whenever the flow of water in hot water piping 116 is above a predetermined activation-flow-threshold, whenever a predetermined time interval has elapsed since water was last drawn from hot water piping 116, and any combination thereof. For example, if the temperature of the water in hot water piping 116 drops below a predetermined activation-temperature-threshold (e.g., 25°C) and faucet 114 is turned on, diverting pump 131 is activated. Conversely, if the temperature in hot water piping 116 measured by

temperature sensor 151 is above a predetermined deactivation-temperature-threshold, diverting pump 131 is stopped operating or prevented from beginning operation. Diverting pump 131 may also be activated in response to turning on faucet 114 if the time interval that has elapsed since system 200 was last used exceeds a predetermined time interval. Alternatively, diverting pump 131 may be activated at regular time intervals, regardless of whether faucet 114 is turned on, thereby providing for a fresh supply of hot water that has not had enough time to cool. Further alternatively, if flow sensor 152 senses that the flow of water in hot water piping 116 is above a predetermined activation-flow-threshold (e.g., 1 liter/min), diverting pump 131 is activated. Conversely, if the flow measured by flow sensor 152 falls below a predetermined deactivation-flow-threshold, the operation of diverting pump 131 is stopped. Flow sensor 152 is generally adapted to distinguish between flow directions. The measured flow may only be used to activate diverting pump 131 if faucet 114 is turned on, in order to avoid activation in case of a leakage in hot water piping 116. Diverting pump 131 may be prevented from being activated if the temperature of the water in hot water piping 116 as measured by temperature sensor 151 is above the deactivation-temperature threshold even if the flow as measured by flow sensor 152 is above the activation-flow-threshold and/or faucet 114 is turned on. It should be noted that the activation-temperature-threshold may be equal to or lower than the deactivation-temperature-threshold, and similarly, the

activation-flow-threshold may be equal to or greater than the deactivation-flow-threshold.

In general, the process of pumping retained water out of hot water piping 116 continues until the flow of water in hot water piping 116 falls below the deactivation flow-threshold. When the process of pumping is complete and water has been pumped out of the evacuation length of hot water piping 116, flow sensor 152 sends a signal indicating that the flow of water has ceased. The same signal is given when faucet 114 is turned off while diverting pump 131 is operating, since, by not letting air into the system, diverting pump 131 is pumping against a vacuum. Generally, the kind of pump used as diverting pump 131 would necessitate the presence of water in the vicinity of diverting pump 131. Consequently, diverting pump 131 is deactivated well before any air reaches diverting pump 131. It is appreciated that diverting pump 131 may be more generally embodied by an air-water exchanger, i.e., any appropriate device operative for replacing water in the piping with air.

According to an embodiment of the disclosed technique, a user may define the temperature-thresholds for activating and deactivating diverting pump 131 via a suitable input unit (not shown) that is operatively coupled with temperature sensor 151. For example, the user may define setpoints for the activation-temperature-threshold or for the deactivation-temperature-threshold. An output unit (not shown) may provide the user with information concerning the real-time temperature in hot water piping

116. Correspondingly, the user may also define the flow-thresholds for activating and deactivating diverting pump 131 via a suitable input unit (not shown) that is operatively coupled with flow sensor 152.

According to an embodiment of the disclosed technique, at least some of the retained water pumped out of the hot water piping may be diverted to a water storage unit. Reference is now made to Figure 2, which is a schematic illustration of the configuration of a water distribution system, generally referenced 200, constructed and operative in accordance with another embodiment of the disclosed technique. System 200 includes all the elements of system 100, with the addition of a hot water tank 140 and an expansion tank 142. Both hot water tank 140 and expansion tank 142 are situated upstream of diverting junction 118, and are capable of storing water. Hot water tank 140 receives cooled water at an inlet port 171, and provides heated water at an outlet port 172. Main piping 119 delivers unheated water to hot water tank 140, such as through an external cold water feed. Alternatively, main piping 119 may deliver heated water to hot water tank 140. Hot water tank 140 may be, for example, an immersion heater.

System 200 further includes a controller 153, coupled with temperature sensor 151, with flow sensor 152, and with diverting pump 131. Controller 153 is operative to selectively activate and deactivate diverting pump 131, in accordance with signals received from temperature sensor 151 and from flow sensor 152. Alternatively, diverting pump 131

may be activated and deactivated directly by temperature sensor 151 or flow sensor 152, or directly by a user.

System 200 also further includes valves 122, 123, 124 and 125, and level measurement devices 156 and 158. Valve 122 is situated at inlet port 171 of hot water tank 140, and regulates water entering hot water tank 140. Valve 123 is situated at outlet port 172 of hot water tank 140, and regulates water exiting hot water tank 140. Valve 125 is situated at inlet port 170 of expansion tank 142, and regulates water entering expansion tank 142. Valve 124 is a three-way valve situated at the junction of main piping 119 and the distal end of diverting piping 117. Valve 124 allows water to enter or leave piping 133 (towards or away from expansion tank 142 and hot water tank 140), and allows water to enter or leave diverting piping 117, but is a non-return valve with respect to main piping 119. Valve 124 may alternatively be embodied by a number of separate valves, by a three-way faucet, by a smart-faucet, or any equivalent device operative to control the flow of water at a junction. Level measurement device 156 is operative to detect the water level in hot water tank 140, and level measurement device 158 is operative to detect the water level in expansion tank 142. Level measurement devices 156 and 158 may be embodied by a level sensor, a ballcock or float valve, and the like.

Diverting pump 131 selectively operates for drawing at least some of the retained water in hot water piping 116 into diverting piping

117 while replacing the displaced water with air, which enters hot water piping 116 via faucet 114. Once all the water has been removed from an evacuation length of hot water piping 116 (and replaced with air), hot water is allowed to refill the evacuation length. It is noted that retained water may be removed from any portion of hot water piping 116, provided that air is able to enter from one end thereof, there is a point somewhere along hot water piping 116 at which the backflow stops, and hot water is returned to the evacuated section of hot water piping 116 to flow toward faucet 114 in the usual manner.

Water distribution system 200 diverts the retained water in diverting piping 117 into hot water tank 140 or expansion tank 142. The retained water is diverted into hot water tank 140 if certain conditions are met, such as if the water level in hot water tank 140, as measured by level measurement device 156, is below a maximum-level-threshold. Accordingly, when diverting pump 131 is activated, valve 124 blocks off main piping 119 and opens diverting piping 117 and piping 133. Valve 122 is opened, while valves 123 and 125 are closed, resulting in water flow along diverting piping 117 and into hot water tank 140, as indicated by arrows 165 and 167. When diverting pump 131 is deactivated, valve 124 closes off diverting piping 117 and opens main piping 119, while valve 123 is opened, thereby allowing water to flow from main piping 119 through hot water tank 140 and into hot water piping 116, as indicated by arrows 160, 167, 164, 163, and 162. Water distribution system may also

divert the retained water into hot water tank 140 if the water level in hot water tank 140 (as measured by level measurement device 156) is below a minimum-level-threshold, even if diverting pump 131 is not in operation.

If the water level in hot water tank 140 is above the maximum-level-threshold, the retained water in diverting piping 117 may be diverting into expansion tank 142, provided the water level in expansion tank 142, as measured by level measurement device 158, is below a maximum-level-threshold. Accordingly, when diverting pump 131 is activated, valve 124 blocks off main piping 119 and opens diverting piping 117 and piping 133. Valve 125 is opened, while valves 122 and 123 are closed, resulting in water flow along diverting piping 117 and into expansion tank 142. When diverting pump 131 is deactivated, valve 124 closes off diverting piping 117 and opens main piping 119, valve 125 is closed and valves 122 and 123 are reopened.

The stored water in expansion tank 142 may be subsequently admitted into hot water tank 140 and reheated for reuse in hot water piping 116. If certain conditions are met, such as if the water level in hot water tank 140, as measured by level measurement device 156, is below a maximum-level-threshold, and/or if the water level in expansion tank 142, as measured by level measurement device 158, is above a minimum-level-threshold, and/or if the flow along hot water piping 116, as measured by flow sensor 152, falls below the deactivation-flow-threshold during the operation of diverting pump, then valve 124 closes off main

piping 119, valve 123 is closed and valves 122 and 125 are opened, thereby admitting water from expansion tank 142 into hot water tank 140. Correspondingly, valve 125 is closed to stop water flow from expansion tank 142 into hot water tank if the required conditions are no longer met, such as if the water level in hot water tank 140 reaches the maximum-level-threshold. Optionally, water may be supplied concurrently to hot water tank 140 from both main piping 119 and expansion tank 142.

Diverting pump 131 may be operated only after a time-delay (e.g., 3 seconds) measured from the receipt of a feedback (e.g., from controller 153), indicative of valve 124 closing off main piping 119 while opening diverting piping 117. Additionally or alternatively, valve 124 may be responsively coupled with faucet 114 and/or with temperature sensor 151 and/or with flow sensor 152. For example, if the flow of water as sensed by flow sensor 152 during a predetermined time-span is above the activation-flow-threshold and/or if the temperature of the water as measured by temperature sensor 151 during the time span falls below the activation-temperature-threshold, valve 124 is directed to close off main piping 119 while opening diverting piping 117, faucet 114 is turned on and diverting pump 131 is then activated, optionally after a specific time-delay (e.g., 2 seconds). Controller 153 may be further coupled with level measurement devices 156 and 158, and selectively divert retained water into or out of hot water tank 140 and expansion tank 142, respectively, in accordance with signals received from level measurement devices 156

and 158. Furthermore, controller 153 may activate diverting pump 131 only if controller 153 has received a signal indicating that faucet 114 has been turned on. Controller 153 may also control the opening and closing of valves 120, 121, 122, 123, 124 and 125, respectively.

It is appreciated that water distribution system 200 may alternatively convey the retained water in diverting piping 117 to a type of water reuse facility or water treatment system. For example, water may be conveyed to an irrigation system, a drainage system, a sewage system, a cooling system, a heating system, a waste removal system, a cistern for a flushing toilet, a decorative fountain system, and the like.

Water distribution system 200 may be configured to avoid water exiting faucet 114 at a temperature that might scald the user. Accordingly, water distribution system 200 may be configured to reduce the temperature of the water exiting faucet 114 to below a maximum-temperature-threshold. For example, water at a temperature below the maximum-temperature-threshold may be supplied to hot water tank 140 via main piping 119 and/or via a length of cold piping (not shown), delivering cold water for cooling down the water in hot water tank 140 below the maximum-temperature-threshold. The cooled down water may then be conveyed from hot water tank 140 to hot water piping 116, after diverting pump 131 draws the retained water out of hot water piping 116. Therefore, water below the maximum-temperature-threshold may be mixed with water equal to or above the maximum-temperature-threshold,

until the temperature of the water in hot water piping 116 is sufficiently cooled. Additionally or alternatively, water at a temperature below the maximum-temperature-threshold may be provided directly to hot water piping 116 from main piping 119 or from a length of cold piping (not shown) to cool down the water, while diverting pump 131 draws the retained water out of hot water piping 116, until the temperature drops below the maximum-temperature-threshold. Further alternatively, if diverting pump 131 is not in operation, cold water from diverting piping 117 may be allowed to enter hot water piping 116 at junction 118, until the water temperature in hot water piping 116 drops below the maximum-temperature-threshold. The water temperature at hot water piping 116 can be adjusted by automatically opening and closing each of valves 120 and 121 until a predetermined temperature level is attained. The predetermined temperature level may be selected to meet safety or energy conservations standards, such as a temperature value of approximately 49°C. It is noted that the above described process for cooling down the water to a temperature below a maximum-temperature-threshold may be performed in conjunction with temperature sensor 151, and if necessary, a second temperature sensor (not shown) situated in the portion of hot water piping 116 between hot water tank outlet 172 and junction 118.

According to an embodiment of the disclosed technique, water distribution system 200 may be equipped with a heat exchanger (not

shown) for maintaining the temperature of the water in hot water piping 116 below the maximum-temperature-threshold. The heat exchanger may be coupled with hot water piping 116 and with main piping 119, or alternatively, with another separate cold water piping (not shown) bypassing hot water tank 140. The heat exchanger may be controllable in accordance with a proportional-integral-derivative controlling scheme to obtain a predetermined temperature setpoint for the water. Alternatively, diverting piping 117 may be configured to enable diverting pump 131 to pump cold water from a cold water source (not shown) into hot water tank 121 while permitting the flow of water from hot water piping 116 to faucet 114, in order to cool down the water exiting hot water tank 140. Further alternatively, water distribution system 200 may continuously maintain the water in hot water tank 140 at a temperature below the maximum-temperature-threshold using a cold water feed (not shown).

Water distribution system 200 may employ a power-supply backup system (not shown), to ensure operability of system components in case of a power outage.

In accordance with an embodiment of the disclosed technique, the water distribution system may include a unit to ensure that cold water from the cold water piping does not enter the hot water piping when pumping the retained water in hot water piping. For example, if faucet 114 is a mixer faucet (i.e., in which the hot and cold water from the respective feeds are mixed together before reaching the outlet) that is set to an

intermediate setting (resulting in the mixing of the hot and cold water), then the activation of diverting pump 131 would result in the pumping of water from the cold water piping in the portion adjacent to the faucet outlet. Reference is now made to Figures 3A and 3B. Figure 3A is a schematic illustration of a unit, generally referenced 250, for preventing cold water from entering the hot water piping when pumping retained water, constructed and operative in accordance with an embodiment of the disclosed technique. Figure 3B is a schematic illustration of the installation of the unit of Figure 3A in a mixer faucet, in accordance with an embodiment of the disclosed technique. Unit 250 includes a hot water piping port 252, a cold water piping port 254, diaphragms 256 and 258, a suction aperture 260, a lip seal 262, an o-ring seal 264, and a valve 266. Hot water piping port 252 is connected to the hot water piping 116 of water distribution system 200, while cold water piping port 254 is connected to a cold water piping 113 (not shown in Figure 2) of water distribution system 200. Referring to Figure 3B, unit 250 is installed between the wall-mounted mixer faucet 114 on one side and the hot water piping 116 and cold water piping 113 protruding from the wall (where the faucet is mounted) on the other side. Diaphragm 256 divides between the cold water chamber and the hot water chamber.

When mixer faucet 114 is turned on to an intermediate setting during normal operation, an equal pressure is provided on either side of diaphragm 256 due to the water flow from hot water piping 116 and the

water flow from cold water piping 113. Consequently, both the hot water and the cold water may flow freely to the faucet outlet 268 through lip seal 262, where the precise temperature of the water exiting faucet 114 is determined by the positioning of the faucet lever(s).

When diverting pump 131 (Figure 2) is activated to remove retained water in the hot water piping portion adjacent to faucet 114, a pressure differential arises, which forces valve 266 and diaphragms 256 and 258 towards suction aperture 260, and seals lip seal 262, such that the cold water cannot pass from cold water piping port 254 toward the faucet outlet 268. Consequently, the cold water is prevented from flowing out of the faucet 114 and from being sucked into the hot water piping 116 (during the pumping process). This sealing is maintained throughout the operation of diverting pump 131. Once diverting pump 131 is deactivated, valve 266 and diaphragms 256 and 258 return to their previous positions, allowing the cold water to flow freely toward faucet outlet 268 once again.

Unit 250 may be embodied by various types of mechanisms, techniques and materials. For example, valve 266 and diaphragm 256 may be shifted between positions on the basis of electrical forces, magnetic forces, mechanical forces, and the like. Accordingly, diaphragm 256 may take on various shapes or forms. Reference is now made to Figures 3C and 3D. Figure 3C is an exploded view of the unit of Figure 3A with a first exemplary configuration, in an opened state (referenced 272) and a closed state (referenced 274), constructed and operative in

accordance with an embodiment of the disclosed technique. Figure 3D is an exploded view of the unit of Figure 3A with a second exemplary configuration, in an opened state (referenced 276) and a closed state (referenced 278), constructed and operative in accordance with another embodiment of the disclosed technique. Referring to Figure 3C, diaphragm 256 is formed as a rigid cylinder. In state 272, diaphragm 256 is in an opened position, due to an equal pressure differential on both sides, enabling free flow of water from cold water piping port 254 through to faucet outlet 268 (as depicted by the arrows). In state 274, diaphragm 256 is in a closed position (i.e., the cylinder has moved to the right), having shifted toward suction aperture 260 due to the pressure differential (depicted by the arrow) arising from the operation of diverting pump 131 (not shown), thereby preventing the cold water from reaching faucet outlet 268.

Referring to Figure 3D, diaphragm 256 is formed as a flexible membrane. In state 276, diaphragm 256 is in an opened position (i.e., the membrane is slack) due to an equal pressure differential on both sides, enabling free flow of water from cold water piping port 254 through to faucet outlet 268 (as depicted by the arrows). In state 278, diaphragm 256 is in a closed position (i.e., the membrane is taut), having shifted toward suction aperture 260 due to the pressure differential (depicted by the arrow) arising from the operation of diverting pump 131 (not shown), thereby preventing the cold water from reaching faucet outlet 268.

If faucet 114 has a hose or extension tubing attached thereto (e.g., such as to facilitate usage in a bathtub or a kitchen sink), a vacuum breaker or an alternative backflow prevention unit may be employed to prevent water from being drawn back through the hose and into the faucet. When there is a pressure reduction within the hose (e.g., due to a water stoppage from the main supply), the vacuum breaker, which is situated between the faucet outlet and the hose inlet, has a mechanism that allows in air from the outside while preventing backflow of water towards the faucet.

Generally, the water distribution system conveys hot and cold water to multiple faucets and water outlets. If one of the faucets is turned on to release hot water and the system (via temperature sensor 151) senses that the water in the hot water piping (116) leading to the turned on faucet (114) has cooled (i.e., is below the activation-threshold-temperature), then the water distribution system (200) activates the diverting pump (131) to remove the water in that hot water piping portion while replacing the displaced water with air, and subsequently refills that hot water piping portion with hot water. However, if another faucet integrated with the water distribution system is turned on to a hot water setting immediately afterwards, the temperature sensor (151) will sense that the water in the hot piping portion is sufficiently hot (since hot water has just recently been introduced), even though the portion of the hot water piping directly adjacent to the second faucet may be cooled.

Consequently, the diverting pump (131) will not be activated and the second faucet will release the cooled water present in the hot piping portion adjacent to the faucet outlet (until the hot water in the further upstream portion of the hot water piping reaches the faucet). In accordance with an embodiment of the disclosed technique, the water distribution system may include a module to ensure that the cooled water at the outlet of a faucet is pumped and diverted when necessary, regardless of whether another faucet previously caused the diverting pump to operate (resulting in the presence of hot water in a subsequent upstream portion of the hot water piping).

Reference is now made to Figure 4A, which is a schematic illustration of a water distribution system, generally referenced 300, having multiple faucets, constructed and operative in accordance with a further embodiment of the disclosed technique. Water distribution system 300 is similar to water distribution system 200 (Figure 2). Water distribution system 300 includes a plurality of faucets 314A and 314B (each of which are analogous to faucet 114), which connect to respective hot water pipings 316A and 316B (each analogous to hot water piping 116) and to respective cold water pipings 313A and 313B (each analogous to cold water piping 113). Water distribution system 300 further includes a diverting pump 331 (analogous to diverting pump 131), a hot water tank 340 (analogous to hot water tank 140) and an expansion tank 342 (analogous to expansion tank 142). Water distribution system 300 further

includes a temperature sensor 351 (analogous to temperature sensor 151) and a flow sensor 352 (analogous to flow sensor 152) situated within a portion of hot water piping 316 upstream of faucets 314A and 314B and adjacent to hot water tank 342. Water distribution system 300 receives a main supply (of cold water) via main piping 319. Valve 320 is situated at the inlet of main piping 319. Valve 321 is situated downstream of diverting pump 331 and valve 322 is situated upstream of diverting pump 131 in diverting piping 317. Valve 323 is situated at an inlet of expansion tank 342, and valve 324 is situated at an outlet of expansion tank 342.

When faucet 314A is turned on to release hot water, temperature sensor 351 senses that the water in hot water piping portion 316 has cooled (i.e., is below the threshold temperature). Consequently, diverting pump 331 is activated, removing the retained water in hot water piping portions 316 and 316A and replacing the removed water with air (entering via faucet 314A). Subsequently, hot water piping portion 316 is refilled with hot water (from hot water tank 340 or expansion tank 342), which flows out through the outlet of faucet 314A along hot water piping portion 316A. If faucet 314B is turned on to release hot water immediately afterwards, temperature sensor 351 will then sense that the water in hot piping portion 316 is sufficiently hot (since hot water has recently been introduced thereto), even though hot water piping portion 316B (directly adjacent to the outlet of faucet 314B) has cooled. As a result, diverting pump 331 is not activated and faucet 314B releases the cooled water

present in hot piping portion 316B (until the hot water in hot water piping portion 316 reaches the outlet of faucet 314B).

Accordingly, a module for ensuring that the cooled water at the outlet of a faucet is pumped and diverted when necessary is installed at the faucet of each outlet of the multiple faucet water distribution system 300. Reference is now made to Figure 4B, which is a schematic illustration of a module, generally referenced 350, for ensuring the pumping and diverting of cooled water at the outlet of a faucet when necessary, while avoiding the unnecessary pumping and diverting of hot water at the faucet outlet, constructed and operative in accordance with an embodiment of the disclosed technique. Module 350 is a flat disk or washer situated at the end of hot water piping 316A at the outlet of faucet 314A. There are two openings on module 350: opening 352, which encompasses a small fraction (e.g., 10%-20%) of the surface area of module 350, and opening 354, which encompasses a large fraction (e.g., 80%-90%) of the surface area of module 350. Opening 352 includes a bimetallic strip, which is made up of two metals having different thermal expansion coefficients, causing the strip to bend a certain direction in response to a change in temperature. For example, when exposed to a temperature above a certain value (e.g., above 28°C), the bimetallic strip causes opening 352 to close by a certain amount (e.g., 80% of the surface area of opening 352 is blocked). Opening 354 includes a one-way/non-return valve, which allows water flow toward the faucet outlet

while preventing water flow in the opposite direction (toward hot water tank 340 at the other end of the hot water piping).

Referring back to Figure 4A, if faucet 314A is turned on to a hot water setting and there is cold water present in hot water piping 316A, opening 352 is fully opened, causing the water to begin flowing out of faucet 314A through openings 352 and 354. Flow sensor 352 detects the flow of water along hot piping portion 316, and initiates the activation of diverting pump 331, which pumps the retained water in hot piping portions 316 and 316A into diverting piping 317. Meanwhile, air from outside faucet 314A enters hot water piping 316A via opening 352, while no air flows in through opening 354 due to the one-way/non-return valve. As all other faucets (e.g., faucet 314B) in water distribution system 300 are turned off, the retained water at the respective outlets of these faucets are not pumped and diverted, and air cannot enter system 300 through these faucet outlets. The operation of diverting pump 331 continues until flow sensor 352 detects that there is substantially no water remaining in hot water piping portion 316, after which the pumping terminates. Hot water is then released from hot water tank 340, which flows along hot water piping portions 316 and 316A toward faucet 314A. Subsequently, the bimetallic strip heats up, causing opening 352 to be substantially blocked off, while opening 354 remains opened and allows hot water to flow through faucet 314A for use. Thus, regardless of whether there is hot water in hot water piping portion 316 when faucet 314A is turned on to a hot water setting,

diverting pump 331 will still be activated as long as there is cool water in hot water piping portion 316A.

Alternatively, if faucet 314A is turned on to a hot water setting and there is hot water present in hot water piping 316A, opening 352 is substantially closed (due to the heating of the bimetallic strip), and water begins flowing out of faucet 314A through opening 354. Flow sensor 352 detects the flow of water along hot piping portion 316, and initiates the activation of diverting pump 331, which begins pumping the retained water in hot piping portions 316 and 316A. A very small amount of air from outside faucet 314A enters hot water piping 316A via opening 352 (only a small fraction of which is opened due to the heating of the bimetallic strip), while no air enters in through opening 354 due to the one-way/non-return valve. As all other faucets (e.g., faucet 314B) in water distribution system 300 are turned off, air cannot enter system 300 through any of these faucet outlets. Since there is a very limited amount of entering air, the flow of water (along hot water piping portions 316 and 316A) toward diverting pump 331 is limited, causing flow sensor 352 to stop detecting a substantial water flow (i.e., the detected flow is below the activation-flow-threshold) and to terminate the operation of diverting pump 331. The hot water present in hot water piping portions 316 and 316A then proceeds to flow via opening 354 through faucet 314A for use (while additional hot water may be provided from hot water tank 340 if necessary). Thus, diverting pump 331 will not be operated (i.e., for a

sufficient duration that results in the pumping and diverting of retained water) as long as there is hot water in hot water piping portion 316A when faucet 314A is turned on to a hot water setting.

Further alternatively, if faucets 314A and 314B are each turned on to a hot water setting concurrently and there is cold water present in either hot water piping portions 316A or 316B (or both), the opening 352 of the associated module 350 is fully opened, leading to the full operation of diverting pump 331 and the pumping of the retained cold water in the associated hot water piping portion, as described hereinabove. The hot water from hot water tank 340 then flows through hot water piping portions 316, 316A and 316B via the openings 354 of the associated modules and out of faucets 314A and 314B for their respective use. Similarly, if faucets 314A and 314B are each turned on to a hot water setting concurrently and there is hot water present in both hot water piping portions 316A or 316B, the openings 352 of the respective modules 350 are substantially blocked, leading to the initial activation and nearly immediate termination of diverting pump 331, as described hereinabove, since the retained water in the respective hot water piping portions need not be pumped and diverted. The hot water in hot water piping portions 316, 316A and 316B (and any additional hot water provided from hot water tank 340 if necessary) then flows via the openings 354 of the associated modules and out of faucets 314A and 314B for their respective use.

It is appreciated that the very brief (e.g., approximately 1 second) pumping implemented by diverting pump 331 after flow sensor 352 detects a flow, when there is hot water present in hot water piping 316A, prevents full closure of, and thus prevents damage to, the hot water piping. Typically, it requires a few seconds to pump water through a piping length of a few meters (depending on the power of the pump).

It is noted that module 350 must be installed in each faucet of a multi-faucet water distribution system to ensure proper functioning of the module throughout the system. It is further noted that the use of module 350 in water distribution system 300 renders temperature sensor 351 redundant, ensuring the proper activation of diverting pump 331 when necessary using only flow sensor 352.

Reference is now made to Figure 5, which is a flow diagram of a water distribution method, operative in accordance with an embodiment of the disclosed technique. In procedure 310, retained water retained in a hot water piping portion of a water distribution system is selectively removed when at least one activation criteria is met. With reference to Figure 2, diverting pump 131 diverts the retained water in hot water piping portion 116 into diverting piping 117. Diverting pump 131 is activated if, for example, faucet 114 is turned on to a hot water setting and/or if temperature sensor 151 detects the temperature of the water in hot water piping portion 116 to be below an activation-temperature-threshold and/or if flow sensor 152 detects the flow of water in hot water piping portion 116

to be above an activation-flow-threshold and/or if a predetermined time interval has elapsed since water was last drawn out of hot water piping portion 116 and/or if at least one aperture is open for admitting ambient air into hot water piping portion 116 and/or if an activation command is provided to diverting pump 131.

In procedure 312, air is admitted into the hot water piping portion to replace the retained water while the retained water is being removed. With reference to Figure 2, air enters hot water piping portion 116 via the outlet of faucet 114, as the water from hot water piping portion 116 is being diverted into diverting piping 117. The air may enter hot water piping 116 through a one-way or non-return valve, which prevents entry of any water. The retained water may be diverted through diverting piping 117 into a water storage unit, such as into hot water tank 140 or expansion tank 142.

In procedure 314, the removal of retained water from the hot water piping portion is ceased when at least one deactivation criteria is met. With reference to Figure 2, diverting pump 131 is deactivated if, for example, all the water in hot water piping portion 116 is removed and flow sensor 152 detects the flow of water in hot water piping portion 116 to be below a deactivation-flow-threshold, and/or if temperature sensor 151 detects the temperature of the water in hot water piping portion 116 to be above a deactivation-temperature-threshold and/or if faucet 114 is turned off, and/or if a predetermined time interval has elapsed since pump 131

was activated and/or if a deactivation command is provided to diverting pump 131.

In procedure 316, the hot piping portion is refilled with hot water from a hot water source. With reference to Figure 2, hot water from hot water tank 140 is directed into hot water piping 116 (as depicted via arrows 163 and 164), or alternatively, hot water from expansion tank 142 is released directly into hot water piping 116, filling the air within.

In procedure 318, hot water is provided to a user. With reference to Figure 2, the hot water that has been refilled into hot water piping 116 flows out through the outlet of faucet 114 to a point-of-use 115.

It will be appreciated by persons skilled in the art that the disclosed technique is not limited to what has been particularly shown and described hereinabove.

CLAIMS

1. A water distribution system comprising:

a hot water piping for providing hot water to a point-of-use;

a diverting piping, connected to said hot water piping at a diverting junction;

an air-water exchanger, situated in said diverting piping, said air-water exchanger operative for selectively removing retained water retained in a hot water piping portion of said hot water piping into said diverting piping when at least one activation criteria is met, while admitting air into said hot water piping portion, said air-water exchanger ceasing operation when at least one deactivation criteria is met; and

a hot water source, connected to said hot water piping, said hot water source refilling said hot water piping portion with hot water after said air-water exchanger ceases operation.

2. The water distribution system of claim 1, further comprising a faucet connected with said hot water piping, wherein said air is admitted into said hot water piping portion through said faucet after said air-water exchanger is activated.

3. The water distribution system of claim 1, further comprising a temperature sensor situated in said hot water piping, operative for measuring the temperature of water in said hot water piping.

4. The water distribution system of claim 1, further comprising a flow sensor situated in said hot water piping, operative for detecting the presence of water in said hot water piping.

5. The water distribution system of claim 2, wherein said activation criteria is selected from the list consisting of:

said faucet is turned on to a hot water setting;

the detected temperature of the water in said hot water piping portion is below an activation-temperature-threshold;

the detected water flow in said hot water piping portion is above an activation-flow-threshold;

a predetermined time interval has elapsed since water was removed from said hot water piping portion;

at least one aperture is open for admitting ambient air into said hot water piping portion;

an activation command is provided to said air-water exchanger; and

any combination of the above.

6. The water distribution system of claim 2, wherein said deactivation criteria is selected from the list consisting of:

said faucet is turned off;

the detected temperature of the water in said hot water piping portion is above a deactivation-temperature-threshold;

the detected water flow in said hot water piping portion is below a deactivation-flow-threshold;

a predetermined time interval has elapsed since said air-water exchanger was activated;

no aperture is open for admitting ambient air into said hot water piping portion;

a deactivation command is provided to said air-water exchanger; and

any combination of the above.

7. The water distribution system of claim 1, wherein said air-water exchanger comprises a diverting pump.

8. The water distribution system of claim 2, further comprising a check valve disposed adjacent to the outlet of said faucet, said check valve operative to permit the entry of ambient air into said hot water piping portion while preventing the entry of water into said hot piping portion, when said air-water exchanger is activated.

9. The water distribution system of claim 1, further comprising a first valve situated between an outlet of said hot water source and said hot water piping portion, said first valve operative to prevent the flow of water from said hot water source into said hot water piping portion when said air-water exchanger is activated.

10. The water distribution system of claim 1, further comprising a second valve situated in said diverting piping, said second valve operative to prevent the flow of water from said hot water piping portion into said diverting piping when said air-water exchanger is deactivated.

11. The water distribution system of claim 1, wherein said retained water is diverted along said diverting piping into a water storage unit.

12. The water distribution system of claim 11, wherein said water storage unit is selected from the list consisting of:

a hot water tank;

an expansion tank;

an irrigation system;

a drainage system;

a sewage system;

a cooling system;

a heating system;

a waste removal system;

a cistern for a flushing toilet;

a decorative fountain system; and

any combination of the above.

13. The water distribution system of claim 1, wherein cooled water is admitted to said hot water piping portion via said diverting piping, to reduce the temperature of water in said hot water piping portion to below a maximum-temperature-threshold.

14. The water distribution system of claim 2, further comprising a unit, situated at the outlet of said faucet, said unit operative to prevent cold water from a cold water piping from entering said hot water piping portion, when said air-water exchanger is activated and said faucet is turned on to an intermediate setting.

15. The water distribution system of claim 14, wherein said unit comprises a diaphragm, configured to selectively shift between a first position that allows water flow from said cold water piping toward the outlet of said faucet, and a second position that prevents water flow from said cold water piping toward said outlet of said faucet.

16. The water distribution system of claim 2, further comprising a backflow prevention unit, operative to prevent water from being drawn back into said faucet toward said hot water piping, while enabling ambient air to enter into said faucet.

17. The water distribution system of claim 2, further comprising a module, situated at the end of said hot water piping at the outlet of said faucet, said module operative to ensure said retained water is removed when necessary and avoiding unnecessary removal of said retained water.

18. The water distribution system of claim 17, wherein said module comprises a washer with a first opening and a second opening, wherein said first opening substantially closes when the ambient temperature is above a temperature threshold level, and wherein said second opening comprises a valve that allows water flow from said hot water piping to said faucet outlet while preventing water flow from said faucet outlet toward said hot water piping.

19. The water distribution system of claim 18, wherein said first opening comprises a bimetallic strip.

20. A water distribution method, comprising the procedures of:

selectively removing retained water retained in a hot water piping portion of a hot water piping of a water distribution system, with an air-water exchanger, into a diverting piping, when at least one activation criteria is met;

admitting air into said hot water piping portion to replace said retained water while said retained water is being removed;

ceasing removal of said retained water from said hot water piping portion when at least one deactivation criteria is met;

refilling said hot water piping portion with hot water from a hot water source; and

providing said hot water to a user at a point-of-use.

21. The water distribution method of claim 20, wherein said air is admitted into said hot water piping portion through a faucet connected with said hot water piping.

22. The water distribution method of claim 20, wherein said procedure of selectively removing retained water comprises pumping said retained water with a diverting pump.

23. The water distribution method of claim 20, further comprising the procedure of measuring the temperature of water in said hot water piping with a temperature sensor.

24. The water distribution method of claim 20, further comprising the procedure of detecting the presence of water in said hot water piping with a flow sensor.

25. The water distribution method of claim 21, wherein said activation criteria is selected from the list consisting of:

said faucet is turned on to a hot water setting;

the detected temperature of the water in said hot water piping portion is below an activation-temperature-threshold;

the detected water flow in said hot water piping portion is above an activation-flow-threshold;

a predetermined time interval has elapsed since water was removed from said hot water piping portion;

at least one aperture is open for admitting ambient air into said hot water piping portion;

an activation command is provided to said air-water exchanger; and

any combination of the above.

26. The water distribution method of claim 21, wherein said deactivation criteria is selected from the list consisting of:

said faucet is turned off;

the detected temperature of the water in said hot water piping portion is above a deactivation-temperature-threshold;

the detected water flow in said hot water piping portion is below a deactivation-flow-threshold;

a predetermined time interval has elapsed since said air-water exchanger was activated;

no aperture is open for admitting ambient air into said hot water piping portion;

a deactivation command is provided to said air-water exchanger; and

any combination of the above.

27. The water distribution method of claim 20, wherein said retained water is diverted along said diverting piping into a water storage unit.

28. The water distribution method of claim 20, further comprising the procedure of admitting cooled water to said hot water piping portion via said diverting piping, to reduce the temperature of water in said hot water piping portion to below a maximum-temperature-threshold.

29. The water distribution method of claim 21, further comprising the procedure of preventing cold water from a cold water piping from entering said hot water piping portion, when said air-water exchanger

is activated and said faucet is turned on to an intermediate setting, with a unit situated at the outlet of said faucet.

30. The water distribution method of claim 29, wherein said procedure of preventing cold water from a cold water piping from entering said hot water piping portion comprises selectively shifting a diaphragm between a first position that allows water flow from said cold water piping toward said outlet of said faucet, and a second position that prevents water flow from said cold water piping toward said outlet of said faucet.

31. The water distribution method of claim 21, further comprising the procedure of preventing water from being drawn back into said faucet, while enabling ambient air to enter into said faucet, with a backflow prevention unit.

32. The water distribution method of claim 21, further comprising the procedure of ensuring that said retained water is removed when necessary and avoiding unnecessary removal of said retained water, with a module situated at the end of said hot water piping at the outlet of said faucet.

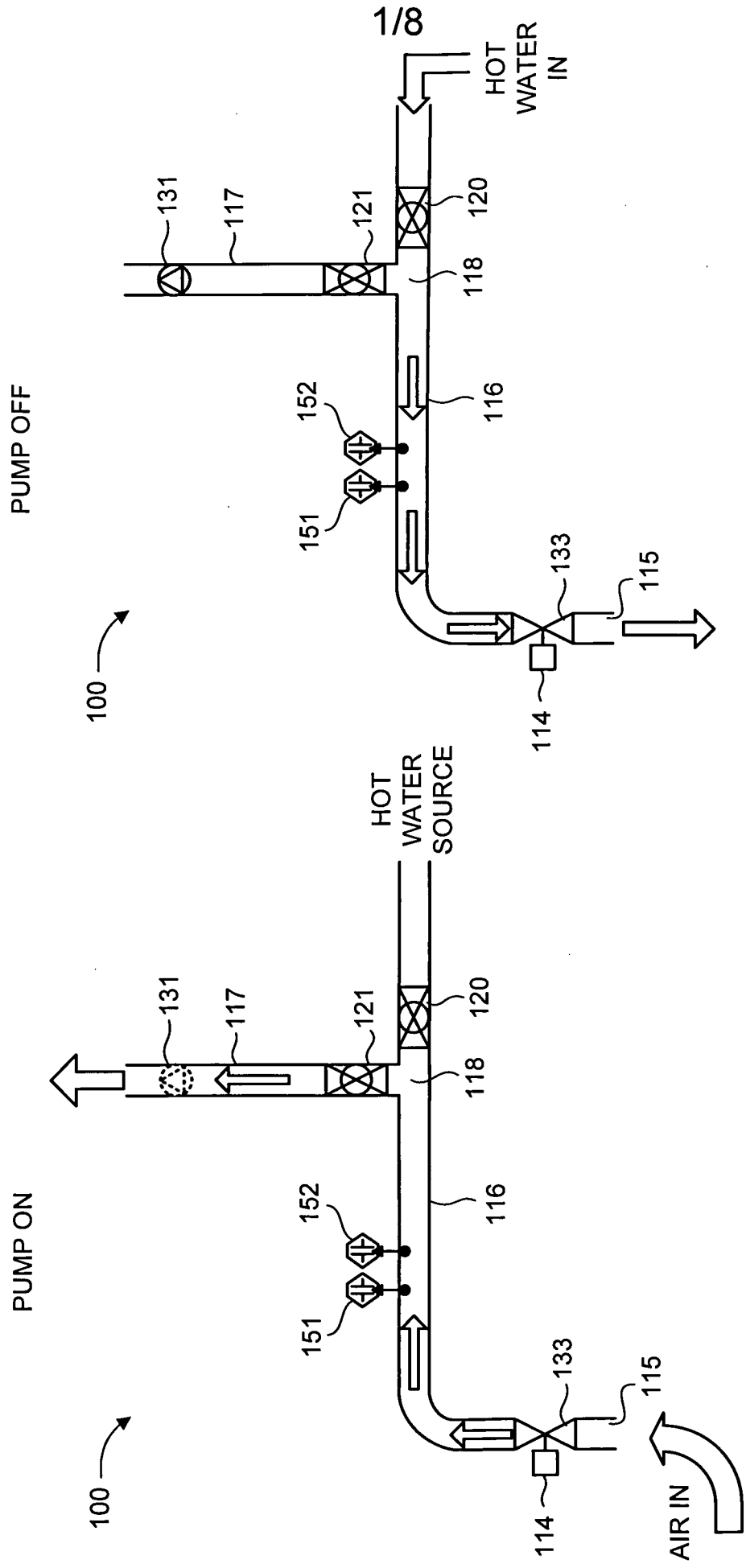

PUMP OFF
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HOT WATER IN
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AIR IN

FIG. 1B

FIG. 1A

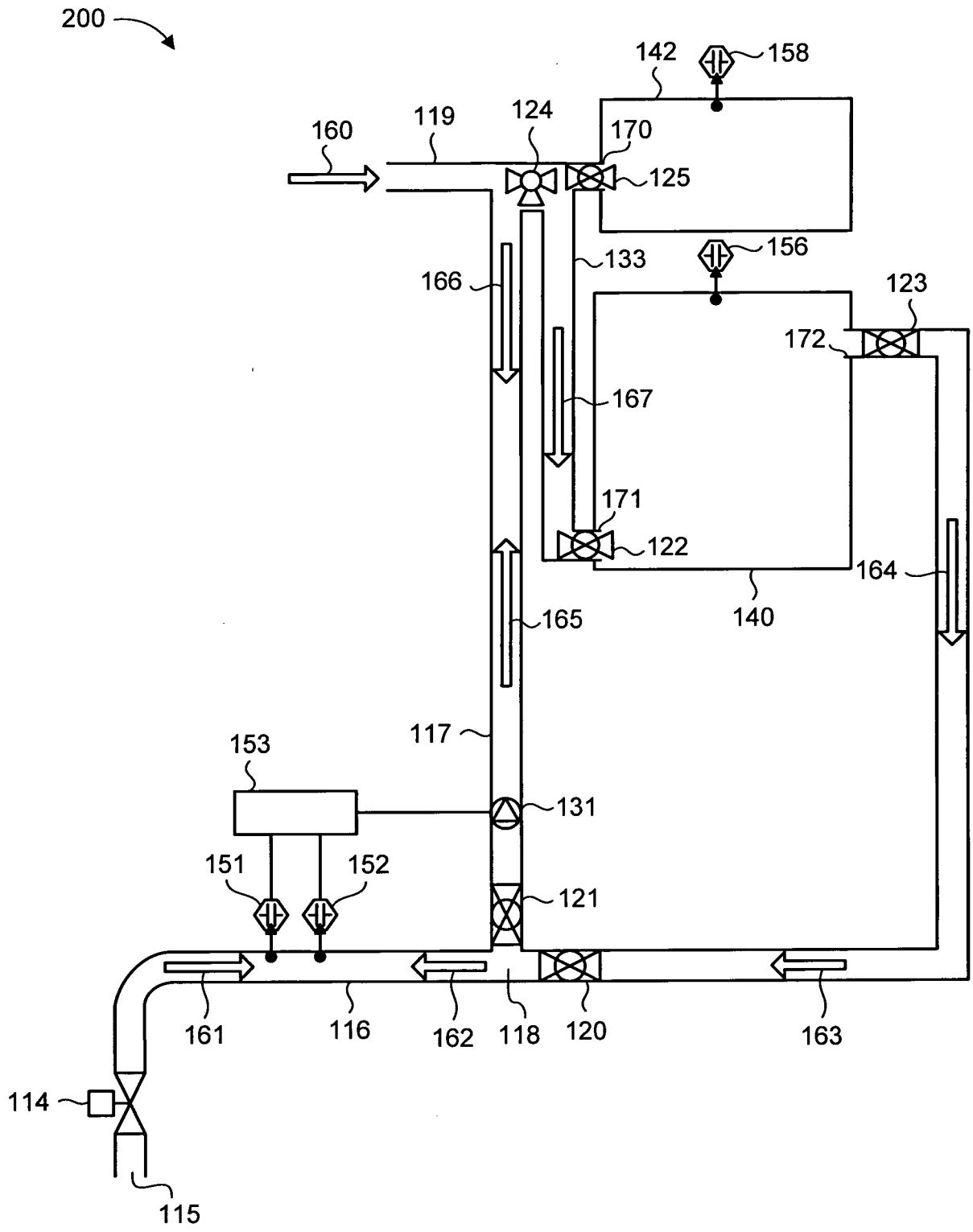

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115

FIG. 2

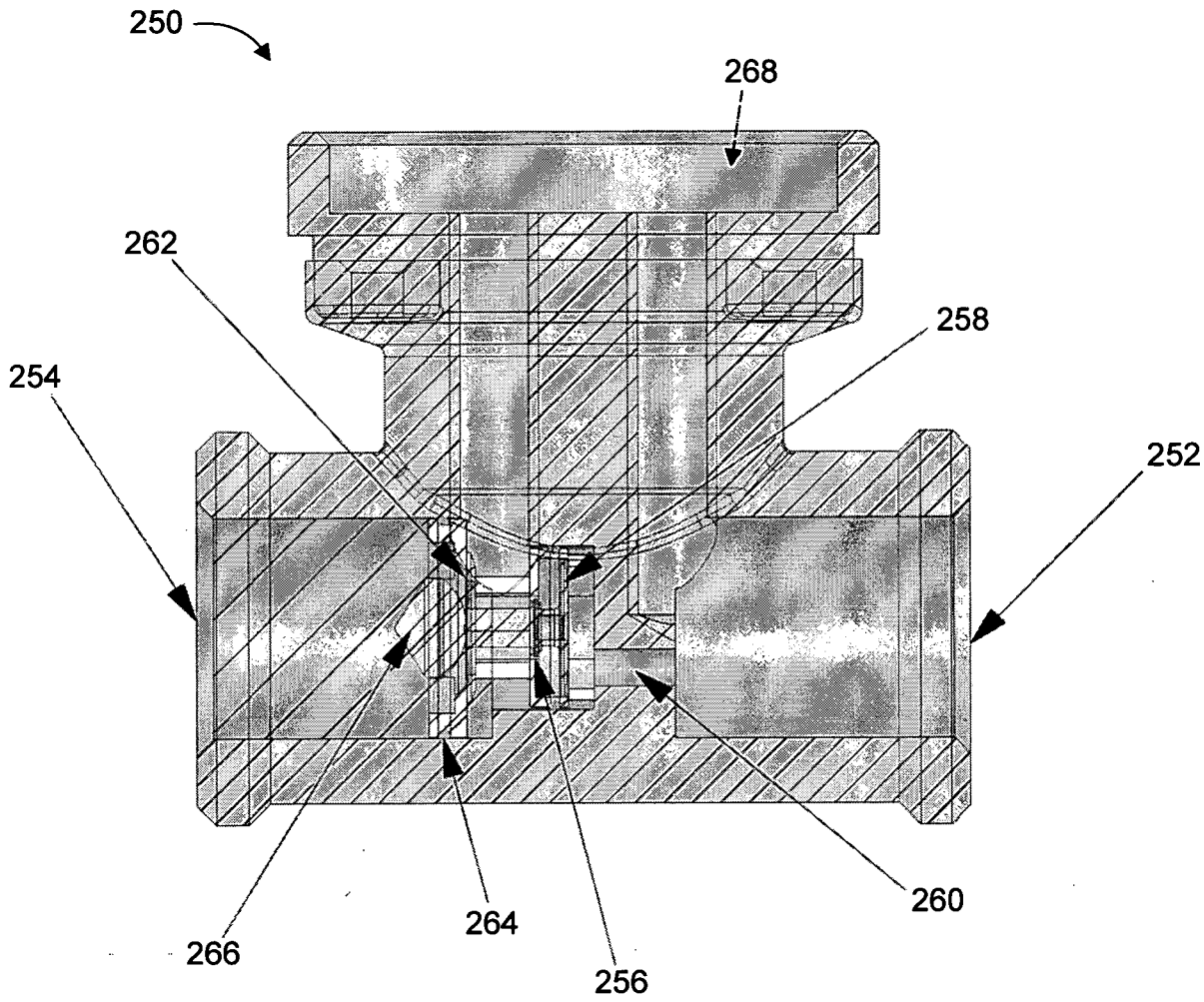


FIG. 3A

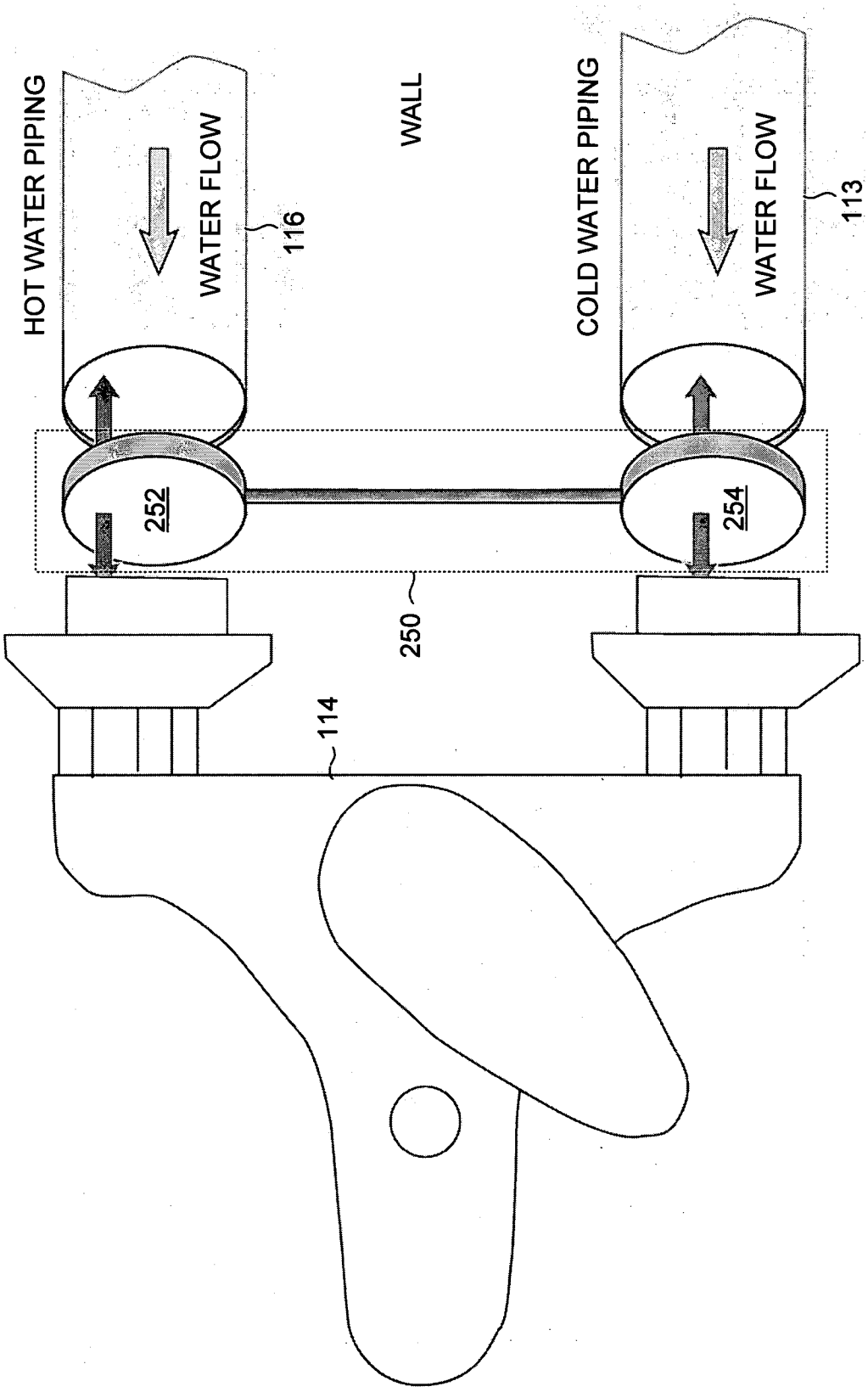

HOT WATER PIPING
WATER FLOW
116
WALL
COLD WATER PIPING
WATER FLOW
113
252
254
250
114

FIG. 3B

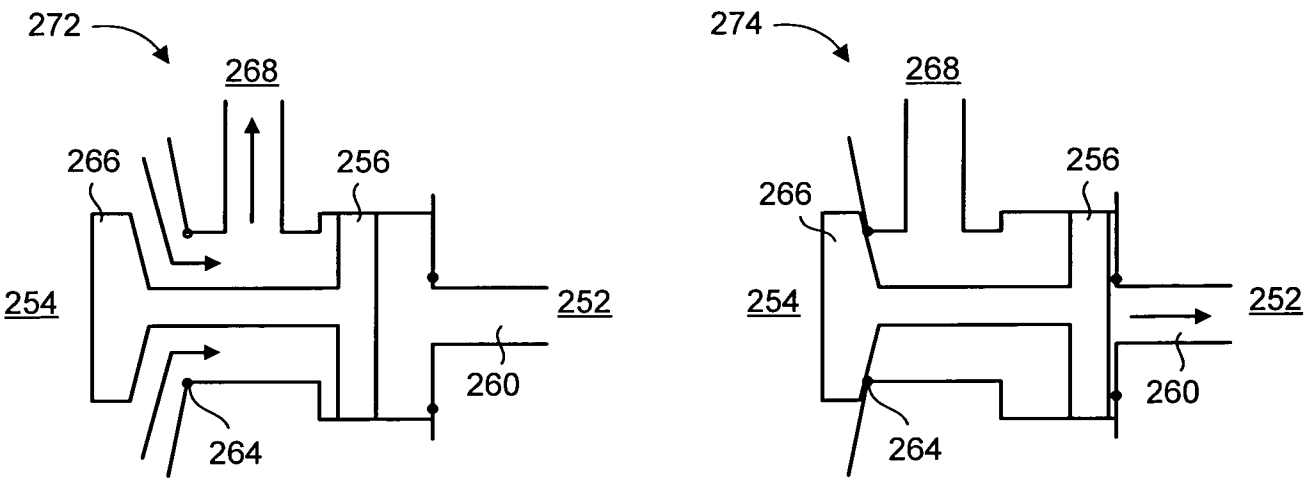

272
268
266
256
254
252
260
264
274
268
256
266
254
252
260
264

FIG. 3C

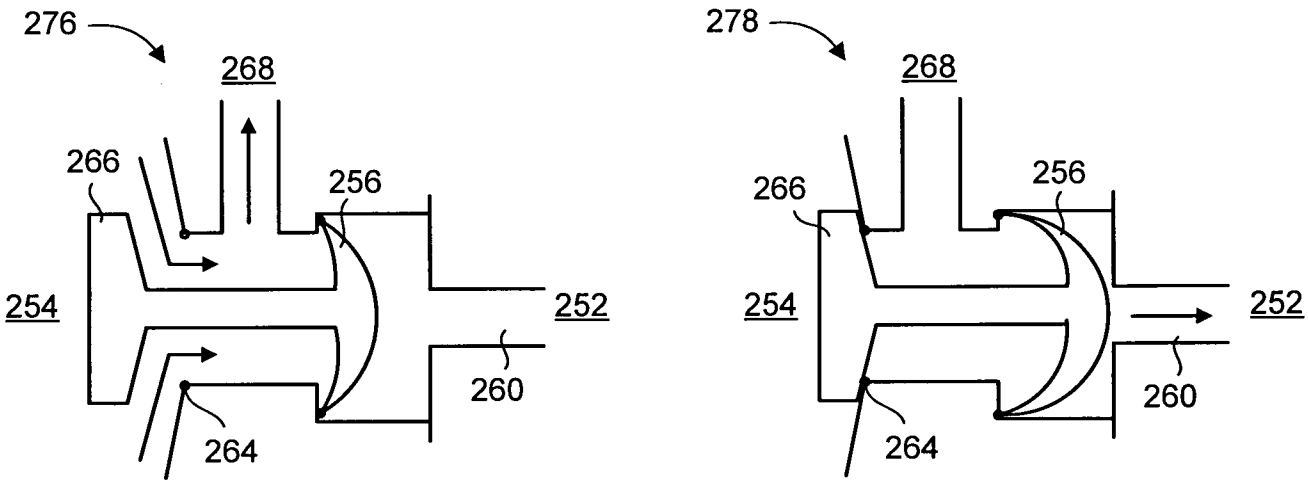

276
268
266
256
254
252
260
264
278
268
266
256
254
252
260
264

FIG. 3D

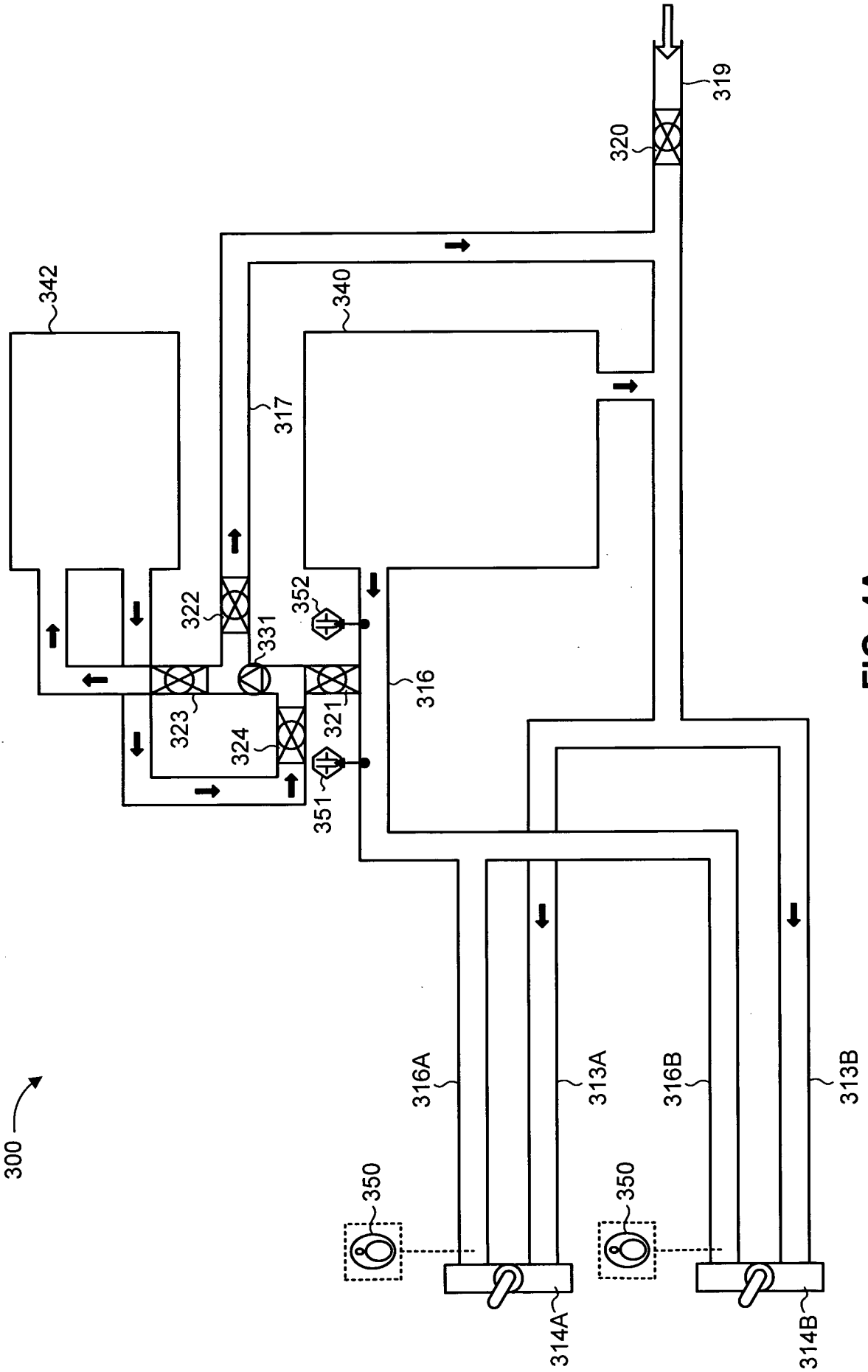

300
342
340
317
319
320
322
331
352
323
324
321
351
316
316A
313A
316B
313B
350
350
314A
314B

FIG. 4A

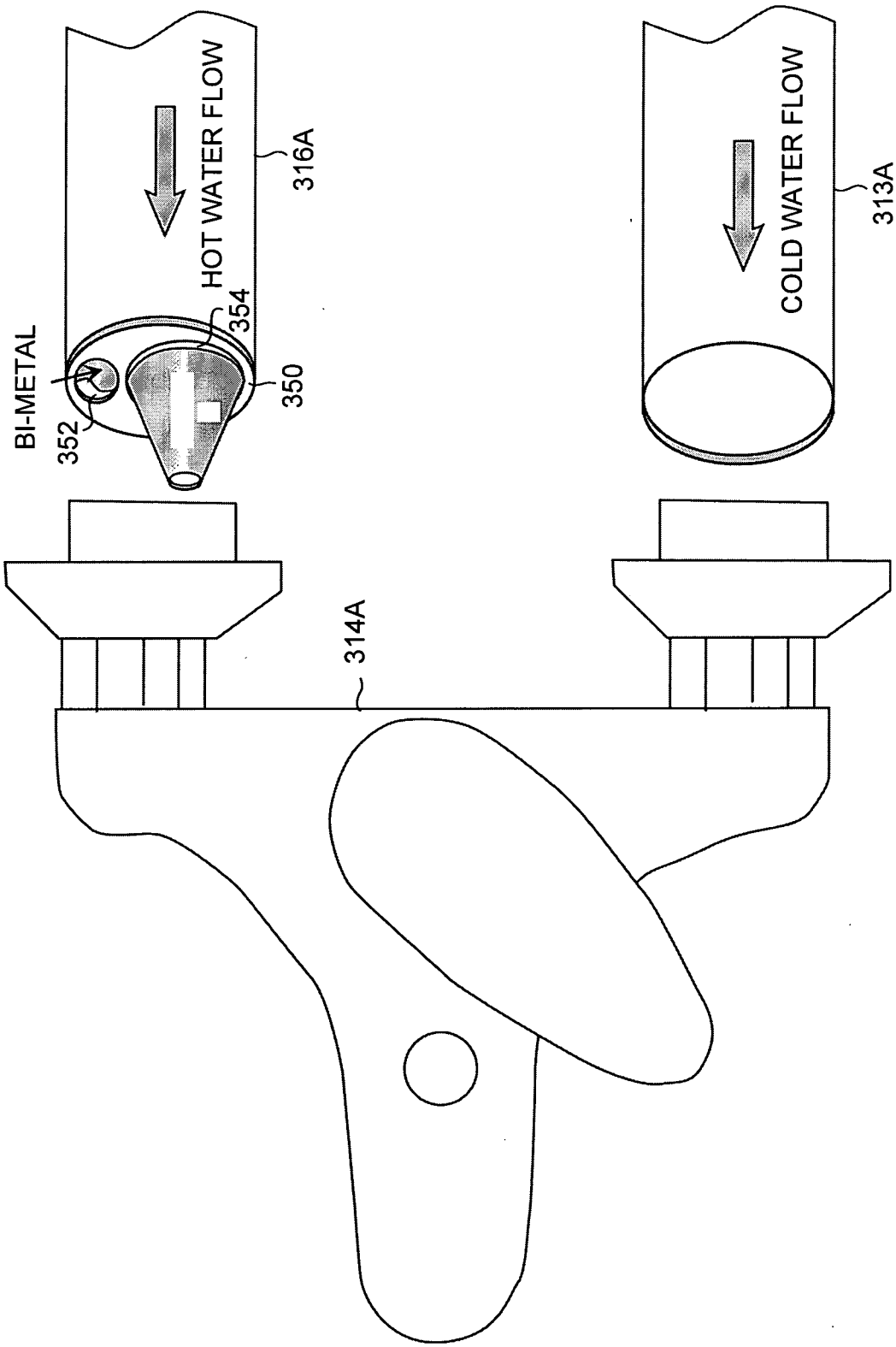

HOT WATER FLOW
316A
354
BI-METAL
352
350
COLD WATER FLOW
313A
314A

FIG. 4B

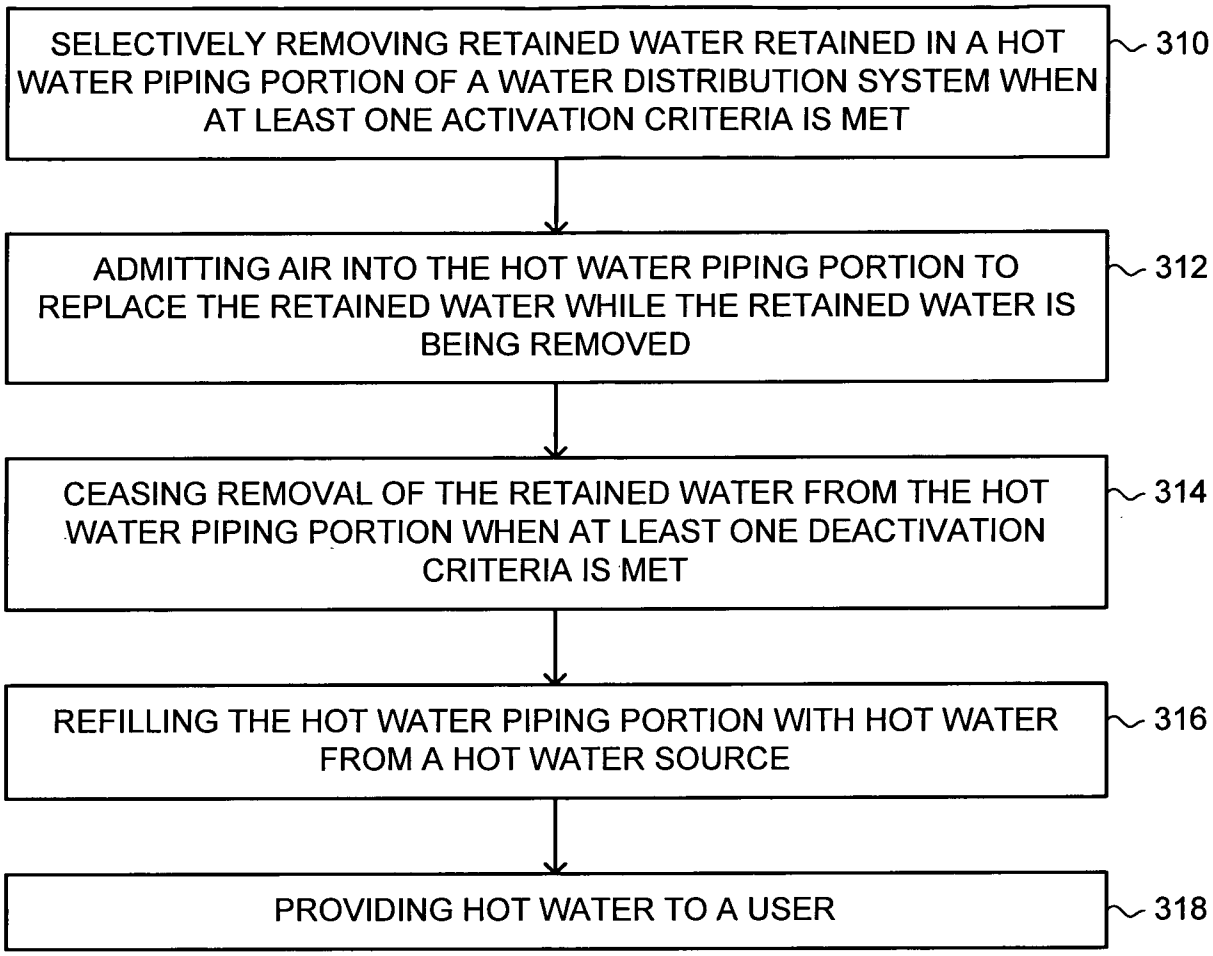

SELECTIVELY REMOVING RETAINED WATER RETAINED IN A HOT WATER PIPING PORTION OF A WATER DISTRIBUTION SYSTEM WHEN AT LEAST ONE ACTIVATION CRITERIA IS MET
310
ADMITTING AIR INTO THE HOT WATER PIPING PORTION TO REPLACE THE RETAINED WATER WHILE THE RETAINED WATER IS BEING REMOVED
312
CEASING REMOVAL OF THE RETAINED WATER FROM THE HOT WATER PIPING PORTION WHEN AT LEAST ONE DEACTIVATION CRITERIA IS MET
314
REFILLING THE HOT WATER PIPING PORTION WITH HOT WATER FROM A HOT WATER SOURCE
316
PROVIDING HOT WATER TO A USER
318

FIG. 5