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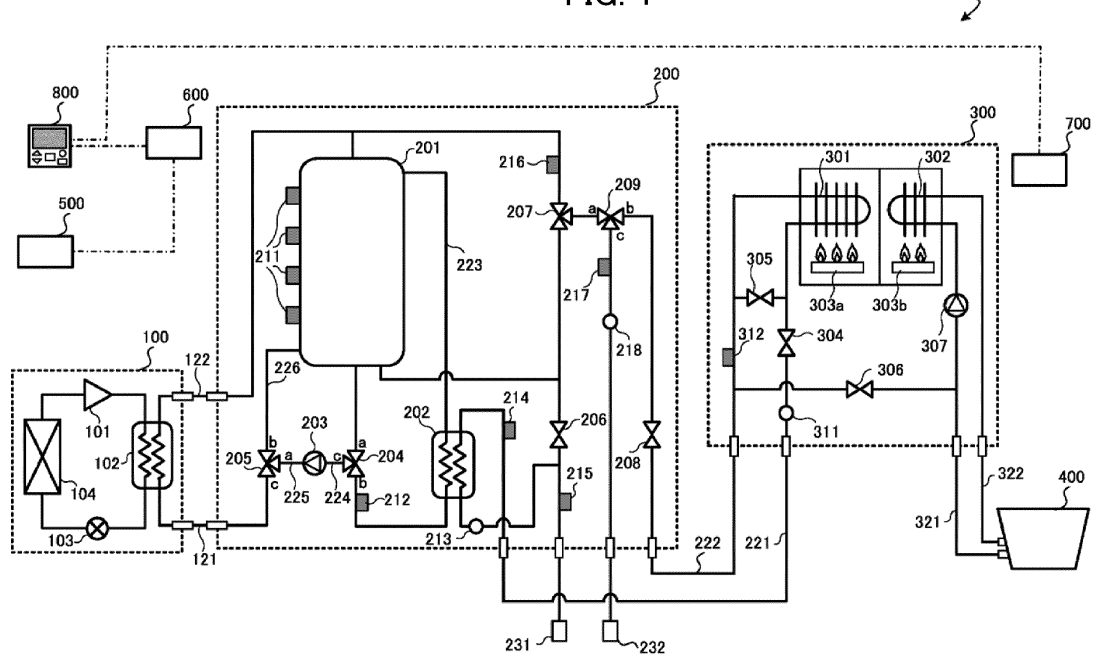
(54) STORAGE TYPE HOT WATER SUPPLYING DEVICE

(57) A heat pump unit (100) is configured to heat water to generate first hot water. A hot water storage tank (201) is configured to store the first hot water generated by the heat pump unit (100). A water-water heat exchanger (202) is configured to preheat municipal water through heat exchange between the first hot water taken from the hot water storage tank (201) and the municipal water. An auxiliary heat source unit (300) is configured to heat the municipal water preheated by the water-water heat exchanger (202) to generate second water. A hot water storage unit controller (600) is configured to control a hot-water supply switching valve (209) to supply the first hot water taken from the hot water storage tank (201) or the second hot water generated by the auxiliary heat source unit (300).

FIG. 1



EP 3 521 727 A1

Description

Technical Field

[0001] The present disclosure relates to a storage-type water heater.

Background Art

[0002] Storage-type water heaters each including a heat pump unit and a hot water storage unit have been introduced into homes and facilities. Recently, storage-type water heaters further including an auxiliary heat source unit have been developed.

[0003] Such storage-type water heaters further including an auxiliary heat source unit are disclosed in, for example, Patent Literature 1 and Patent Literature 2. According to the disclosure of Patent Literature 1, hot water is supplied by mixing water with the hot water coming from a hot water storage tank when run-out of hot water does not occur, while hot water is supplied by heating the water coming from an outgoing hot-water pipe with an auxiliary heat source when run-out of hot water occurs. According to the disclosure of Patent Literature 2, a water heater includes a first heat exchanger that exchanges heat of a heat medium with feedwater and a second heater exchanger that exchanges heat of an auxiliary heat source with feedwater. Hot water is supplied solely through heat exchange by the first heat exchanger when the first heat exchanger can achieve a target hot-water supply temperature, while hot water is supplied through heat exchange by both the first and second heat exchangers or solely by the second heat exchanger when the first heat exchanger cannot achieve the target hot-water supply temperature.

Citation List

Patent Literature

[0004]

Patent Literature 1: Unexamined Japanese Patent Application Kokai Publication No. 2010-210180

Patent Literature 2: Unexamined Japanese Patent Application Kokai Publication No. 2011-214793

Summary of Invention

Technical Problem

[0005] According to the disclosure of Patent Literature 1, however, the pressure reducing valve directed toward the hot water storage tank is connected in series via the water volume variable valve to the auxiliary heat source, which requires a higher pressure setting for the pressure reducing valve. Consequently, the hot water storage tank needs to be highly pressure-resistant, and thus to be thicker-walled, causing concerns about higher cost. On the other hand, according to the disclosure of Patent Literature 2, the water flow path divides into the hot water storage tank side and the hot-water supply side, and thus a higher water pressure is acceptable on the hot-water supply side without regard to pressure resistance of the hot water storage tank. Nevertheless, to use heat in the hot water storage tank for supplying hot water, heat exchange through the first heat exchanger is needed.

[0006] In other words, according to the disclosure of Patent Literature 2, some temperature difference is needed between the heat medium on the hot water storage tank side and the water on the hot-water supply side, which means, as compared with direct use of hot water from the hot water storage tank for supplying hot water, the temperature of stored hot water needs to be higher than the hot-water supply temperature setting. This poses the problem of a lower coefficient of performance (COP) caused when, for example, heat is stored in the hot water storage tank by using a heat pump unit. In addition, the heat medium returning to the hot water storage tank after subjected to heat exchange in the first heat exchanger has a higher temperature than feedwater because of temperature difference for heat exchange. Therefore, heating the heat medium in the hot water storage tank with a heat pump results in a lower COP than direct heating of municipal water.

[0007] Thus, a storage-type water heater that provides higher efficiency is demanded.

[0008] In view of the above circumstances, an objective of the present disclosure is to provide a storage-type water heater achieving higher efficiency.

Solution to Problem

[0009] To achieve the above-described objective, a storage-type water heater according to the present disclosure includes first heating means for heating water to generate first hot water, a hot water storage tank configured to store the first hot water generated by the first heating means, a heat exchanger configured to preheat municipal water through heat exchange between the first hot water taken from the hot water storage tank and the municipal water, second heating means for heating the municipal water preheated by the heat exchanger to generate second hot water; and control means for supplying the first hot water taken from the hot water storage tank or the second hot water generated by the second heating means.

Advantageous Effects of Invention

[0010] The storage-type water heater according to the present disclosure can achieve higher efficiency.

Brief Description of Drawings

[0011]

FIG. 1 is a configuration diagram illustrating a configuration of a storage-type water heater according to an embodiment of the present disclosure;

FIG. 2 is a block diagram for illustrating a connection structure in the storage-type water heater;

FIG. 3 is a schematic diagram for illustrating a path of water flowing during a water-heating operation;

FIG. 4 is a flowchart for illustrating control of a hot-water supply switching valve;

FIG. 5 is a schematic diagram for illustrating a path of water flowing during a direct hot-water supply operation;

FIG. 6 is a flowchart for illustrating a direct hot-water supply process;

FIG. 7 is a schematic diagram for illustrating a path of water flowing during an indirect hot-water supply operation;

FIG. 8 is a flowchart for illustrating an indirect hot-water supply process;

FIG. 9 is a schematic diagram for illustrating a relationship of changes in water temperature between the primary side and the secondary side;

FIG. 10 is a schematic diagram for illustrating a relationship between a rotation frequency of a circulation pump and a secondary side flow rate;

FIG. 11 is a flowchart for illustrating an auxiliary heating process;

FIG. 12 is a schematic diagram for illustrating a path of water flowing during a bathtub filling operation;

FIG. 13 is a flowchart for illustrating a bathtub filling process;

FIG. 14 is a schematic diagram for illustrating a relationship between individual elements and control targets;

FIG. 15 is a schematic diagram for illustrating a relationship of flow rate between the hot water storage tank side and the heat pump side;

FIG. 16A is a graph for illustrating hot-water supplying loads during a day;

FIG. 16B is a graph for illustrating changes in quantity of stored heat in the hot water storage tank during a day;

FIG. 16C is a graph for illustrating changes in heating capacity in a heat pump unit during a day;

FIG. 16D is a graph for illustrating changes in heating capacity in an auxiliary heat source unit during a day;

FIG. 17 is a configuration diagram illustrating a configuration of a hot water storage unit according to another embodiment;

FIG. 18 is a flowchart for illustrating another indirect hot-water supply process;

FIG. 19A is a schematic diagram illustrating a specific example of returning preheat return water to a lower portion;

FIG. 19B is a schematic diagram illustrating another specific example of returning the preheat return water to a lower portion; and

FIG. 19C is a schematic diagram illustrating a specific example of returning the preheat return water to a middle portion.

Description of Embodiments

[0012] Embodiments of the present disclosure are described in detail with reference to the drawings. The same reference signs are given to the same or like elements throughout the drawings referred to herein. The present disclosure is not limited to the following embodiments, and various modifications may be made without departing from the scope of the disclosure.

Configuration of storage-type water heater

[0013] FIG. 1 is a configuration diagram illustrating a configuration of a storage-type water heater 1 according to an embodiment of the present disclosure. The storage-type water heater 1 includes, as major components, a heat pump unit 100, which is first heating means, a hot water storage unit 200 that stores and supplies hot water, and an auxiliary heat source unit 300, which is second heating means. The storage-type water heater 1 further includes a bathtub 400, a heat pump controller 500 that controls the heat pump unit 100, a hot water storage unit controller 600 that controls the hot water storage unit 200, an auxiliary heat source controller 700 that controls the auxiliary heat source unit 300, and a remote controller 800 operated by a user.

[0014] The heat pump unit 100 includes a compressor 101, a refrigerant-water heat exchanger 102, an expansion valve 103, and an evaporator 104. These elements are circularly connected to form a refrigeration cycle circuit (refrigerant circuit) through which refrigerant is circulated. The heat pump unit 100 and the hot water storage unit 200 are connected via a heat pump incoming water pipe 121 and a heat pump outgoing hot-water pipe 122.

[0015] The compressor 101 compresses the refrigerant to increase its temperature and pressure. Examples of the refrigerant that may be used include, without limitation, CO_2, HFC, HC, and HFO. The compressor 101 includes an inverter circuit capable of changing the capacity (feed per unit) depending on the rotation frequency. Under control of the heat pump controller 500, the compressor 101 adjusts the rotation frequency so as to meet the target heating capacity.

[0016] The refrigerant-water heat exchanger 102 is a heating source used for heating the water (low-temperature water) fed through the heat pump incoming water pipe 121 to a target heating temperature. The refrigerant-water heat exchange 102, which may be, for example, a plate heat exchanger or double-pipe heat exchanger, exchanges heat between the refrigerant and water. Through heat exchange in the refrigerant-water heat exchanger 102, the refrigerant dissipates heat to decrease its temperature, while water absorbs heat to increase its temperature. The refrigerant-water heat exchanger 102 supplies heated water (first hot water) to the hot water storage unit 200 (specifically, a hot water storage tank 201 described below) through the heat pump outgoing hot-water pipe 122.

[0017] The expansion valve 103 expands the refrigerant to decrease its temperature and pressure. Under control of the heat pump controller 500, the expansion valve 103 adjusts a degree of opening of the valve. For example, the expansion valve 103 adjusts the degree of opening so that the compressor suction superheat degree of the refrigerant or the compressor discharge temperature reaches a target temperature.

[0018] The evaporator 104 exchanges heat between the refrigerant and outside air fed by a blower fan (not illustrated). Through heat exchange in the evaporator 104, the refrigerant absorbs heat while the outside air dissipates heat to decrease its temperature.

[0019] The hot water storage unit 200 includes, as major components, a hot water storage tank 201, a water-water heat exchanger 202, a circulation pump 203, a suction switching valve 204, a discharge switching valve 205, a tank pressure reducing valve 206, a tank mixing valve 207, a hot-water pressure reducing valve 208, and a hot-water supply switching valve 209. The hot water storage unit 200 is connected to the auxiliary heat source unit 300 via an auxiliary heat source incoming water pipe 221 and an auxiliary heat source outgoing hot-water pipe 222.

[0020] The hot water storage tank 201 is made of, for example, metal (e.g., stainless steel) or resin, and accepts, from an upper portion of the hot water storage tank 201, hot water fed through the heat pump outgoing hot-water pipe 122. As a result, temperature stratification is formed in the hot water storage tank 201, composed of higher-temperature hot water and lower-temperature water from top to bottom. On the hot water storage tank 201, a plurality of stored hot-water temperature sensors 211 is disposed along the height direction to detect temperatures of stored water.

[0021] The water-water heat exchanger 202 exchanges heat between hot water (high-temperature water) taken from an upper portion of the hot water storage tank 201 through a preheat intake path 223 and municipal water (low-temperature water). Specifically, the water-water heat exchanger 202 includes a primary side path for a flow of the hot water fed through the preheat intake path 223 and a secondary side path for a flow of the municipal water fed from a feedwater terminal 231. Through heat exchange in the water-water heat exchanger 202, the hot water flowing through the primary side path dissipates heat to decrease its temperature, while the municipal water flowing through the secondary side path absorbs heat to increase its temperature. The preheated municipal water is fed to the auxiliary heat source unit 300 through the auxiliary heat source incoming water pipe 221.

[0022] A tank return temperature sensor 212 is disposed on the outlet side of the primary side path (suction switching valve 204 side) so as to detect the temperature of the low-temperature water (water with heat dissipated). A preheat flow rate sensor 213 is disposed on the inlet side of the secondary side path so as to measure the flow rate of the municipal water. A preheat temperature sensor 214 is disposed on the outlet side of the secondary side path so as to detect the temperature of the preheated municipal water.

[0023] The circulation pump 203 accepts the water fed through a pump suction pipe 224 and sends the water through a pump discharge pipe 225. For example, during the water-heating operation (hot-water storing operation) described below, the circulation pump 203 supplies the low-temperature water taken from a lower portion (bottom) of the hot water storage tank 201 to the heat pump unit 100 through the heat pump incoming water pipe 121, and returns the hot water heated in the heat pump unit 100 to an upper portion (top) of the hot water storage tank 201 through the heat pump outgoing hot-water pipe 122. During the operation, the rotation frequency of the circulation pump 203 is adjusted so that the temperature of outgoing hot-water from the refrigerant-water heat exchanger 102 reaches a target stored hot-water temperature. During the indirect hot-water supply operation described below, the circulation pump 203 causes the water with a temperature decreased through the water-water heat exchanger 202 (the aforementioned primary side path) to return to the lower portion of the hot water storage tank 201 through a preheat return path 226.

[0024] The suction switching valve 204, which may be a three-way valve, for example, includes water inlets a and b and a water outlet c. The water inlet a is connected to the hot water storage tank 201 (lower portion) via a pipe. The water inlet b is connected to the water-water heat exchanger 202 (outlet of the primary side path) via a pipe. The water outlet c is connected to the circulation pump 203 via the pump suction pipe 224. During the water-heating operation, the suction switching valve 204 switches the inlet to the water inlet a (opens between the water inlet a and the water outlet c, and closes between the water inlet b and the water outlet c) so that the pump suction pipe 224 is connected to the lower portion of the hot water storage tank 201. During the indirect hot-water supply operation, the suction switching valve 204 switches the inlet to the water inlet b (opens between the water inlet b and the water outlet c, and closes between the water inlet a and the water outlet c) so that the pump suction pipe 224 is connected to the outlet of the primary side path in the water-water heat exchanger 202.

[0025] The discharge switching valve 205, which may be a three-way valve, for example, includes a water inlet a and water outlets b and c. The water inlet a is connected to the circulation pump 203 via the pump discharge pipe 225. The water outlet b is connected to the hot water storage tank 201 (lower portion) via the preheat return path 226. The water outlet c is connected to the heat pump unit 100 via the heat pump incoming water pipe 121. During the water-heating operation, the discharge switching valve 205 switches the outlet to the water outlet c (opens between the water inlet a and the water outlet c, and closes between the water inlet a and the water outlet b) so that the pump discharge pipe 225 is connected to the heat pump incoming water pipe 121. During the indirect hot-water supply operation, the discharge switching valve 205 switches the outlet to the water outlet b (opens between the water inlet a and the water outlet b, and closes between the water inlet a and the water outlet c) so that the pump discharge pipe 225 is connected to the preheat return path 226.

[0026] When the municipal water fed from the feedwater terminal 231 is allowed to flow into the hot water storage tank 201, the tank pressure reducing valve 206 reduces the supply pressure of the municipal water to a level equal to a predetermined tank pressure. A feedwater temperature sensor 215 is disposed on the feedwater terminal 231 side of the tank pressure reducing valve 206 so as to detect the temperature of the supplied municipal water.

[0027] The tank mixing valve 207 mixes the hot water (high-temperature water) flowing from an upper portion of the hot water storage tank 201 with the municipal water fed from the feedwater terminal 231. In other words, during the direct hot-water supply operation (in the direct hot-water supply mode) in which hot water taken from the hot water storage tank 201 is supplied via the hot-water supply terminal 232, the tank mixing valve 207 mixes the hot water taken from the hot water storage tank 201 with the municipal water to adjust the hot water temperature to a preset temperature, and then supplies the hot water via the hot-water supply terminal 232. A tank outgoing hot-water temperature sensor 216 is disposed on the hot water storage tank 201 side of the tank mixing valve 207 so as to detect the temperature of the hot water that is going to be mixed with municipal water.

[0028] The hot-water pressure reducing valve 208 reduces the pressure of the hot water fed from the auxiliary heat source unit 300 through the auxiliary heat source outgoing hot-water pipe 222 to a predetermined supply pressure. In other words, during the indirect hot-water supply operation (in the indirect hot-water supply mode) in which the hot water taken from the hot water storage tank 201 is used to preheat the municipal water, the hot-water pressure reducing valve 208 reduces the pressure of the hot water generated from the preheated municipal water.

[0029] The hot-water supply switching valve 209, which may be a three-way valve, for example, includes water inlets a and b and a water outlet c. The water inlet a is connected to the tank mixing valve 207 via a pipe. The water inlet b is connected to the hot-water pressure reducing valve 208 via a pipe. The water outlet c is connected to the hot-water supply terminal 232 via a pipe. During the direct hot-water supply operation, the hot-water supply switching valve 209 switches the inlet to the water inlet a (opens between the water inlet a and the water outlet c, and closes between the water inlet b and the water outlet c) so that the tank mixing valve 207 is connected to the hot-water supply terminal 232. During the indirect hot-water supply operation, the hot-water supply switching valve 209 switches the inlet to the water inlet b (opens between the water inlet b and the water outlet c, and closes between the water inlet a and the water outlet c) so that the hot-water pressure reducing valve 208 is connected to the hot-water supply terminal 232. A supplied hot-water temperature sensor 217 is disposed on the hot-water supply terminal 232 side of the hot-water supply switching valve 209 so as to detect the temperature of the supplied hot water. A supplied hot-water flow rate sensor 218 is also disposed on the hot-water supply terminal 232 side so as to measure the flow rate of the supplied hot water.

[0030] The auxiliary heat source unit 300 includes, as major components, a hot-water supply heat exchanger 301, a reheating heat exchanger 302, burners 303 (303a and 303b), a water volume regulating valve 304, a bypass valve 305, a bathtub filling valve 306, and a reheating pump 307. The auxiliary heat source unit 300 is connected to the bathtub 400 via a bathtub return pipe 321 and a bathtub supply pipe 322.

[0031] The hot-water supply heat exchanger 301 exchanges heat between the heat provided by the burner 303a and the municipal water (municipal water preheated in the hot water storage unit 200). In other words, the hot-water supply heat exchanger 301 heats the preheated municipal water fed from the auxiliary heat source incoming water pipe 221 via the water volume regulating valve 304 with the heat provided by the burner 303a to generate hot water (second hot water).

[0032] The reheating heat exchanger 302 exchanges heat between the heat provided by the burner 303b and the hot water fed from the bathtub 400. In other words, the reheating heat exchanger 302 heats, with heat provided by the burner 303b, the hot water supplied from the bathtub 400 by the reheating pump 307 through the bathtub return pipe 321. The heated water is returned to the bathtub 400 through the bathtub supply pipe 322.

[0033] The water volume regulating valve 304 regulates the flow rate of the preheated municipal water fed from the hot water storage unit 200 through the auxiliary heat source incoming water pipe 221. An auxiliary heat source flow rate sensor 311 is disposed on the auxiliary heat source incoming water pipe 221 side of the water volume regulating valve 304 so as to measure the flow rate of the preheated municipal water.

[0034] By the bypass valve 305, some of the preheated municipal water fed through the water volume regulating valve 304 bypasses the heat exchanger to flow to the auxiliary heat source outgoing hot-water pipe 222. An auxiliary heat source outgoing hot-water temperature sensor 312 is disposed on the auxiliary heat source outgoing hot-water pipe 222 side of the bypass valve 305 so as to detect the temperature of the outgoing hot water from the auxiliary heat source unit 300.

[0035] When the bathtub 400 is going to be filled with hot water, the bathtub filling valve 306 opens to feed the hot water generated in the hot-water supply heat exchanger 301 to the bathtub 400 through the bathtub return pipe 321 and the bathtub supply pipe 322.

[0036] The heat pump controller 500 controls the heat pump unit 100. The hot water storage unit controller 600 controls the hot water storage unit 200. Note that the hot water storage unit controller 600 and the heat pump controller 500 are electrically connected to send and receive necessary information therebetween. The auxiliary heat source controller 700 controls the auxiliary heat source unit 300.

[0037] The remote controller 800 is electrically connected to the hot water storage unit controller 600 and to the auxiliary heat source controller 700 to send and receive necessary information therebetween. The remote controller 800, which has operation buttons and a display arranged thereon, is used for operations including, for example, giving instructions to the hot water storage unit controller 600 or to the auxiliary heat source controller 700 in response to user operations and displaying the operational status of the hot water storage unit 200 or the auxiliary heat source unit 300 on the basis of information provided by the hot water storage unit controller 600 or the auxiliary heat source controller 700.

[0038] The following describes the storage-type water heater 1 focusing on the hot water storage unit controller 600. FIG. 2 is a block diagram for illustrating a connection structure in the storage-type water heater 1. As illustrated in FIG. 2, the hot water storage unit controller 600 includes a measurer 601, a calculator 602, a controller 603, and a storage 604.

[0039] To the hot water storage unit controller 600 configured as above, the stored hot-water temperature sensors 211, the tank return temperature sensor 212, the preheat flow rate sensor 213, the preheat temperature sensor 214, the feedwater temperature sensor 215, the tank outgoing hot-water temperature sensor 216, the supplied hot-water temperature sensor 217, and the supplied hot-water flow rate sensor 218 are connected as input. The remote controller 800 is connected as input/output to the hot water storage unit controller 600. The hot water storage unit controller 600 is connected as output to the heat pump controller 500 and actuators of the circulation pump 203, the suction switching valve 204, the discharge switching valve 205, the tank mixing valve 207, and the hot-water supply switching valve 209.

[0040] The measurer 601 takes various measurements including temperatures and flow rates in accordance with information detected by the above-described sensors 211 to 218.

[0041] The calculator 602 performs calculation for control actions based on various measurements taken by the measurer 601. For example, during the water-heating operation, the calculator 602 performs calculation for actions of the heat pump unit 100 based on the quantity of stored heat in the hot water storage tank 201. During general hot-water supply, the calculator 602 performs calculation for actions of the hot water storage unit 200 or the auxiliary heat source unit 300 based on the quantity of stored heat in the hot water storage tank 201 so that direct or indirect hot-water supply is carried out.

[0042] The controller 603 controls the heat pump unit 100 and actuators of the circulation pump 203 and the above-described valves 204 to 209 based on the control actions resulting from the calculation by the calculator 602.

[0043] The storage 604 stores various pieces of information such as predetermined constants and setting values sent from the remote controller 800. For example, the storage 604 stores a specified value (tank direct hot-water supply threshold) representing a maximum quantity of heat estimated for a single hot-water supply and a reference value (heat pump water-heating threshold) used for reheating. The calculator 602 and the controller 603 are allowed to refer to or rewrite the information stored in the storage 604, if necessary.

[0044] The measurer 601, the calculator 602, and the controller 603 described above may be implemented by a microcomputer, for example. The storage 604 may be implemented by a semiconductor memory, for example.

Water-heating operation (hot-water storing operation)

[0045] The following describes the water-heating operation (hot-water storing operation) carried out in the storage-type water heater 1 according to an embodiment of the present disclosure. During the water-heating operation, the suction switching valve 204 and the discharge switching valve 205 are controlled by the hot water storage unit controller 600 as described below.

[0046] The hot water storage unit controller 600 causes the suction switching valve 204 to switch the inlet to the water inlet a (opens between the water inlet a and the water outlet c, and closes between the water inlet b and the water outlet c) so that the pump suction pipe 224 is connected to a lower portion of the hot water storage tank 201. Meanwhile, the hot water storage unit controller 600 causes the discharge switching valve 205 to switch the outlet to the water outlet c (opens between the water inlet a and the water outlet c, and closes between the water inlet a and the water outlet b) so that the pump discharge pipe 225 is connected to the heat pump incoming water pipe 121.

[0047] While the suction switching valve 204 and the discharge switching valve 205 are controlled as above, the hot water storage unit controller 600 activates the circulation pump 203. Thus, as illustrated in FIG. 3, the water (low-temperature water) taken from a lower portion of the hot water storage tank 201 flows through the suction switching valve 204, the circulation pump 203, the discharge switching valve 205, and the heat pump incoming water pipe 121 in this order, and is fed to the refrigerant-water heat exchanger 102. Next, the water is heated up in the refrigerant-water heat exchanger 102 through heat exchange with refrigerant, and then led to an upper portion of the hot water storage tank 201 through the heat pump outgoing hot-water pipe 122. In this way, the hot water storage unit controller 600 can cause the water taken from a lower portion of the hot water storage tank 201 to be heated in the heat pump unit 100, which is first heating means, and can cause the heated up hot water to be sent to an upper portion of the hot water storage tank 201. Such a water-heating operation continuously adds a layer of higher-temperature water from above to the stored hot water in the hot water storage tank 201.

[0048] For such a water-heating operation, the temperature of stored hot-water in the hot water storage tank 201 is determined in accordance with, for example, the hot-water supply temperature setting made to the remote controller 800. The temperature of stored hot-water is determined by adding a predetermined temperature to the hot-water supply temperature setting, partly because heat is dissipated from a surface of the hot water storage tank 201 during a period from water heating in the heat pump unit 100 to the actual hot-water supply and because the tank mixing valve 207 is a valve that mixes municipal water (feedwater) by some ratio other than 0. For example, the temperature of stored hot-water is $40 + \alpha$ °C for the hot-water supply temperature setting of 40 °C. The remote controller 800 instructs the hot water storage unit controller 600 of the temperature of stored hot-water determined as above.

[0049] In general, such a water-heating operation is carried out during late-night charge hours to which a lower electricity price is applied. After the water-heating operation, however, the water-heating operation (water-reheating operation) can be resumed when the quantity of stored heat in the hot water storage tank 201 drops below a predetermined threshold (heat pump water-heating threshold).

[0050] During the water-heating operation, the hot water storage unit controller 600 instructs the heat pump controller 500 of the target heating temperature that is the target temperature of stored hot-water. When the quantity of stored heat in the hot water storage tank 201 becomes equivalent to the target quantity of stored hot water, the heat pump unit 100 stops the water-heating operation. The target quantity of stored hot water may be calculated from, for example, a difference between a hot-water supplying load estimated for a period from the present time to a determined time and the current quantity of stored heat in the hot water storage tank. The estimated hot-water supplying load is preferably determined by learning hot-water supplying loads occurring in the past several days.

Control of hot-water supply switching valve

[0051] Referring to FIG. 4, the following describes controlling the hot-water supply switching valve 209 during general hot-water supply by which hot water is supplied from the hot-water supply terminal 232. FIG. 4 is a flowchart for illustrating control of the hot-water supply switching valve. During the general hot-water supply, either of the following modes is carried out: the direct hot-water supply mode (direct hot-water supply operation) in which hot water is directly supplied from the hot water storage tank 201; and the indirect hot-water supply mode (indirect hot-water supply operation/feedwater preheat and hot-water supply operation) in which municipal water is preheated in the water-water heat exchanger 202 followed by additional heating in the auxiliary heat source unit 300, and then the heated water is supplied. The hot-water supply switching valve 209 is controlled to switch the hot-water supply between the direct hot-water supply mode and the indirect hot-water supply mode.

[0052] When the control of the hot-water supply switching valve is started, the hot water storage unit controller 600 calculates the quantity of stored heat in the hot water storage tank 201 (step S101). Specifically, the calculator 602 calculates the quantity of stored heat in the hot water stored in the hot water storage tank 201 on the basis of temperatures detected by the stored hot-water temperature sensors 211 disposed along the height direction of the hot water storage tank 201. For this purpose, the calculator 602 calculates the quantity of stored heat that is retained in the hot water in the hot water storage tank 201 and is effective for a hot-water supplying load. For example, for a general hot-water supplying load, which gives the thermal energy retained in hot water in the hot water storage tank 201 to the municipal water through mixing, the calculator 602 calculates the quantity of stored heat by integrating with respect to the volume of the hot water storage tank 201 using the feedwater temperature as a reference temperature for thermal energy. Alternatively, the calculator 602 may calculate the quantity of stored heat by integrating with respect to a limited region of the hot water having a temperature not lower than a predetermined temperature (45 °C, for example).

[0053] The hot water storage unit controller 600 determines whether the calculated quantity of stored heat is equal to or greater than a specified value (step S102). For example, the calculator 602 reads the specified value (tank direct hot-water supply threshold) representing a maximum quantity of heat estimated for a single hot-water supply from the storage 604, and then determines whether the quantity of stored heat is equal to or greater than the specified value. As the tank direct hot-water supply threshold, the storage 604 stores, for example, the highest value (the highest quantity of heat) of hot-water supplying loads (hot-water supplying loads for general supply) occurring in the past several days and each representing a single hot-water supply. The hot-water supplying load may be calculated by, for example, multiplying a summed volume of supplied hot water obtained by the supplied hot-water flow rate sensor 218 by a temperature difference between the hot-water temperature detected by the supplied hot-water temperature sensor 217 and the municipal-water temperature detected by the feedwater temperature sensor 215.

[0054] When the hot water storage unit controller 600 determines that the quantity of stored heat is equal to or greater than the specified value (Yes in step S102), the hot water storage unit controller 600 carries out the direct hot-water supply mode (step S103). In the direct hot-water supply mode, the hot water storage unit controller 600 switches the water inlet of the hot-water supply switching valve 209 to the water inlet a (opens between the water inlet a and the water outlet c, and closes between the water inlet b and the water outlet c) so that the tank mixing valve 207 is connected to the hot-water supply terminal 232.

[0055] On the other hand, when the hot water storage unit controller 600 determines that the quantity of stored heat is less than the specified value (No in step S102), the hot water storage unit controller 600 carries out the indirect hot-water supply mode (step S104). In the indirect hot-water supply mode, the hot water storage unit controller 600 switches the water inlet of the hot-water supply switching valve 209 to the water inlet b (opens between the water inlet b and the water outlet c, and closes between the water inlet a and the water outlet c) so that the hot-water pressure reducing valve 208 is connected to the hot-water supply terminal 232.

[0056] According to the above-described control of the hot-water supply switching valve, the operation mode is switched to the indirect hot-water supply mode when the quantity of stored heat in the hot water storage tank 201 drops below a specified value (tank direct hot-water supply threshold). However, the mode may be switched on the basis of other information. For example, the mode may be switched to the indirect hot-water supply mode when any of the stored hot-water temperature sensors 211 detects a temperature lower than the hot-water supply temperature setting plus β °C. In addition, the specified value (tank direct hot-water supply threshold) to be compared with the quantity of stored heat may be replaced by a fixed value representing a relatively high general hot-water supplying load, for example, a fixed value representing a load of single supply for shower (50 L based on 40 °C). Furthermore, the user may be allowed to select any value as the specified value using the remote controller 800.

Direct hot-water supply operation

[0057] The following describes the hot-water supply operation in the direct hot-water supply mode (direct hot-water supply operation). As described above, in the direct hot-water supply mode, the hot-water supply switching valve 209 switches the water inlet to the water inlet a so that the tank mixing valve 207 is connected to the hot-water supply terminal 232. Then, for example, when a hot-water faucet (not illustrated) connected to the hot-water supply terminal 232 is opened (when a hot-water supplying load occurs), the hot water taken from an upper portion of the hot water storage tank 201 flows through the tank mixing valve 207 and the hot-water supply switching valve 209 in this order, and then the hot water is supplied from the hot-water supply terminal 232, as illustrated in FIG. 5.

[0058] Referring to FIG. 6, the following describes a direct hot-water supply process in such a direct hot-water supply mode. FIG. 6 is a flowchart for illustrating the direct hot-water supply process. The direct hot-water supply process is started when, for example, a hot-water faucet connected to the hot-water supply terminal 232 is opened.

[0059] The hot water storage unit controller 600 waits until the hot-water supply flow rate is equal to or greater than a reference value (No in step S201). As the reference value, a lowest limit value is preset so as to ensure, for example, that the supplied hot-water flow rate sensor 218 can stably detect the flow rate of supplied hot water. When a hot-water faucet is opened in this waiting state and the flow rate of supplied hot water increases to the reference value or higher (Yes in step S201), the hot water storage unit controller 600 performs temperature-regulating control of the tank mixing valve 207 (step S202). In this step, high-temperature water is supplied from an upper portion of the hot water storage tank 201 to the tank mixing valve 207, while municipal water (low-temperature water) flows through the tank pressure reducing valve 206 to flow into a lower portion of the hot water storage tank 201. The tank mixing valve 207, which is a valve for adjusting the temperature of hot water supplied to the hot-water supply terminal 232, mixes high-temperature water fed from an upper portion of the hot water storage tank 201 with municipal water fed through the tank pressure reducing valve 206, and adjusts a variable mixture ratio so that the hot-water temperature detected by the supplied hot-water temperature sensor 217 is equal to the hot-water supply temperature setting, and the delivers the hot water.

[0060] The hot water storage unit controller 600 determines whether the hot-water supply flow rate is less than the reference value (step S203). If determining that the hot-water supply flow rate is not less than the reference value (No in step S203), the hot water storage unit controller 600 continues the temperature-regulating control in step S202.

[0061] On the other hand, when determining that the hot-water supply flow rate is less than the reference value (Yes in step S203), the hot water storage unit controller 600 exits the direct hot-water supply process to return to the waiting state.

[0062] During the direct hot-water supply operation, the hot-water supply switching valve 209 connects the tank mixing valve 207 to the hot-water supply terminal 232, and thus no water flows into the auxiliary heat source unit 300 and no heating occurs in the auxiliary heat source unit 300.

Indirect hot-water supply operation (feedwater preheat and hot-water supply operation)

[0063] The following describes the hot-water supply operation in the indirect hot-water supply mode (indirect hot-water supply operation). As described above, in the indirect hot-water supply mode, the water inlet of the hot-water supply switching valve 209 is switched to the water inlet b, and thus the hot-water pressure reducing valve 208 is connected to the hot-water supply terminal 232. When a hot-water supplying load occurs in this state, the hot water taken from an upper portion of the hot water storage tank 201 is fed through the preheat intake path 223 and then through the water-water heat exchanger 202 (the primary side path), as illustrated in FIG. 7. Then, the hot water dissipates heat to reduce its temperature (become low-temperature water) through heat exchange with municipal water (low-temperature water) in the water-water heat exchanger 202. The water thus having a lower temperature is fed through the suction switching valve 204, the circulation pump 203, the discharge switching valve 205, and the preheat return path 226 in this order to return to the lower portion of the hot water storage tank 201.

[0064] Meanwhile, the municipal water supplied from the feedwater terminal 231 is fed to the water-water heat exchanger 202 (the secondary side path). The municipal water is preheated through heat exchange with hot water (high-temperature water) in the water-water heat exchanger 202, and then fed through the auxiliary heat source incoming water pipe 221, the water volume regulating valve 304, and the hot-water supply heat exchanger 301 in this order. Then, the preheated water is heated up in the hot-water supply heat exchanger 301, fed through the auxiliary heat source outgoing hot-water pipe 222, the hot-water pressure reducing valve 208, and the hot-water supply switching valve 209 in this order, and then supplied from the hot-water supply terminal 232.

[0065] The following describes an indirect hot-water supply process in such an indirect hot-water supply mode with reference to FIG. 8. FIG. 8 is a flowchart for illustrating the indirect hot-water supply process. The indirect hot-water supply process is started when, for example, a hot-water faucet connected to the hot-water supply terminal 232 is opened. While the indirect hot-water supply process is performed, the auxiliary heat source controller 700 carries out the auxiliary heating process illustrated in FIG. 11, which is described later.

[0066] The hot water storage unit controller 600 causes the suction switching valve 204 to switch to the water inlet connected to the water-water heat exchanger 202 (step S301). In other words, the hot water storage unit controller 600 causes the suction switching valve 204 to switch the inlet to the water inlet b (opens between the water inlet b and the water outlet c, and closes between the water inlet a and the water outlet c) so that the pump suction pipe 224 is connected to the water-water heat exchanger 202.

[0067] The hot water storage unit controller 600 causes the discharge switching valve 205 to switch to the water outlet connected to the preheat return path 226 (step S302). In other words, the hot water storage unit controller 600 causes the discharge switching valve 205 to switch the outlet to the water outlet b (opens between the water inlet a and the water outlet b, and closes between the water inlet a and the water outlet c) so that the pump discharge pipe 225 is connected to the preheat return path 226.

[0068] The hot water storage unit controller 600 waits until the preheat flow rate is equal to or greater than a reference value (No in step S303). As the reference value, a lowest limit value is preset so as to ensure, for example, that the preheat flow rate sensor 213 can stably detect the preheat flow rate. When a hot-water faucet is opened in this waiting state and the preheat flow rate increases to the reference value or higher (Yes in step S303), the hot water storage unit controller 600 performs temperature-regulating control of the circulation pump 203 (step S304). At this time, the circulation pump 203 is activated to cause the hot water taken from an upper portion of the hot water storage tank 201 to flow into the water-water heat exchanger 202 (the primary side path) through the preheat intake path 223, and then to flow through the suction switching valve 204, the circulation pump 203, and the discharge switching valve 205 in this order to return to the lower portion of the hot water storage tank 201 through the preheat return path 226. Meanwhile, the municipal water (low-temperature water) flows into the water-water heat exchanger 202 (the secondary side path) from the feedwater terminal 231, and then flows into the auxiliary heat source unit 300 through the auxiliary heat source incoming water pipe 221. At this time, the water-water heat exchanger 202 heats the municipal water in the secondary side path with the hot water in the primary side path. Thus, the hot water in the primary side path decreases its temperature and returns to the lower portion of the hot water storage tank 201, while the municipal water in the secondary side path increases its temperature (that is, the municipal water is preheated) and flows into the auxiliary heat source unit 300. The hot water storage unit controller 600 performs temperature-regulating control of the circulation pump 203 to control the rotation frequency and adjust the flow rate. A detailed description is given below.

[0069] FIG. 9 shows changes in water temperature in the primary and secondary sides paths in the water-water heat exchanger 202. As illustrated in FIG. 9, the water-water heat exchanger 202 exchanges heat with counter-current. For temperature-regulating control of the circulation pump 203, the rotation frequency is controlled so that, for example, the temperature difference ΔTwL between Twlo and Tw2i is kept consistent with a predetermined value, where Tw1o is the water temperature at an outlet of the primary side path as detected by the tank return temperature sensor 212, and Tw2i is the water temperature at an inlet of the secondary side path as detected by the feedwater temperature sensor 215.

[0070] Specifically, suppose that the flow rate on the secondary, feedwater side is lower. In this case, for example, when the circulation pump 203 is running at a higher rotation frequency and thus the flow rate on the primary side is excessively high, Tw1o becomes higher and the water flowing into a lower portion of the hot water storage tank 201 has a higher temperature. In this case, temperature-regulating control is performed by decreasing the rotation frequency of the circulation pump 203 so as to adjust ΔTwL to a predetermined value. On the other hand, suppose that the flow rate on the secondary side is higher. In this case, for example, when the circulation pump 203 is running at a lower rotation frequency and thus the flow rate on the primary side is excessively low, Twlo becomes lower. Then, to obtain a sufficient amount of heating for preheating the feedwater, temperature-regulating control is performed by increasing the rotation frequency of the circulation pump 203 so as to adjust ΔTwL to a predetermined value. In other words, by controlling the rotation frequency of the circulation pump 203 depending on ΔTwL, the water on the primary side is allowed to flow in the water-water heat exchanger 202 at an appropriate flow rate reflecting consideration for the amount of heating and the heat-exchange efficiency relative to the secondary side flow rate. Thus, by controlling ΔTwL appropriately, the lower portion of the hot water storage tank 201 can be kept at a lower temperature and, during reheating, the temperature of water supplied from the heat pump incoming water pipe 121 (heat pump incoming water temperature) can be lowered, which is particularly effective when CO_2 is used as the refrigerant. Appropriate control of ΔTwL also provides heat exchange in an amount sufficient for the flow rate on the secondary side, thus achieving fully effective preheating of the municipal water to be fed to the auxiliary heat source unit 300.

[0071] Alternatively, as illustrated in FIG. 10, the rotation frequency of the circulation pump 203 may be controlled with respect to the secondary side flow rate detected by the preheat flow rate sensor 213. Since the rotation frequency of the circulation pump 203 is approximately proportional to the primary side flow rate, the primary side flow rate can be controlled appropriately with respect to the flow rate of the secondary side to be heated.

[0072] Referring back to FIG. 8, the hot water storage unit controller 600 determines whether the preheat flow rate is less than the reference value (step S305). When determining that the preheat flow rate is not less than the reference value (No in step S305), the hot water storage unit controller 600 continues the temperature-regulating control in step S304.

[0073] On the other hand, when determining that the preheat flow rate is less than the reference value (Yes in step S305), the hot water storage unit controller 600 exits the indirect hot-water supply process to return to the waiting state.

[0074] The following describes the auxiliary heating process carried out by the auxiliary heat source controller 700 with reference to FIG. 11. FIG. 11 is a flowchart for illustrating the auxiliary heating process. The auxiliary heating process is started in parallel with the above-described indirect hot-water supply process.

[0075] The auxiliary heat source controller 700 waits until the auxiliary heat source flow rate is equal to or greater than a reference value (No in step S401). As the reference value, a lowest limit value is preset so as to ensure, for example, that the auxiliary heat source flow rate sensor 311 can stably detect the auxiliary heat source flow rate. When a hot-water faucet is opened in this waiting state and the auxiliary heat source flow rate increases to the reference value or higher (Yes in step S401), the auxiliary heat source controller 700 turns on the burner 303a (step S402). As the burner 303a burns fuel, the municipal water (preheated municipal water) is heated in the hot-water supply heat exchanger 301.

[0076] The auxiliary heat source controller 700 performs temperature-regulating control of the burner 303a, the water volume regulating valve 304, and the bypass valve 305 (step S403). For example, the auxiliary heat source controller 700 controls the amount of combustion by the burner 303a so that the auxiliary heat source outgoing hot-water temperature sensor 312 detects a target supplied hot-water temperature. At the same time, the auxiliary heat source controller 700 controls the water volume regulating valve 304 to adjust the flow rate of the municipal water (preheated municipal water) flowing into the auxiliary heat source unit 300. Further at the same time, the auxiliary heat source controller 700 controls the bypass valve 305 to adjust the flow rate of the water bypassing the hot-water supply heat exchanger 301 so that the supplied hot-water temperature reaches a target supplied hot-water temperature. In this way, water is heated to a target supplied hot-water temperature in the auxiliary heat source unit 300. The water then flows into the hot water storage unit 200 again through the auxiliary heat source outgoing hot-water pipe 222, undergoes pressure reduction in the hot-water pressure reducing valve 208, passes through the hot-water supply switching valve 209, and is supplied.

[0077] The auxiliary heat source controller 700 determines whether the auxiliary heat source flow rate is less than the reference value (step S404). When determining that the auxiliary heat source flow rate is not less than the reference value (No in step S404), the auxiliary heat source controller 700 continues the temperature-regulating control in step S403.

[0078] On the other hand, when determining that the auxiliary heat source flow rate is less than the reference value (Yes in step S404), the auxiliary heat source controller 700 turns off the burner 303a (step S405) and exits the auxiliary heating process to return to the waiting state.

[0079] As described above, in the auxiliary heating process, water is heated to a target supplied hot-water temperature in the auxiliary heat source unit 300, and then flows into the hot water storage unit 200 again through the auxiliary heat source outgoing hot-water pipe 222, undergoes pressure reduction in the hot-water pressure reducing valve 208, passes through the hot-water supply switching valve 209, and is supplied. During this process, no water from the hot water storage tank 201 is directly supplied because the hot-water supply switching valve 209 connects the hot-water pressure reducing valve 208 to the hot-water supply terminal 232.

[0080] The preheat flow rate sensor 213 may be alternatively disposed on the outlet side of the secondary side path in the water-water heat exchanger 202.

[0081] The hot water storage unit controller 600 may alternatively control the rotation frequency of the circulation pump 203 targeted at a temperature of the preheated municipal water (preheat temperature) as detected by the preheat temperature sensor 214. Specifically, as the rotation frequency of the circulation pump 203 is increased, the water-water heat exchanger 202 exchanges a larger quantity of heat to raise the preheat temperature. As the preheat temperature is increased, the amount of heating needed in the auxiliary heat source unit 300 for a fixed hot-water supply temperature setting is decreased, thus reducing the amount of combustion by the burner 303a. However, when the preheat temperature is excessively high, the temperature of incoming water to the auxiliary heat source unit 300 is also high. As a result, the auxiliary heat source unit 300 may fail to control the temperature of supplied hot-water or the burner 303a may stop burning. Therefore, the hot water storage unit controller 600 may control the rotation frequency of the circulation pump 203 so that, for example, the preheat temperature is adjusted to an upper limit (30 °C, for example) of the temperature of incoming water to the auxiliary heat source unit 300.

[0082] As compared with controlling the primary side flow rate targeted at ΔTwL, controlling the primary side flow rate targeted at a preheat temperature as above results in a higher tank return temperature on the primary side, and a higher temperature of incoming water to the heat pump unit 100 during a water-reheating operation. In contrast to CO2 and other refrigerants that transition to the supercritical state without condensing on the high pressure side, HFC, HC, HFO, and other refrigerants that condense on the high pressure side cause a COP drop by a smaller amount relative to an increase in temperature of incoming water. Therefore, controlling the primary side flow rate targeted at a preheat temperature is effective when a substance condensing on the high pressure side is used as the refrigerant.

Bathtub filling operation

[0083] The following describes the bathtub filling operation by which the bathtub 400 is filled with hot water. During the bathtub filling operation, the above-described indirect hot-water supply mode is carried out without regard to the quantity of stored heat in the hot water storage tank 201. When the bathtub filling operation is started, the hot water taken from an upper portion of the hot water storage tank 201 is fed through the preheat intake path 223 and then through the water-water heat exchanger 202 (the primary side path), as illustrated in FIG. 12. Then, the hot water dissipates heat to reduce its temperature (become low-temperature water) through heat exchange with municipal water (low-temperature water) in the water-water heat exchanger 202. The water thus having a lower temperature is fed through the suction switching valve 204, the circulation pump 203, the discharge switching valve 205, and the preheat return path 226 in this order to return to the lower portion of the hot water storage tank 201.

[0084] Meanwhile, the municipal water supplied from the feedwater terminal 231 is fed to the water-water heat exchanger 202 (the secondary side path). The municipal water is preheated through heat exchange with hot water (high-temperature water) in the water-water heat exchanger 202, and then fed through the auxiliary heat source incoming water pipe 221, the water volume regulating valve 304, and the hot-water supply heat exchanger 301 in this order. Then, the preheated water is heated in the hot-water supply heat exchanger 301, is fed through the bathtub filling valve 306 and then through bathtub return pipe 321, and is supplied to the bathtub 400. The hot water is also supplied to the bathtub 400 from the bathtub supply pipe 322, indication of which is omitted in FIG. 12.

[0085] The following describes a bathtub filling process for such a bathtub filling operation with reference to FIG. 13. FIG. 13 is a flowchart for illustrating the bathtub filling process. The bathtub filling process is carried out in parallel with the above-described indirect hot-water supply process in FIG. 8.

[0086] The auxiliary heat source controller 700 waits until an instruction to fill the bathtub is given by the remote controller 800 (No in step S501). When the instruction to fill the bathtub is given by the remote controller 800 (Yes in step S501), the auxiliary heat source controller 700 having been in the waiting state opens the bathtub filling valve 306 (step S502) and turns on the burner 303a (step S503). As the burner 303a burns fuel, the municipal water (preheated municipal water) is heated in the hot-water supply heat exchanger 301.

[0087] The auxiliary heat source controller 700 performs temperature-regulating control of the burner 303a, the water volume regulating valve 304, and the bypass valve 305 (step S504). When the bathtub filling valve 306 is opened, the preheated municipal water flows into the auxiliary heat source unit 300, passes through the auxiliary heat source flow rate sensor 311 and the water volume regulating valve 304. Then the preheated municipal water divides into flows: one is heated in the hot-water supply heat exchanger 301 and another bypasses the heat exchanger to pass through the bypass valve 305, both of which then join together and pass through the bathtub filling valve 306, and hot water is supplied to the bathtub 400 from both the bathtub supply pipe 322 and the bathtub return pipe 321. During the operation, the auxiliary heat source controller 700 controls, for example, the amount of combustion by the burner 303a so that the auxiliary heat source outgoing hot-water temperature sensor 312 detects a target bathtub filling temperature. At the same time, the auxiliary heat source controller 700 controls the water volume regulating valve 304 to adjust the flow rate of the municipal water (preheated municipal water) flowing into the auxiliary heat source unit 300. Further at the same time, the auxiliary heat source controller 700 controls the bypass valve 305 to adjust the flow rate of the water bypassing the hot-water supply heat exchanger 301 so that the supplied hot-water temperature reaches a target bathtub filling temperature.

[0088] The auxiliary heat source controller 700 determines whether the summed flow volume for bathtub filling is equal to or greater than the amount of hot water to fill the bathtub (step S505). In other words, since the auxiliary heat source flow rate sensor 311 sums the water flow volume during the bathtub filling operation, the auxiliary heat source controller 700 determines whether the summed flow volume is equal to or greater than the amount of hot water to fill the bathtub, as specified on the remote controller 800. When determining that the summed water flow volume is less than the amount of hot water to fill the bathtub (No in step S505), the auxiliary heat source controller 700 continues the temperature-regulating control in step S504.

[0089] On the other hand, when determining that the summed water flow volume for bathtub filling is equal to or greater than the amount of hot water to fill the bathtub (Yes in step S505), the auxiliary heat source controller 700 turns off the burner 303a (step S506), closes the bathtub filling valve 306 (step S507), exits the bathtub filling process, and returns to the waiting state.

[0090] During the bathtub filling process described above, whether to stop bathtub filling is determined in step S505 by using the flow volume summed by the auxiliary heat source flow rate sensor 311. However, whether to stop bathtub filling may alternatively be determined by using a water level sensor (not illustrated) that detects the water level in the bathtub 400.

[0091] During the bathtub filling operation, the indirect hot-water supply mode is carried out without regard to the quantity of stored heat in the hot water storage tank 201. Note that, however, in the case where the bathtub filling operation is performed concurrently with a general hot-water supply operation, the direct hot-water supply mode is carried out for the general hot-water supply operation as long as the quantity of stored heat in the hot water storage tank 201 is greater than a predetermined value. On the other hand, when the quantity of stored heat in the hot water storage tank 201 is equal to or less than a predetermined value, the indirect hot-water supply mode is carried out for the general hot-water supply operation.

Reheat and heat-retaining operation

[0092] The following describes a reheat and heat-retaining operation. The reheat and heat-retaining operation is performed when the mode selected on the remote controller 800 is the heat retention mode in which the bathtub 400 is kept warm at a constant temperature, or when the reheat button on the remote controller 800 is pressed so as to reheat the water in the bathtub 400. During the heating and heat retaining operation, the bathtub filling valve 306 is closed.

[0093] The auxiliary heat source controller 700 causes the reheating pump 307 to rotate to circulate hot water through the bathtub 400, the bathtub return pipe 321, the reheating pump 307, the reheating heat exchanger 302, and the bathtub supply pipe 322 in this order. Meanwhile, the auxiliary heat source controller 700 turns on the burner 303b to heat the circulating hot water. Not that the indirect hot-water supply process is not carried out during the reheat and heat-retaining operation.

Concurrent water-heating and indirect hot-water supply operations

[0094] The following describes the case where the water-heating operation (hot-water storing operation) and the indirect hot-water supply operation (feedwater preheat and hot-water supply operation) are concurrently carried out. Note that the indirect hot-water supply operation may be started during the water-heating operation; likewise, the water-heating operation may be started during the indirect hot-water supply operation.

[0095] During these operations, the hot water storage unit controller 600 controls actuators of the individual elements as listed in FIG. 14. In general, supplied hot water flows through the secondary side path in the water-water heat exchanger 202 at a maximum flow rate of about 15 to 20 L/min. Accordingly, water flows on the primary side at a comparable flow rate. On the other hand, during the water-heating operation, water flows into the heat pump unit 100 for at a water-heating flow rate of, for example, about 1.15 L/min., assuming that the heating capacity is 4.5 kW when the feedwater temperature is 9 °C in winter and the stored hot-water temperature is 65 °C. Therefore, in the case where the circulation pump 203 is shared between the water-heating operation and the indirect hot-water supply operation, flow rates need to be controlled separately between the water flowing into the heat pump unit 100 to be heated and the water flowing through the primary side path in the water-water heat exchanger 202, and some of the water from the primary side path in the water-water heat exchanger 202 needs to be allowed to flow into the heat pump unit 100 while the remaining water needs to be returned to a lower portion of the hot water storage tank 201.

[0096] Specifically, the hot water storage unit controller 600 controls the rotation frequency of the circulation pump 203 so that the temperature difference ΔTwL between Tw1o and Tw2i is kept constant (kept consistent with a predetermined value), where Twlo is the water temperature at an outlet of the primary side path and Tw2i is the water temperature at an inlet of the secondary side path in the water-water heat exchanger 202. In addition, the hot water storage unit controller 600 controls the temperature of outgoing hot-water from the heat pump unit 100 by controlling a degree of opening of the discharge switching valve 205 to adjust the water-heating flow rate in the heat pump. Furthermore, the hot water storage unit controller 600 causes the suction switching valve 204 to switch the inlet so that the pump suction pipe 224 is connected to the water-water heat exchanger 202 (primary side path).

[0097] FIG. 15 shows a relationship between the degree of opening of the discharge switching valve 205 and flow rates. As the degree of opening of the discharge switching valve 205 changes from 0 to the maximum in steps, the flow rate ratio (%) on either side of the hot water storage tank and the heat pump is changing while the total flow rate ratio is 100%. Thus, during the controls shown in FIG. 14, the hot water storage unit controller 600 controls, for the indirect hot-water supply operation, the rotation frequency of the circulation pump 203 to adjust the flow rate of water required in the primary side path in the water-water heat exchanger 202, while controlling the degree of opening of the discharge switching valve 205 in steps to adjust the ratio between the flow rate of water to the heat pump unit 100 for the water-heating operation and the flow rate of remaining water returning to a lower portion of the hot water storage tank 201.

Example operations during a day

[0098] Referring to FIGS. 16A to 16D, the following describes an example of operations during a day. FIG. 16A shows hot-water supplying loads during a day. FIG. 16B shows changes in quantity of stored heat in the hot water storage tank 201 during a day. FIG. 16C shows changes in heating capacity in the heat pump unit 100 during a day. FIG. 16D shows changes in heating capacity in the auxiliary heat source unit 300 during a day.

[0099] As illustrated in FIG. 16C, the heat pump unit 100 is operational (the water-heating operation is performed) during a late-night time period, which is usually set to a time period ending before 7:00 (24-hour time), to increase the quantity of stored heat in the hot water storage tank 201 as indicated in FIG. 16B. The quantity of heat to be stored in the hot water storage tank 201 may be the rated maximum quantity of stored heat of the hot water storage tank 201 or may be a quantity of stored heat calculated from an estimated hot-water supplying load.

[0100] As illustrated in FIG. 16A, during a period from 7:00 to around 18:00, general hot-water supplying loads arising from hot-water faucets (lavatory or kitchen faucets, for example) occur. Since these general hot-water supplying loads are lighter than those for taking a bath, the hot water storage unit controller 600 deals with these loads by carrying out the direct hot-water supply operation. Note that the quantity of stored heat gradually decreases during a time period when no general hot-water supply occurs because of heat dissipation from the hot water storage tank 201.

[0101] When a bathtub filling load occurs around 19:00 as shown in FIG. 16A, the auxiliary heat source unit 300 starts the bathtub filling operation as seen in FIG. 16D. Meanwhile, the indirect hot-water supply operation (feed-water preheat operation) is carried out in the hot water storage unit 200. Thus, the quantity of stored heat in the hot water storage tank 201 drops concurrently with heating in the auxiliary heat source unit 300, as indicated in FIGS. 16B and 16D. After the bathtub filling operation is started, the quantity of stored heat in the hot water storage tank 201 sharply drops as indicated in FIG. 16B, and thus the quantity of stored heat falls below the tank direct hot-water supply threshold. A general hot-water supplying load, such as shower, occurs thereafter. However, the hot water storage unit controller 600 continues the indirect hot-water supply operation without the water-heating operation until the quantity of stored heat in the hot water storage tank 201 drops below the heat pump water-heating threshold.

[0102] When the quantity of stored heat in the hot water storage tank 201 drops below the heat pump water-heating threshold owing to a general hot-water supplying load occurring continuously, the hot water storage unit controller 600 starts the water-heating operation. When any general hot-water supplying load occurs thereafter, the hot water storage unit controller 600 carries out the indirect hot-water supply operation until the quantity of stored heat in the hot water storage tank 201 exceeds the tank direct hot-water supply threshold. In this way, the hot water storage unit controller 600 carries out the above-described concurrent operation when the indirect hot-water supply operation is started during the water-heating operation. The target value of the quantity of stored heat in the hot water storage tank 201 is calculated by estimating and summing remaining loads to occur by the end of the day, the target value being smaller than that for the in a late-night time period.

[0103] When any general hot-water supplying load occurs after the boiling operation, the hot water storage unit controller 600 carries out the direct hot-water supply operation if the quantity of stored heat in the hot water storage tank 201 is greater than the tank direct hot-water supply threshold, or carries out the indirect hot-water supply operation if the quantity of stored heat is less than the tank direct hot-water supply threshold. The quantity of stored heat should be controlled to become a minimum at 24:00, which is the end of a day. However, some quantity of stored heat may still be present at 24:00 if a general hot-water supplying load is expected to occur after 24:00.

Effects

[0104] As described above, when a sufficient quantity of stored heat for covering a general hot-water supplying load is present in the hot water storage tank 201, the hot water storage tank 201 directly supplies hot water while low-temperature municipal water flows into a lower portion of the hot water storage tank 201. Thus, the heat pump unit 100 can operate at a higher COP during the water-heating operation. In particular, the present embodiment is effective when CO_2 is used as the refrigerant, because CO_2 is in a supercritical cycle on the high-pressure side and a higher COP is achieved by lower-temperature incoming water to the heat pump unit 100.

[0105] The preheat flow rate sensor 213 is disposed in the hot water storage unit 200 while the auxiliary heat source flow rate sensor 311 is disposed in the auxiliary heat source unit 300. Thus, when, for example, municipal water that is to flow into the auxiliary heat source unit for a general hot-water supply operation is preheated in the hot water storage unit 200, the individual actuators can be independently controlled without the need for communications between the hot water storage unit controller 600 and the auxiliary heat source controller 700.

[0106] The municipal water that is to flow into the auxiliary heat source unit 300 is branched before the tank pressure reducing valve 206, undergoes preheating in the water-water heat exchanger 202, and then flows into the auxiliary heat source unit 300. Therefore, by using a heat exchanger causing a low pressure loss such as a plate heat exchanger as the water-water heater exchanger 202, the water can flow into the auxiliary heat source unit 300 at a higher water pressure. After the water passes through those elements which cause a greater pressure loss in relation to a higher flow rate of supplied hot water, such as the water volume regulating valve 304, the hot-water supply heat exchanger 301, and the bypass valve 305, the water undergoes pressure reduction in the hot-water pressure reducing valve 208 to a secondary side pressure that is equal to a pressure setting for the hot water storage tank 201. Therefore, the supplied hot water is inhibited from reducing its flow rate caused by a pressure loss. Instead of disposing the hot-water pressure reducing valve 208, a check valve may be disposed between the tank mixing valve 207 and the hot-water supply switching valve 209 to limit the hot-water flow to the direction from the tank mixing valve 207 to the hot-water supply switching valve 209, so that no water pressure derived from the auxiliary heat source unit 300 is applied to the hot water storage unit 200.

[0107] The municipal water that is to flow into the auxiliary heat source unit 300 is branched before the tank pressure reducing valve 206. Therefore, separate pressures can be set between the water flowing into the hot water storage tank 201 and the water flowing into the auxiliary heat source unit 300. Thus, the pressure of water flowing into the auxiliary heat source unit 300 can be set to a higher value while the pressure of water flowing into the hot water storage tank 201 can be set to a low value. As a result, the hot water storage tank 201 can be manufactured at low cost. Furthermore, the hot water storage tank 201 can be easily made larger in size, and the ratio of heating in the heat pump unit 100 can be increased, thus contributing to improved energy saving.

[0108] During a general hot-water supply operation, the direct hot-water supply operation is performed to directly supply hot water from the hot water storage tank 201 when a larger quantity of heat is stored, whereas the indirect hot-water supply operation is performed when a smaller quantity of heat is stored. Therefore, the heat stored in the hot water storage tank 201 can be efficiently used.

[0109] The rotation frequency of the circulation pump 203 is controlled depending on the temperature difference between the temperature of water returning to the tank and the feedwater temperature. Therefore, lower COPs can be reduced when lower-temperature water returning to the tank is reheated in the heat pump unit 100.

[0110] Even when the water-heating operation occurs concurrently with the indirect hot-water supply operation, the water-heating flow rate and the preheating flow rate can be separately adjusted by controlling the rotation frequency of the circulation pump 203 and the degree of opening of the discharge switching valve 205. Therefore, a water circuit can be built at low cost with a single pump.

[0111] General hot-water supply is dealt with by the direct hot-water supply operation, whereas bathtub filling operations are performed with the indirect hot-water supply operation only. Therefore, the hot water storage tank 201 can be made smaller in size as compared with, for example, handling bathtub filling operations by the direct hot-water supply operation. Assuming that connecting pipes to the bathtub 400 (bathtub return pipe 321 and bathtub supply pipe 322) are connected in the auxiliary heat source unit 300 as in the present embodiment and that bathtub filling is handled by the direct hot-water supply operation in which hot water taken from the hot water storage tank 201 is used for bathtub filling, an additional pipe connecting the hot water storage unit 200 to the auxiliary heat source unit 300 will be needed for bathtub filling, making the water circuit complicated. Therefore, by using the preheated municipal water (feedwater preheating) as a way of utilizing heat in the hot water storage tank 201 for bathtub filling operations, the water circuit can be simplified.

[0112] Concerning gas-powered water heaters that usually need a higher feedwater pressure, the present embodiment allows for preheating without reducing the feedwater pressure, and therefore the present embodiment is effective when the storage-type water heater is added to a gas-powered water heater already installed.

[0113] Assuming that the water is left in the hot water storage tank 201 at a temperature lower than 45 °C for several days, Legionella or other saprophytic bacteria may propagate, and thus the water needs to be re-heated to a high temperature (65 °C or higher, for example) in the heat pump unit 100 before supplied and used. In this case, assuming that the water before reheating has a temperature of 40 °C or higher, reheating this water directly in the heat pump unit 100 will result in a lower COP owing to a higher temperature of incoming water. In contrast, performing the indirect hot-water supply operation to lower the stored hot-water temperature followed by reheating, a higher reheating COP can be obtained and heat can be efficiently used through feedwater preheating. In addition, since the pressure on the high-pressure side can be lowered during the water-heating operation in relation to a lower temperature of incoming water to the heat pump unit 100, the refrigerant circuit can have a lower design pressure.

[0114] A maximum value (tank direct hot-water supply threshold) of the past hot-water supplying loads (for a single hot-water supply) is used for switching from the direct hot-water supply operation to the indirect hot-water supply operation. Therefore, the hot water storage tank 201 is less likely to run out of hot water during a general hot-water supply. Furthermore, any remaining quantity of stored heat can be used for the indirect hot-water supply operation. Therefore, the stored heat is not wasted even when a relatively high value is given to the threshold.

Variation 1

[0115] FIG. 17 illustrates a configuration of a hot water storage unit 900 according to another embodiment. Compared with the hot water storage unit 200 described above, the hot water storage unit 900 allows for switching between a middle position and a lower position (lower portion) of the hot water storage tank 201 to which the water is returned after used for preheating municipal water during the indirect hot-water supply operation. In other words, the hot water storage unit 900 includes a return position switching valve 901 disposed midway in the preheat return path 226.

[0116] The return position switching valve 901, which may be a three-way valve, for example, includes a water inlet a and water outlets b and c. The water inlet a is connected to the discharge switching valve 205 via the preheat return path 226. The water outlet b is connected to a lower portion of the hot water storage tank 201 via a pipe. The water outlet c is connected to a middle portion of the hot water storage tank 201 via a pipe.

[0117] The following describes an indirect hot-water supply process in the hot water storage unit 900 with reference to FIG. 18. FIG. 18 is a flowchart for illustrating the indirect hot-water supply process according to this variation. The indirect hot-water supply process is started when, for example, a hot-water faucet connected to the hot-water supply terminal 232 is opened. The same reference signs are given to the same steps as those in the indirect hot-water supply process in FIG. 8. While the indirect hot-water supply process is performed, the auxiliary heat source controller 700 carries out the above-described auxiliary heating process illustrated in FIG. 11.

[0118] The hot water storage unit controller 600 causes the suction switching valve 204 to switch to the water inlet connected to the water-water heat exchanger 202 (step S301), and causes the discharge switching valve 205 to switch to the water outlet connected to the preheat return path 226 (step S302).

[0119] The hot water storage unit controller 600 determines whether the hot water storage tank 201 at a middle portion has a temperature higher than the control target temperature at an outlet of the primary side path, Tw2i + ΔTwL (step S601). The hot water storage unit controller 600 calculates the temperature at the middle portion of the hot water storage tank 201 from a temperature distribution detected by the stored hot-water temperature sensors 211.

[0120] When determining that the temperature at the middle portion is higher than Tw2i + ΔTwL (Yes in step S601), the hot water storage unit controller 600 switches the return position switching valve 901 to the outlet connecting to the lower side of the hot water storage tank 201 (step S602).

[0121] As an example, it is assumed here that, as illustrated in FIG. 19A, the hot water storage tank 201 has a temperature distribution composed of a higher-temperature part (45 °C or above) higher than a general hot-water supply temperature setting (about 40 °C) and a lower-temperature part (less than 20 °C) lower than the temperature of municipal water, and that the middle portion of the hot water storage tank 201 is included in the higher-temperature part. In this case, the temperature at the middle portion is higher than Tw2i + ΔTwL, and thus the outlet of the return position switching valve 901 is connected to the lower side of the hot water storage tank 201 so that the water on the primary side after used for preheating, which is herein referred to as preheat return water, is returned to the lower side of the hot water storage tank 201.

[0122] As another example, it is assumed here that, as illustrated in FIG. 19B, the hot water storage tank 201 has a temperature distribution composed of a middle-temperature part (20 to 45 °C) and a lower-temperature part, and that the middle portion of the hot water storage tank 201 is included in the middle-temperature part. In this case, to avoid a loss that will be caused when the water on the primary side is returned to the middle portion of the hot water storage tank 201 after used for heating and the returned water is mixed with the middle-temperature water, the outlet of the return position switching valve 901 is connected to the lower side of the hot water storage tank 201 so that the water on the primary side is returned to the lower side of the hot water storage tank 201 after used for preheating.

[0123] On the other hand, when determining that the temperature at a middle portion is lower than Tw2i + ΔTwL (No in step S601), the hot water storage unit controller 600 switches the return position switching valve 901 to the outlet connecting to the middle of the hot water storage tank 201 (step S603).

[0124] As an example, it is assumed here that, as illustrated in FIG. 19C, the hot water storage tank 201 has a temperature distribution composed of a middle-temperature part and a lower-temperature part, and that the middle portion of the hot water storage tank 201 is included in the lower-temperature part. In this case, temperature rise will occur in the lower-temperature part when the water on the primary side is returned to the lower side of the hot water storage tank 201 after used for heating and the returned water is mixed with the middle-temperature water. Hence, the outlet of the return position switching valve 901 is connected to the middle of the hot water storage tank 201 so that the water on the primary side is returned to the middle portion of the hot water storage tank 201 after used for preheating.

[0125] The hot water storage unit controller 600 waits until the preheat flow rate is equal to or greater than a reference value (No in step S303). When a hot-water faucet is opened in this waiting state and the preheat flow rate increases to the reference value or higher (Yes in step S303), the hot water storage unit controller 600 performs temperature-regulating control of the circulation pump 203 (step S304).

[0126] The hot water storage unit controller 600 determines whether the preheat flow rate is less than the reference value (step S305). When determining that the preheat flow rate is not less than the reference value (No in step S305), the hot water storage unit controller 600 continues the temperature-regulating control in step S304.

[0127] On the other hand, when determining that the preheat flow rate is less than the reference value (Yes in step S305), the hot water storage unit controller 600 exits the auxiliary heating process to return to the waiting state.

[0128] In this way, the hot water storage unit 900 allows the primary side water that has been used for preheating feedwater to return to a position switched between a middle portion and a lower portion of the hot water storage tank. Therefore, mid-temperature water can be efficiently used while the incoming water to the heat pump unit 100 can be maintained at a lower temperature.

Variation 2

[0129] In the foregoing embodiments, the hot water storage unit controller 600 starts the indirect hot-water supply operation when the quantity of stored heat in the hot water storage tank 201 drops. However, the user may be allowed to select the indirect hot-water supply operation using the remote controller 800, without regard to the quantity of stored heat in the hot water storage tank 201. For example, use of a large amount of supplied hot water during the daytime may cause run-out of hot water in the hot water storage tank 201 and reheating may occur in the heat pump unit 100. As a result, the running cost may be increased due to a higher electricity charge. In such cases, the indirect hot-water supply operation can be started by selecting the indirect hot-water supply operation on the remote controller 800, irrespective of whether the quantity of stored heat in the hot water storage tank 201 is higher than the tank direct hot-water supply threshold. Accordingly, since the auxiliary heat source unit 300 is used for supplying hot water, the use ratio of the stored heat in the hot water storage tank 201 is decreased, thus reducing water-heating operations involving a higher electricity charge that may be started due to run-out of hot water. Then, the water heater may be configured to return to the direct hot-water supply operation when a predetermined time has elapsed after selection of the indirect hot-water supply operation, so that no adverse effect is caused by the user forgetting to return to the direct hot-water supply operation.

[0130] In addition, high electricity charge hours may be set in advance by using the remote controller 800 so that the indirect hot-water supply operation is performed during the specified hours.

[0131] Furthermore, the water heater may be configured such that the quantity of exchanged heat for feedwater preheating is reduced after the indirect hot-water supply operation is selected on the remote controller 800. The quantity of exchanged heat for feedwater preheating can be reduced by increasing the target value of ΔTwL to decrease the primary side flow rate, as compared with the case where the indirect hot-water supply operation is started when the quantity of stored heat in the hot water storage tank 201 drops below a specified value as described above. As a result, the use ratio of the stored heat in the hot water storage tank 201 can be further reduced. The remote controller 800 may be used to stop the indirect hot-water supply operation to prevent the circulation pump 203 from rotating. In this case, since the water-water heat exchanger 202 is caused to stop preheating the feedwater, the use ratio of the auxiliary heat source unit 300 can be increased to 100%.

[0132] In the foregoing embodiments, a program executed by the hot water storage unit controller 600 can be distributed in a form of a non-transitory computer-readable recording medium storing the program, such as a compact disc read-only memory (CD-ROM), a digital versatile disc (DVD), a magneto-optical disk (MO), a USB memory, or a memory card. Then, such a program may be installed on a specific or general-purpose computer, and the computer can function as the hot water storage unit controller 600 according to the foregoing embodiments.

[0133] The above-described program may be stored on a disk device or the like of a server device on a communication network such as the Internet to enable the program to be downloaded to the computer, for example by superimposing the program onto a carrier wave. Moreover, the above-described processing can be achieved even by execution while the program is transferred through the communication network. Furthermore, the above-described processing can be achieved by executing all or part of the program on the server device, and executing the program while sending and receiving by the computer the information relating to such processing through the communication network.

[0134] Moreover, if the above-described functions are executed by sharing the functions between an operating system (OS) and application programs, or are executed by both the OS and the application programs in cooperation with each other, the non-OS portion alone may be stored and distributed in the above-described recording medium, or alternatively, may be, for example, downloaded to the computer.

[0135] The foregoing describes some example embodiments for explanatory purposes. Although the foregoing discussion has presented specific embodiments, persons skilled in the art will recognize that changes may be made in form and detail without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. This detailed description, therefore, is not to be taken in a limiting sense, and the scope of the invention is defined only by the included claims, along with the full range of equivalents to which such claims are entitled.

Industrial Applicability

[0136] The present disclosure may be suitably adopted as a storage-type water heater used in homes and facilities.

Reference Signs List

[0137]

1	Storage-type water heater
100	Heat pump unit
101	Compressor
102	Refrigerant-water heat exchanger
103	Expansion valve
104	Evaporator
121	Heat pump incoming water pipe
122	Heat pump outgoing hot-water pipe
200, 900	Hot water storage unit
201	Hot water storage tank
202	Water-water heat exchanger
203	Circulation pump
204	Suction switching valve
205	Discharge switching valve
206	Tank pressure reducing valve
207	Tank mixing valve
208	Hot-water pressure reducing valve
209	Hot-water supply switching valve
901	Return position switching valve
211	Stored hot-water temperature sensor
212	Tank return temperature sensor
213	Preheat flow rate sensor
214	Preheat temperature sensor
215	Feedwater temperature sensor
216	Tank outgoing hot-water temperature sensor
217	Supplied hot-water temperature sensor
218	Supplied hot-water flow rate sensor
221	Auxiliary heat source incoming water pipe
222	Auxiliary heat source outgoing hot-water pipe
223	Preheat intake path
224	Pump suction pipe
225	Pump discharge pipe
226	Preheat return path
231	Feedwater terminal
232	Hot-water supply terminal
300	Auxiliary heat source unit
301	Hot-water supply heat exchanger
302	Reheating heat exchanger
303a, 303b	Burner
304	Water volume regulating valve
305	Bypass valve
306	Bathtub filling valve
307	Reheating pump
311	Auxiliary heat source flow rate sensor
312	Auxiliary heat source outgoing hot-water temperature sensor
321	Bathtub return pipe
322	Bathtub supply pipe
400	Bathtub
500	Heat pump controller
600	Hot water storage unit controller
601	Measurer
602	Calculator
603	Controller
604	Storage
700	Auxiliary heat source controller
800	Remote controller
901	Return position switching valve

Claims

1. A storage-type water heater comprising:

    first heating means for heating water to generate first hot water;
    a hot water storage tank configured to store the first hot water generated by the first heating means;
    a heat exchanger configured to preheat municipal water through heat exchange between the first hot water taken from the hot water storage tank and the municipal water;
    second heating means for heating the municipal water preheated by the heat exchanger to generate second hot water; and
    control means for supplying the first hot water taken from the hot water storage tank or the second hot water generated by the second heating means.

2. The storage-type water heater according to claim 1, wherein the control means is configured to take the first hot water from the hot water storage tank to supply the first hot water when a quantity of stored heat of the first hot water stored in the hot water storage

tank is equal to or greater than a specified value defined for a single hot-water supply, and to cause the second heating means to generate the second hot water to supply the second hot water when the quantity of stored heat is less than the specified value.

3. The storage-type water heater according to claim 1, wherein the control means is configured to, when hot water is to be supplied to a bathtub, cause the second heating means to generate the second hot water to supply the second hot water.

4. The storage-type water heater according to claim 1, wherein
a primary side path through which the first hot water taken from the hot water storage tank flows and a secondary side path through which the municipal water flows are disposed in the heat exchanger, and
the control means is configured to control a rotation frequency of a pump so that a temperature difference between an outlet temperature of the primary side path and an inlet temperature of the secondary side path is kept consistent with a predetermined value, the pump being configured to circulate the first hot water that is to flow through the primary side path.

5. The storage-type water heater according to claim 1, wherein
a primary side path through which the first hot water taken from the hot water storage tank flows and a secondary side path through which the municipal water flows are disposed in the heat exchanger, and
the control means is configured to control a rotation frequency of a pump so that a ratio between a flow rate in the primary side path and a flow rate in the secondary side path is kept consistent with a predetermined value, the pump being configured to circulate the first hot water that is to flow through the primary side path.

6. The storage-type water heater according to claim 1, wherein
a primary side path through which the first hot water taken from the hot water storage tank flows and a secondary side path through which the municipal water flows are disposed in the heat exchanger, and
the control means is configured to control a rotation frequency of a pump so that an outlet temperature of the secondary side path is kept consistent with a predetermined value, the pump being configured to circulate the first hot water that is to flow through the primary side path.

7. The storage-type water heater according to claim 1, wherein
a primary side path through which the first hot water taken from the hot water storage tank flows and a secondary side path through which the municipal water flows are disposed in the heat exchanger, and
the control means is configured to control a rotation frequency of a pump so that an outlet temperature of the secondary side path is kept consistent with an upper limit value determined for the second heating means, the pump being configured to circulate the first hot water that is to flow through the primary side path.

8. The storage-type water heater according to claim 1, wherein
a primary side path through which the first hot water taken from the hot water storage tank flows and a secondary side path through which the municipal water flows are disposed in the heat exchanger, and
the control means is configured to, when a flow rate in the secondary side path becomes equal to or greater than a predetermined value, activate a pump configured to circulate the first hot water that is to flow through the first side path.

9. The storage-type water heater according to claim 1, wherein
the first hot water that has undergone heat exchange in the heat exchanger is returned to a lower portion of the hot water storage tank, and
the control means is configured to cause the second heating means to generate the second hot water to supply the second hot water when a quantity of stored heat of the first hot water stored in the hot water storage tank falls below a first lower limit value, and to supply water taken from a lower portion of the hot water storage tank to the first heating means and cause the first heating means to reheat the water when the quantity of stored heat of the first hot water falls below a second lower limit value that is lower than the first lower limit value.

10. The storage-type water heater according to claim 1, wherein
the hot water storage tank and the second heating means are connected in parallel to (i) a feedwater terminal from which the municipal water is supplied and (ii) a hot-water supply terminal to which the first hot water and the second hot water are supplied,
a pressure reducing valve is disposed between the feedwater terminal and an incoming water path to the hot water storage tank, and
an incoming water path to the second heating means is branched between the feedwater terminal and the pressure reducing valve.

11. The storage-type water heater according to claim 1, wherein
a primary side path through which the first hot water taken from an upper portion of the hot water storage tank flows and a secondary side path through which the municipal water flows are disposed in the heat

exchanger,
a suction switching valve configured to switch between the primary side path and a path through which water taken from a lower portion of the hot water storage tank flows is disposed in a suction path to a pump, and
a discharge switching valve configured to switch between an incoming water path to the first heating means and a path through which water flows into a lower portion of the hot water storage tank is disposed in a discharge path from the pump.

12. The storage-type water heater according to claim 11, the control means is configured to, when an indirect hot-water supply operation is performed concurrently with a water-heating operation, control the discharge switching valve to adjust a flow rate ratio between water flowing into the first heating means and water flowing into a lower portion of the hot water storage tank, the indirect hot-water supply operation being an operation by which the second heating means is caused to generate the second hot water to supply the second hot water, the water-heating operation being an operation by which water taken from a lower portion of the hot water storage tank is supplied to the first heating means and the first hot water is generated by the first heating means.

13. The storage-type water heater according to claim 1, the control means is configured to, when instructed of an indirect hot-water supply operation by a user via a remote controller, cause the second heating means to generate the second hot water to supply the second hot water.

14. The storage-type water heater according to claim 13, wherein the remote controller is configured to, when a predetermined time has elapsed after the indirect hot-water supply operation, instruct the control means to return to a direct hot-water supply operation by which the first hot water taken from the hot water storage tank is supplied.

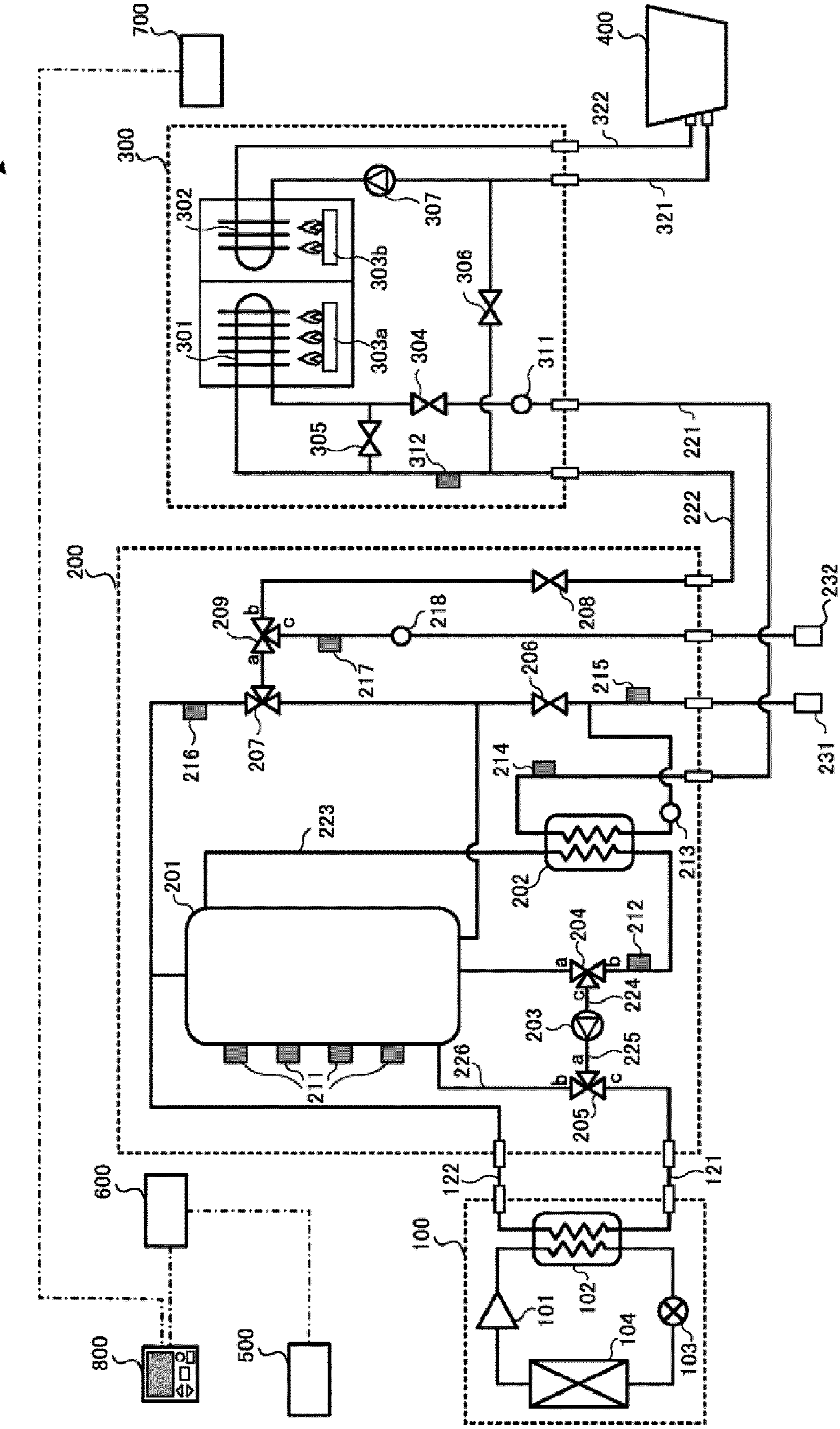
15. The storage-type water heater according to claim 13, wherein the remote controller is configured to allow a user to set a time period in which the indirect hot-water supply operation is performed.

16. The storage-type water heater according to claim 13, wherein the control means is configured to reduce a quantity of heat exchanged between the first hot water and the municipal water in the heat exchanger.

17. The storage-type water heater according to claim 1, wherein
a primary side path through which the first hot water taken from an upper portion of the hot water storage tank flows and a secondary side path through which the municipal water flows are disposed in the heat exchanger, and
the control means is configured to, when instructed to stop an indirect hot-water supply operation by a user via a remote controller, cause the second heating means to generate the second hot water to supply the second hot water, with the first hot water being prevented from flowing into the primary side path.

18. The storage-type water heater according to claim 1, wherein the first hot water that has undergone heat exchange in the heat exchanger is returned to a return inlet disposed higher than a lower portion of the hot water storage tank.

FIG. 1


1
700
400
300
322
321
302
301
307
303b
303a
306
304
305
311
312
221
222
200
209
b
c
a
218
208
217
232
206
215
207
216
231
214
223
213
201
202
204
212
a
b
c
224
203
225
226
a
b
c
211
205
122
121
600
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104
103
800
500

FIG. 2

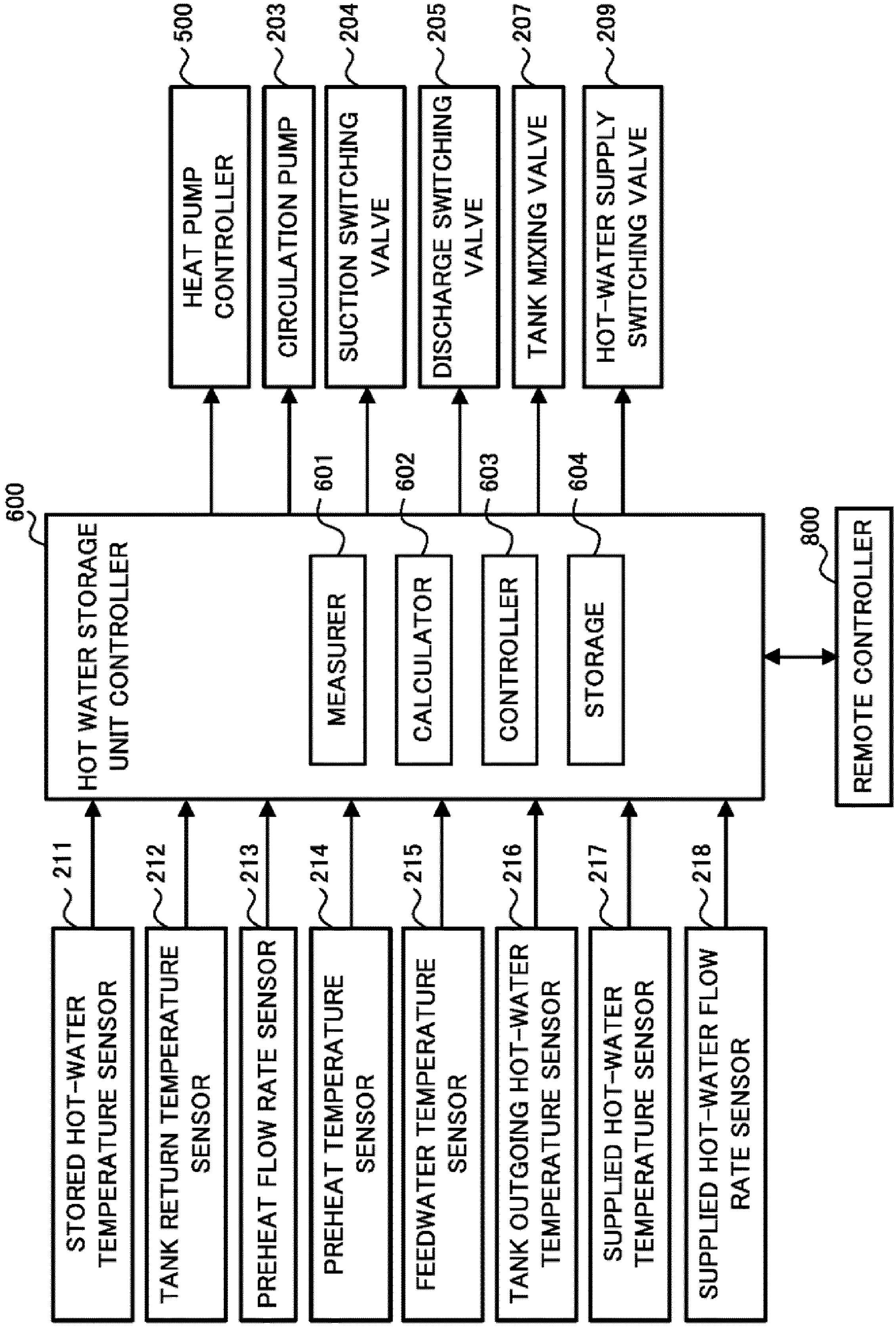

STORED HOT-WATER TEMPERATURE SENSOR
211
TANK RETURN TEMPERATURE SENSOR
212
PREHEAT FLOW RATE SENSOR
213
PREHEAT TEMPERATURE SENSOR
214
FEEDWATER TEMPERATURE SENSOR
215
TANK OUTGOING HOT-WATER TEMPERATURE SENSOR
216
SUPPLIED HOT-WATER TEMPERATURE SENSOR
217
SUPPLIED HOT-WATER FLOW RATE SENSOR
218
HOT WATER STORAGE UNIT CONTROLLER
600
MEASURER
601
CALCULATOR
602
CONTROLLER
603
STORAGE
604
REMOTE CONTROLLER
800
HEAT PUMP CONTROLLER
500
CIRCULATION PUMP
203
SUCTION SWITCHING VALVE
204
DISCHARGE SWITCHING VALVE
205
TANK MIXING VALVE
207
HOT-WATER SUPPLY SWITCHING VALVE
209

FIG. 3

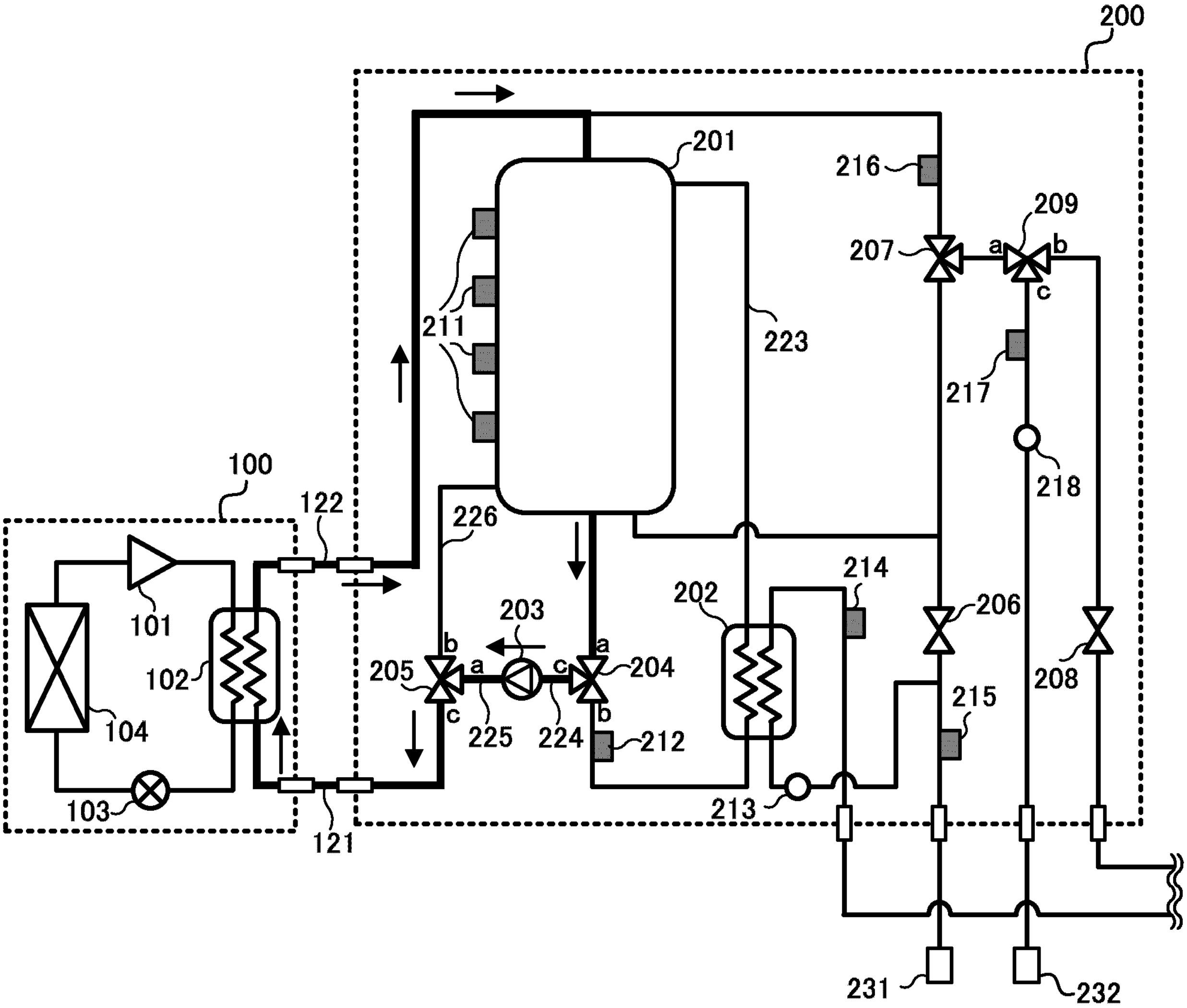

200
201
216
209
207
a
b
c
211
223
217
218
100
122
226
214
202
203
206
b
a
205
a
c
204
208
215
102
101
104
c
225
224
b
212
103
213
121
231
232

FIG. 4

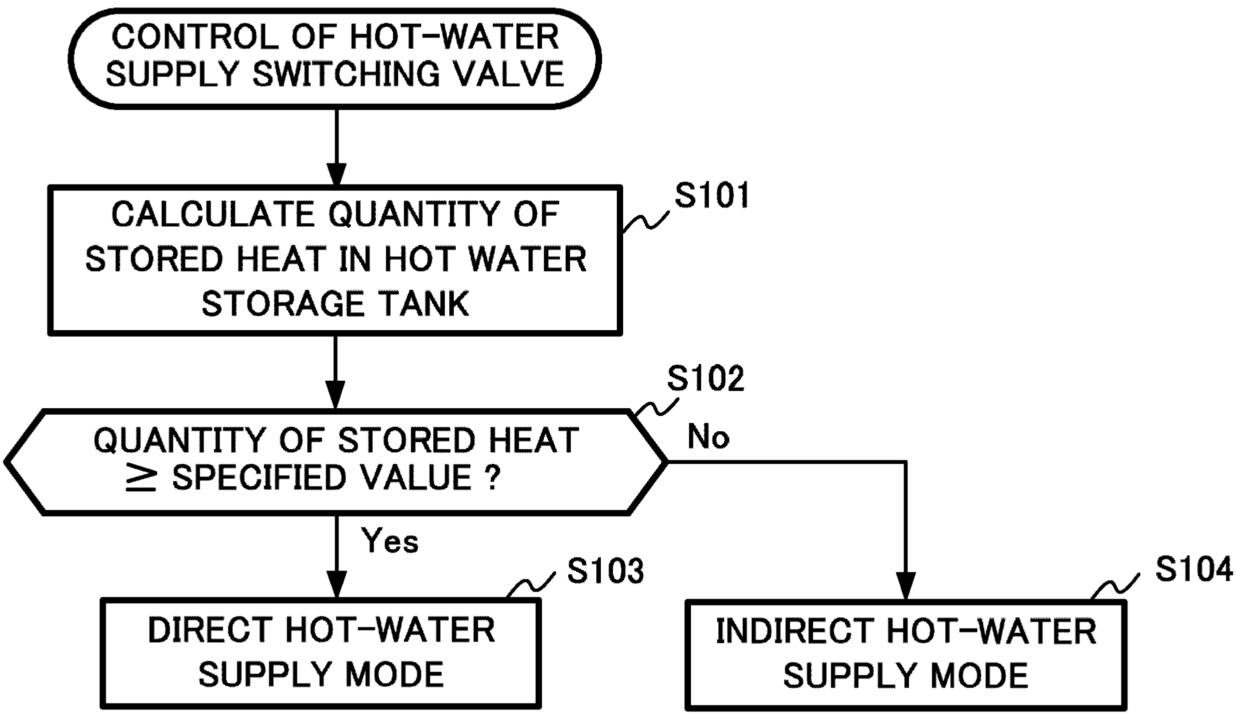
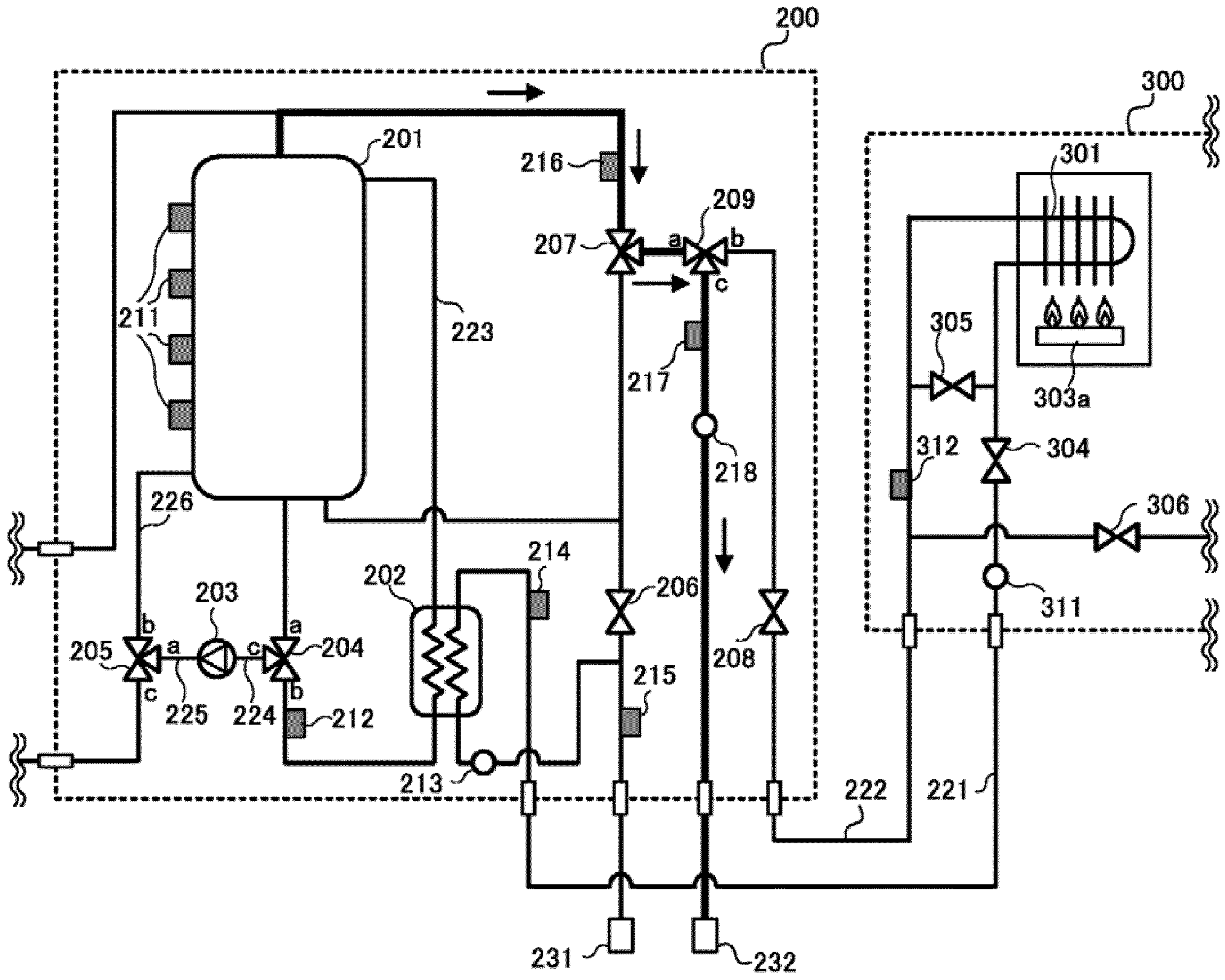

CONTROL OF HOT-WATER SUPPLY SWITCHING VALVE
CALCULATE QUANTITY OF STORED HEAT IN HOT WATER STORAGE TANK
S101
S102
QUANTITY OF STORED HEAT ≥ SPECIFIED VALUE ?
No
Yes
S103
DIRECT HOT-WATER SUPPLY MODE
S104
INDIRECT HOT-WATER SUPPLY MODE

FIG. 5


200
300
201
301
216
209
207
a
b
c
211
223
217
305
303a
218
312
304
306
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214
203
202
206
311
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208
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222
221
231
232

FIG. 6

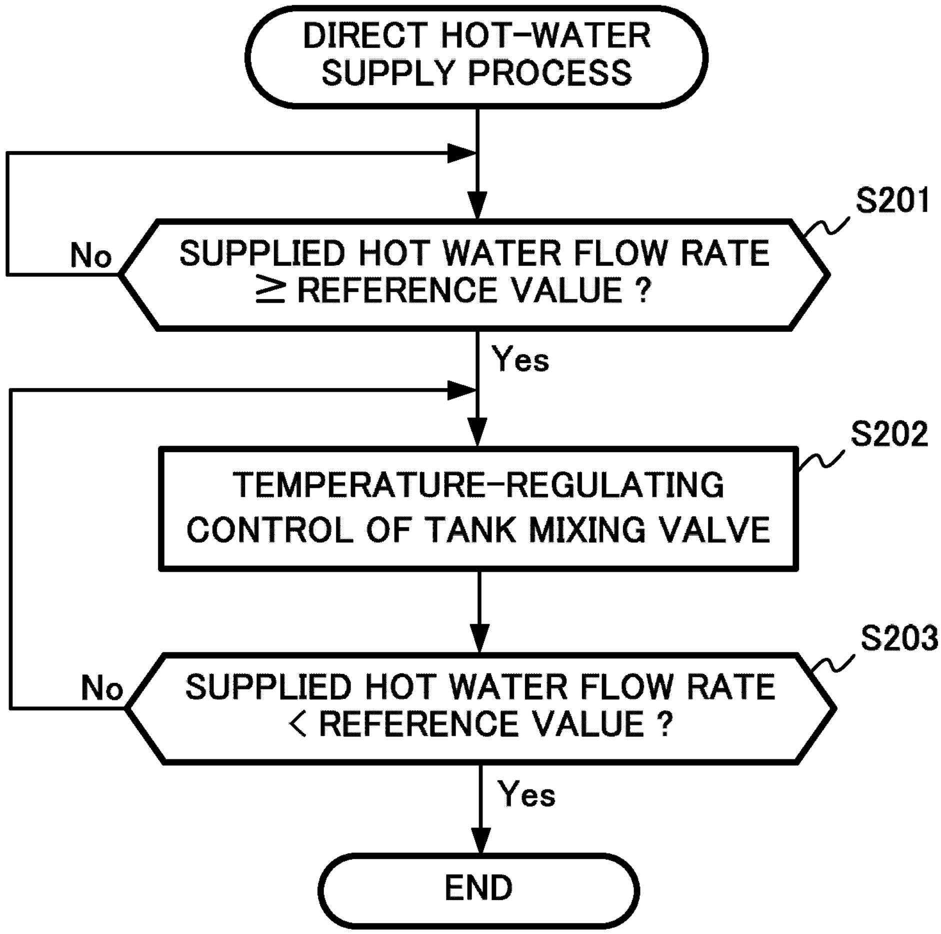

DIRECT HOT-WATER SUPPLY PROCESS
S201
No
SUPPLIED HOT WATER FLOW RATE ≥ REFERENCE VALUE ?
Yes
S202
TEMPERATURE-REGULATING CONTROL OF TANK MIXING VALVE
S203
No
SUPPLIED HOT WATER FLOW RATE < REFERENCE VALUE ?
Yes
END

FIG. 7

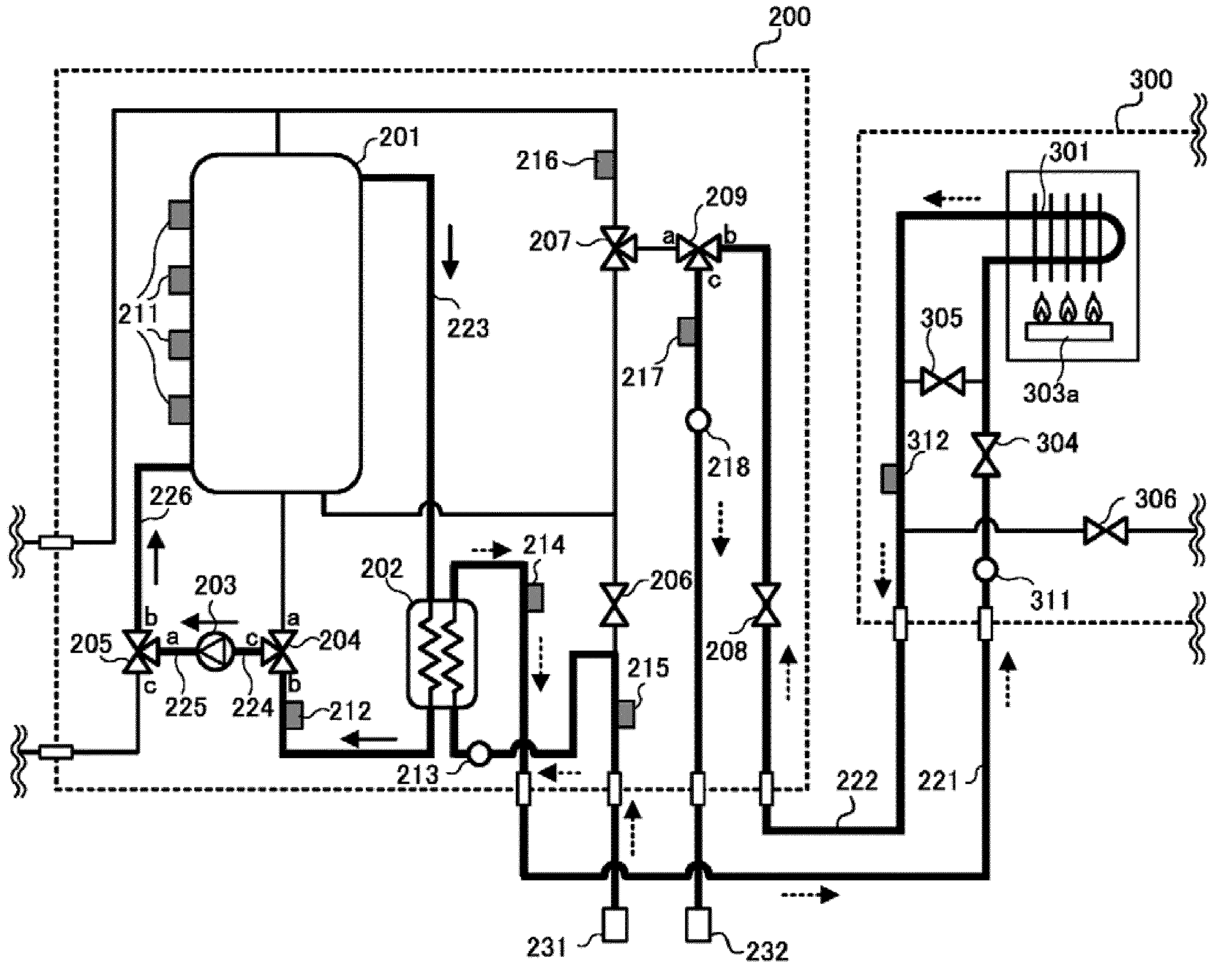

200
300
301
201
216
209
207
a
b
c
211
223
305
217
303a
312
304
218
226
306
214
203
202
206
311
b
a
205
a
c
204
208
215
c
b
225
224
212
213
222
221
231
232

FIG. 8

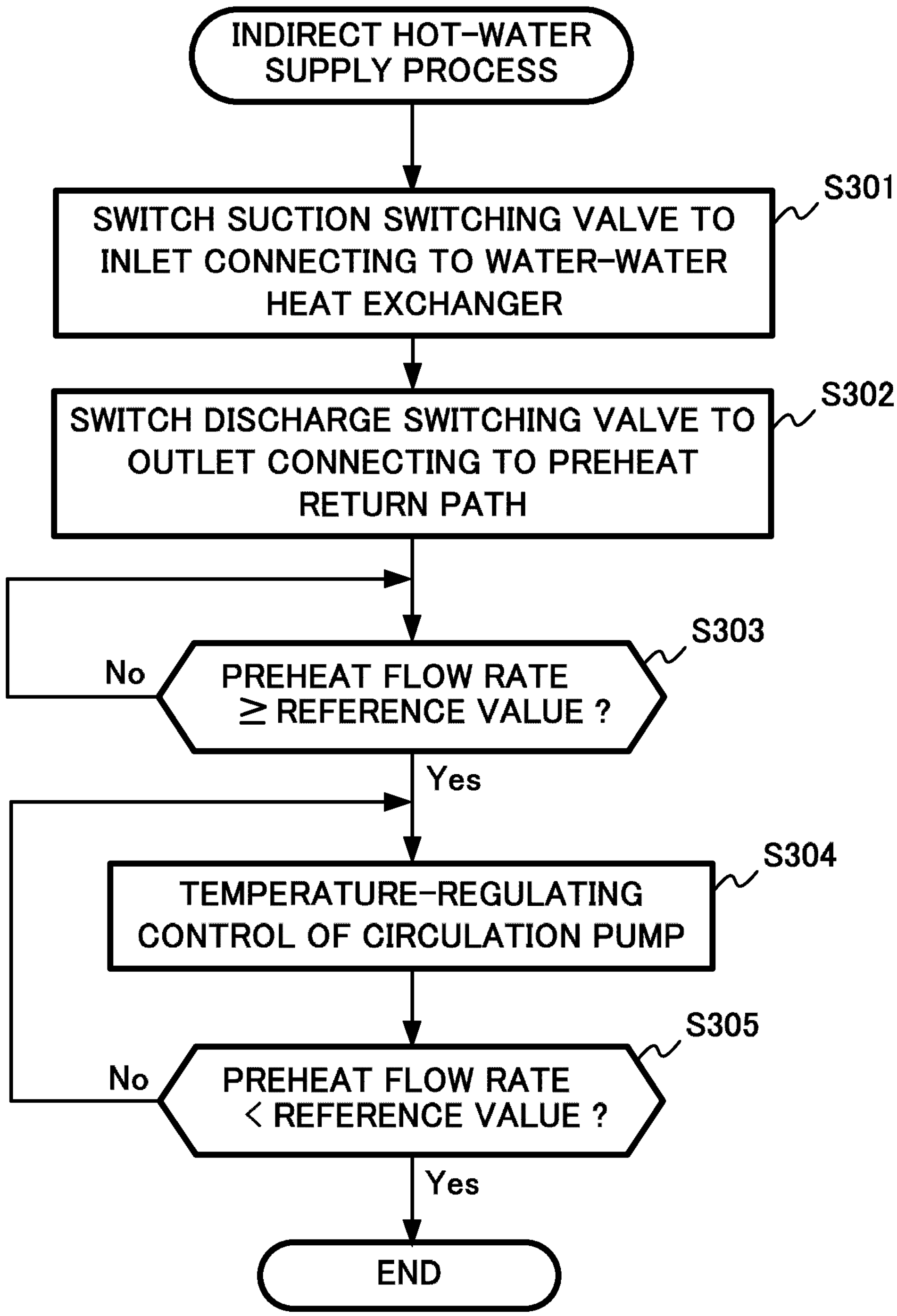

INDIRECT HOT-WATER SUPPLY PROCESS
S301
SWITCH SUCTION SWITCHING VALVE TO INLET CONNECTING TO WATER-WATER HEAT EXCHANGER
S302
SWITCH DISCHARGE SWITCHING VALVE TO OUTLET CONNECTING TO PREHEAT RETURN PATH
S303
PREHEAT FLOW RATE ≥ REFERENCE VALUE ?
No
Yes
S304
TEMPERATURE-REGULATING CONTROL OF CIRCULATION PUMP
S305
PREHEAT FLOW RATE < REFERENCE VALUE ?
No
Yes
END

FIG. 9

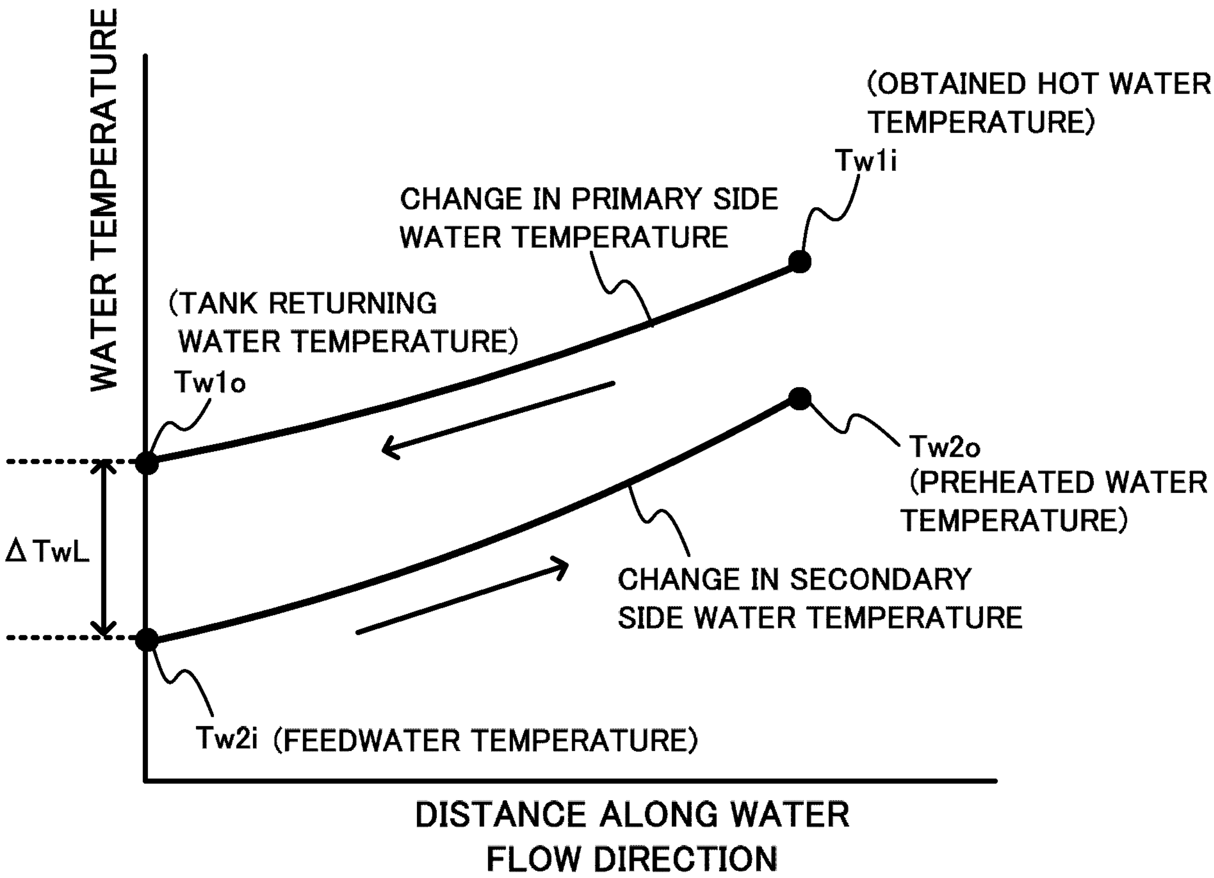

WATER TEMPERATURE
(OBTAINED HOT WATER TEMPERATURE)
Tw1i
CHANGE IN PRIMARY SIDE WATER TEMPERATURE
(TANK RETURNING WATER TEMPERATURE)
Tw1o
Tw2o
(PREHEATED WATER TEMPERATURE)
ΔTwL
CHANGE IN SECONDARY SIDE WATER TEMPERATURE
Tw2i (FEEDWATER TEMPERATURE)
DISTANCE ALONG WATER FLOW DIRECTION

FIG. 10

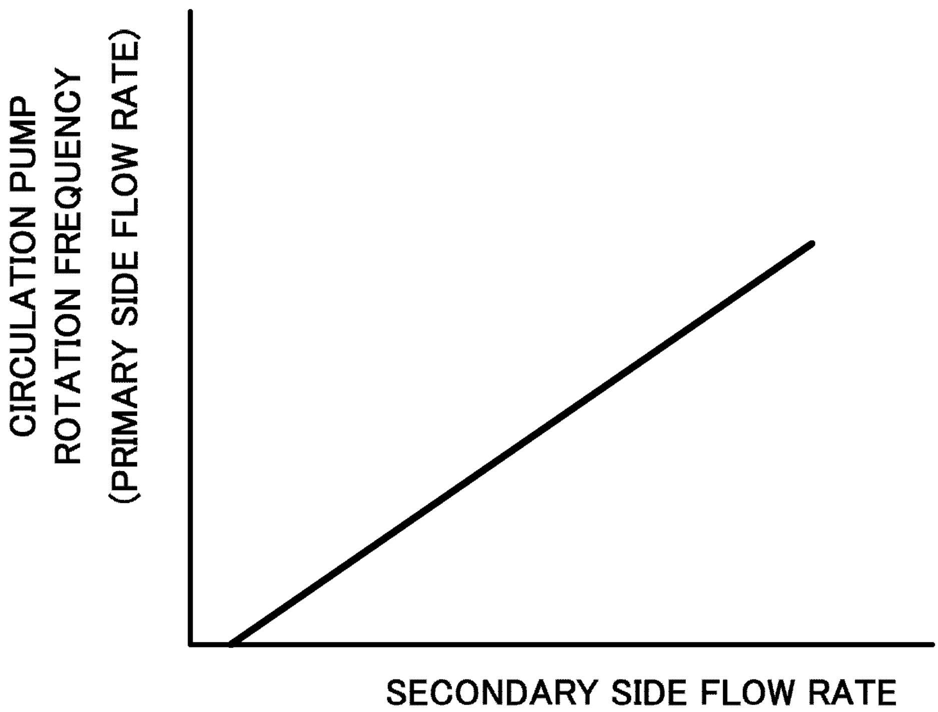

CIRCULATION PUMP
ROTATION FREQUENCY
(PRIMARY SIDE FLOW RATE)
SECONDARY SIDE FLOW RATE

FIG. 11

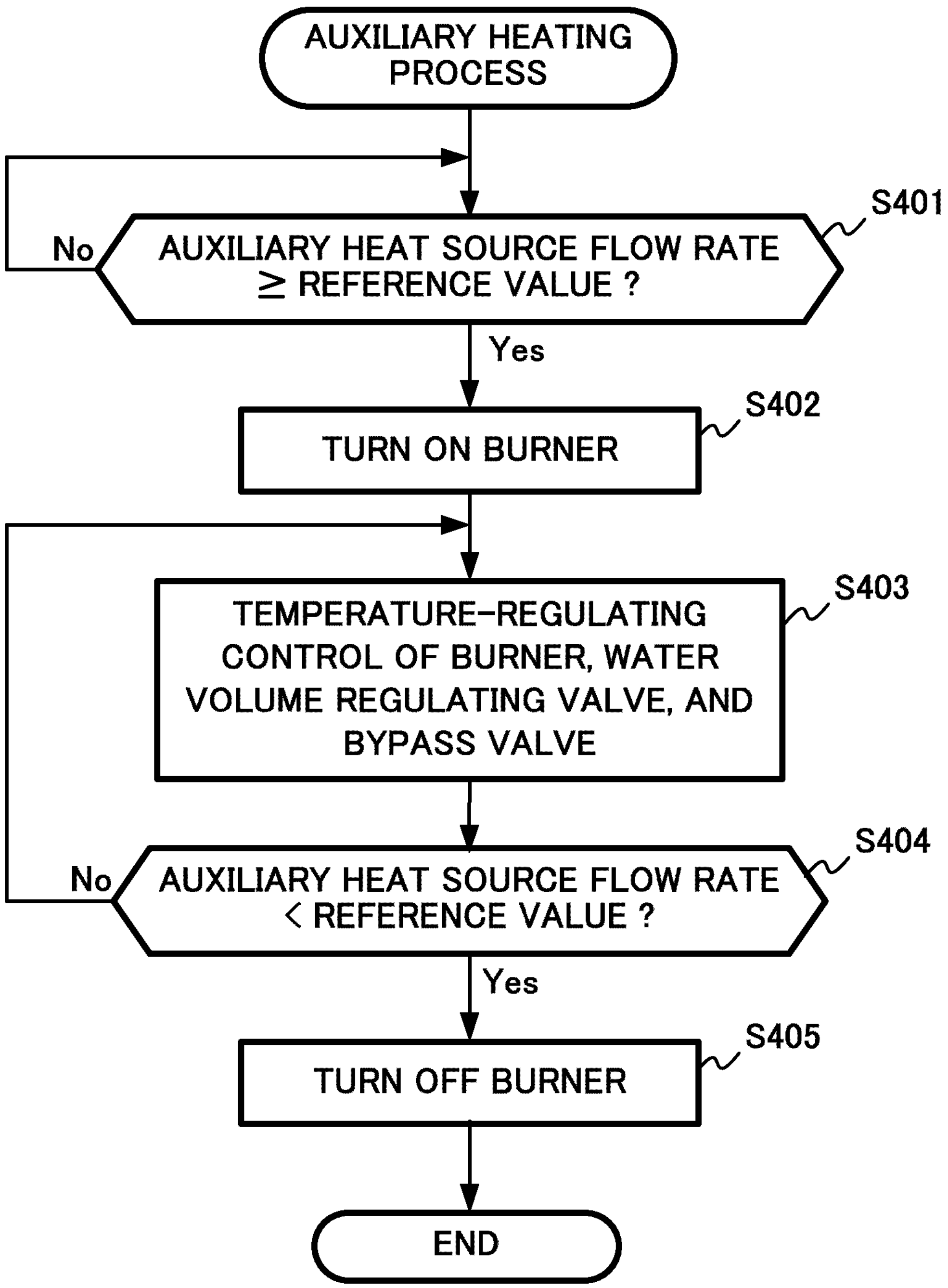

AUXILIARY HEATING PROCESS
S401
No
AUXILIARY HEAT SOURCE FLOW RATE ≥ REFERENCE VALUE ?
Yes
S402
TURN ON BURNER
S403
TEMPERATURE-REGULATING CONTROL OF BURNER, WATER VOLUME REGULATING VALVE, AND BYPASS VALVE
S404
No
AUXILIARY HEAT SOURCE FLOW RATE < REFERENCE VALUE ?
Yes
S405
TURN OFF BURNER
END

FIG. 12

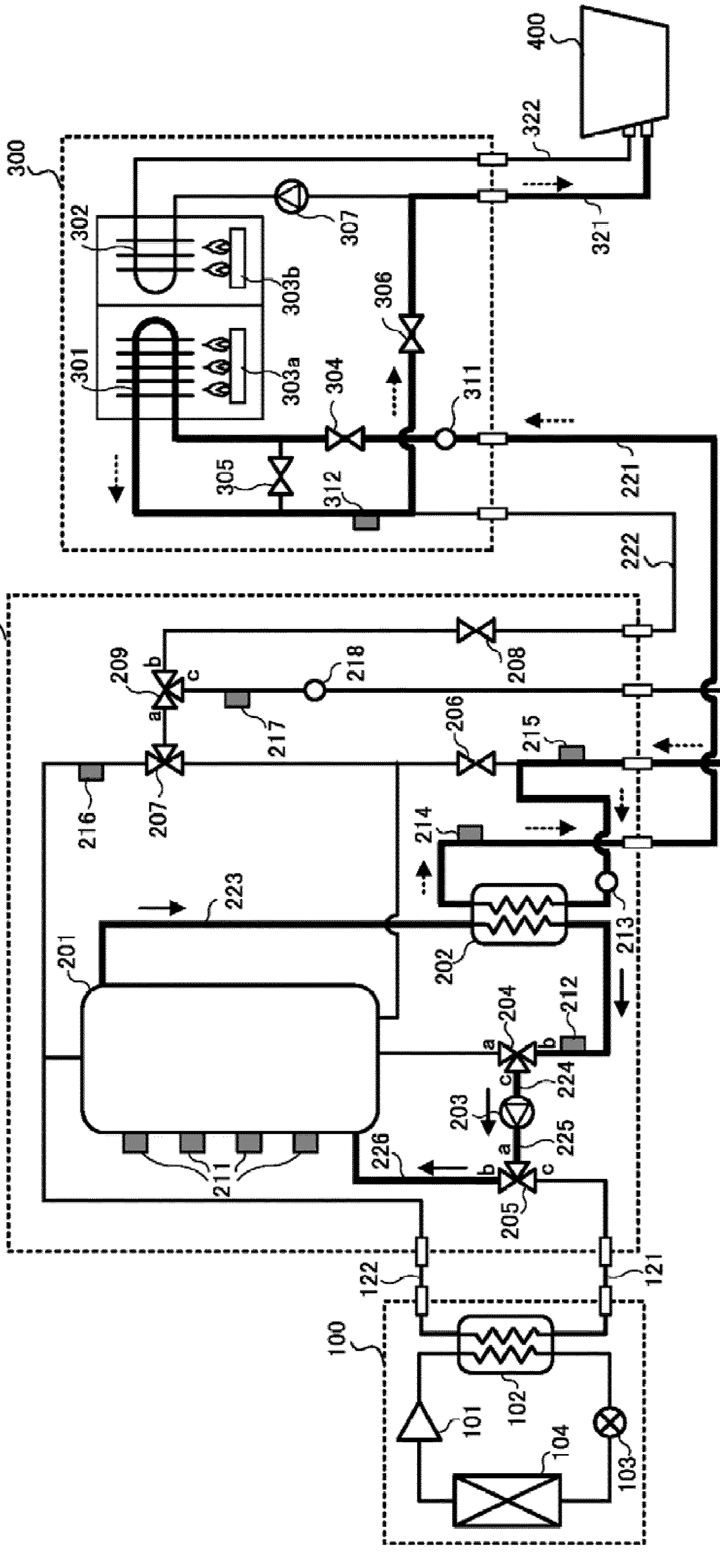

400
322
321
300
302
307
303b
306
301
303a
304
311
305
312
221
222
200
209
a
b
c
218
208
232
217
206
215
207
216
214
231
223
213
202
201
204
212
224
203
225
226
211
205
122
121
100
101
102
104
103

FIG. 13

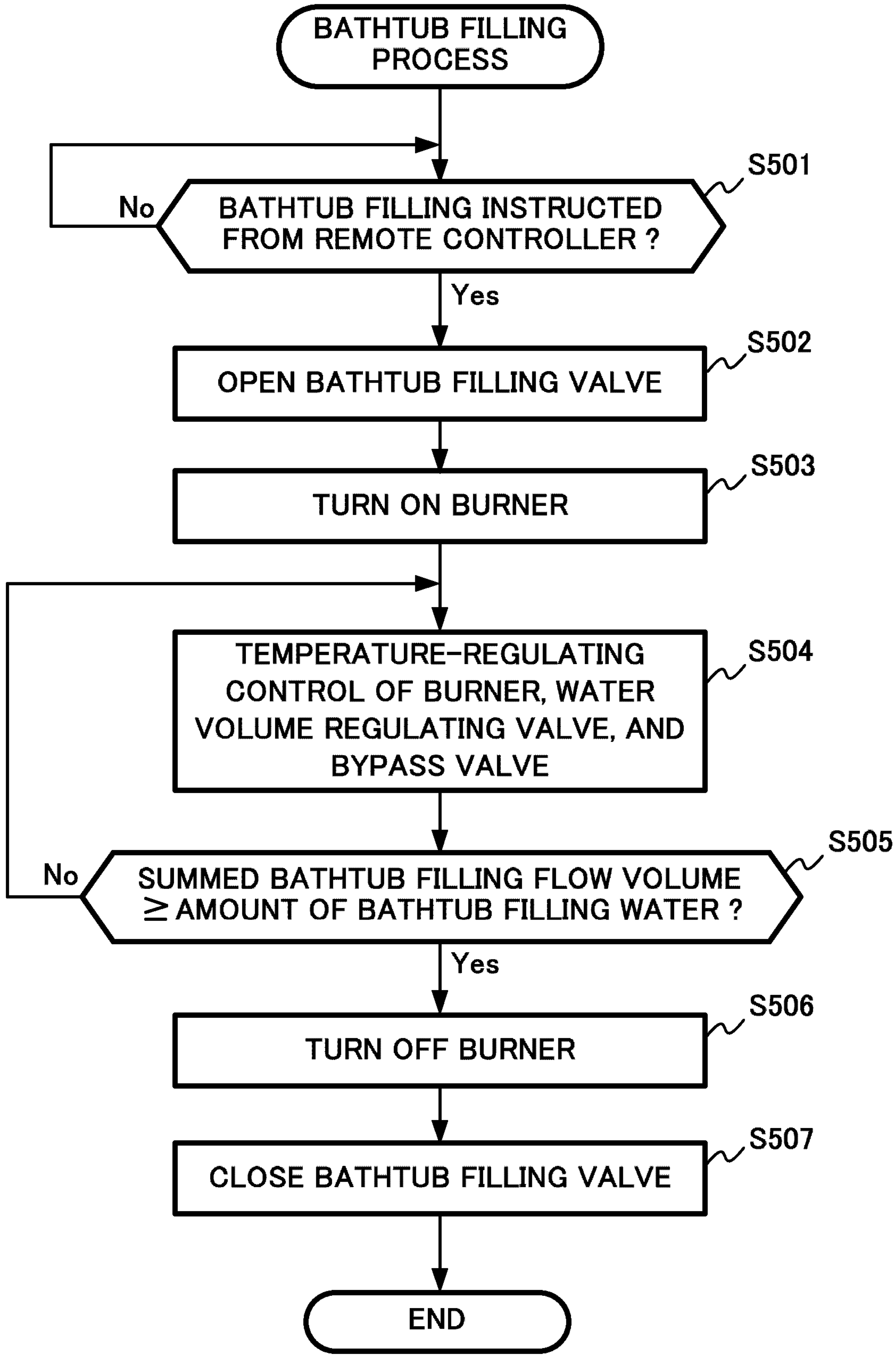

BATHTUB FILLING PROCESS
S501
No
BATHTUB FILLING INSTRUCTED FROM REMOTE CONTROLLER ?
Yes
S502
OPEN BATHTUB FILLING VALVE
S503
TURN ON BURNER
S504
TEMPERATURE-REGULATING CONTROL OF BURNER, WATER VOLUME REGULATING VALVE, AND BYPASS VALVE
S505
No
SUMMED BATHTUB FILLING FLOW VOLUME ≥ AMOUNT OF BATHTUB FILLING WATER ?
Yes
S506
TURN OFF BURNER
S507
CLOSE BATHTUB FILLING VALVE
END

FIG. 14

ELEMENT	CONTROL ITEM	CONTROL TARGET
CIRCULATION PUMP	ROTATION FREQUENCY	ΔTwL
SUCTION SWITCHING VALVE	DEGREE OF OPENING	WATER-WATER HEAT EXCHANGER PRIMARY SIDE PATH FULL OPEN
DISCHARGE SWITCHING VALVE	DEGREE OF OPENING	HEAT PUMP OUTGOING WATER TEMPERATURE (WATER-HEATING FLOW RATE)

FIG. 15

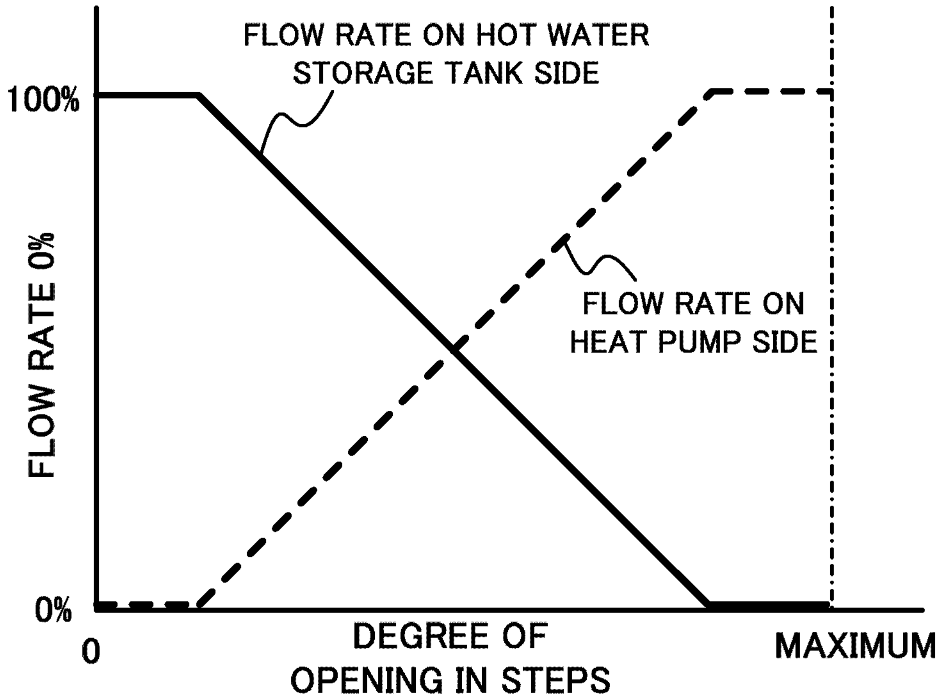

FLOW RATE ON HOT WATER STORAGE TANK SIDE
100%
FLOW RATE 0%
0%
0
DEGREE OF OPENING IN STEPS
MAXIMUM
FLOW RATE ON HEAT PUMP SIDE

FIG. 16A

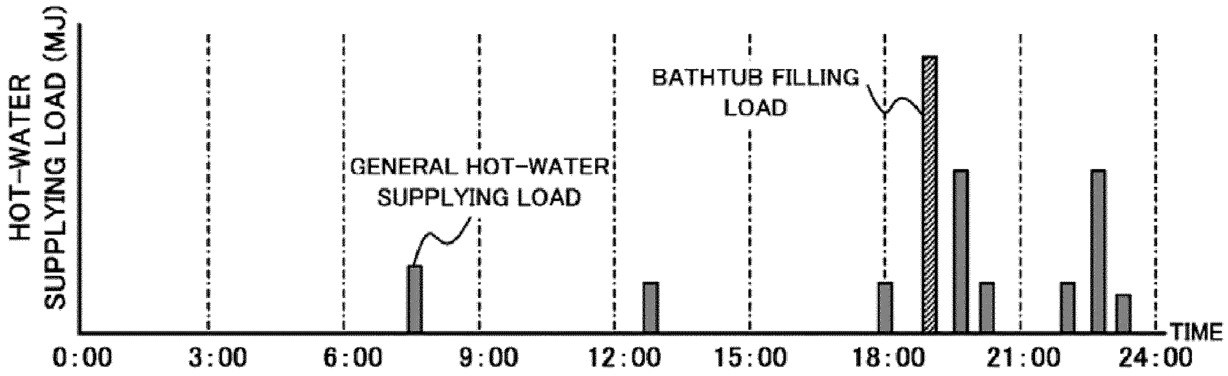


FIG. 16B

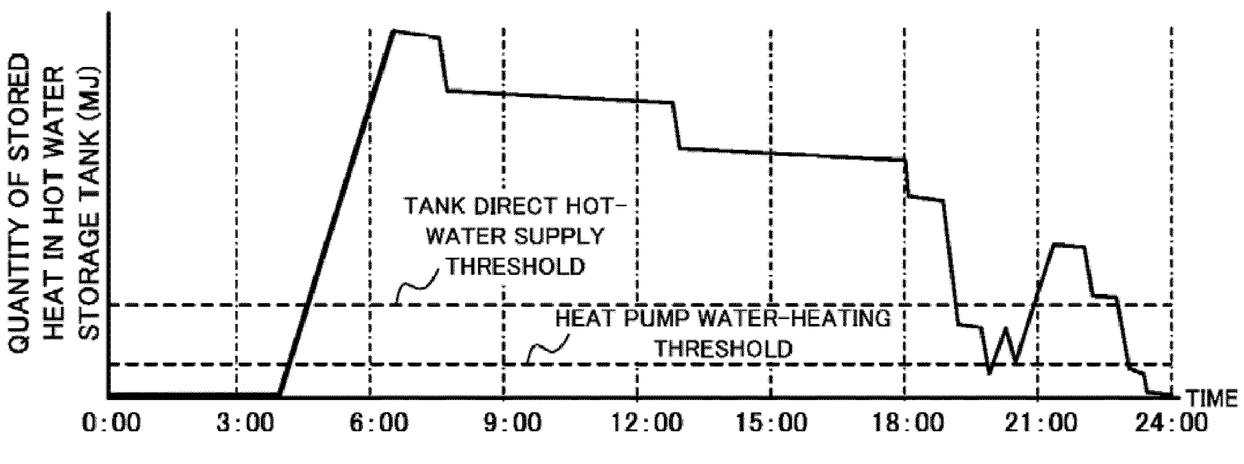


FIG. 16C

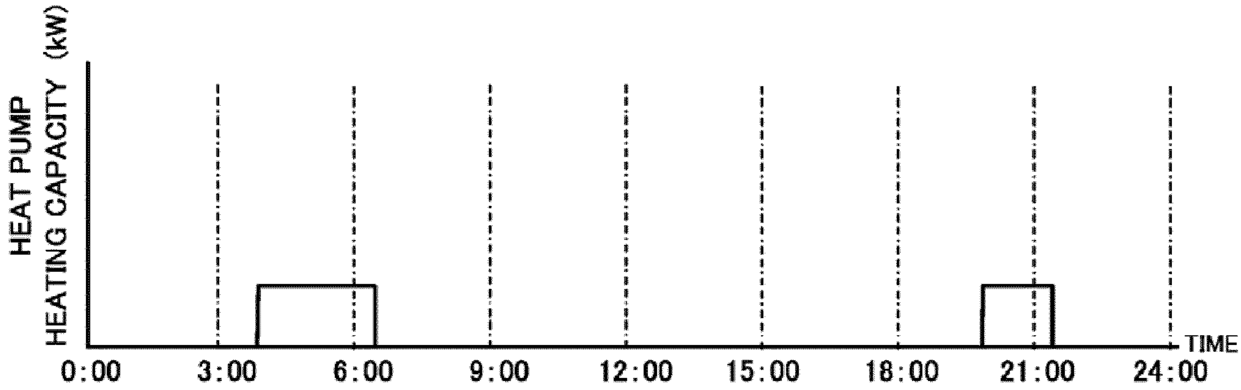


FIG. 16D

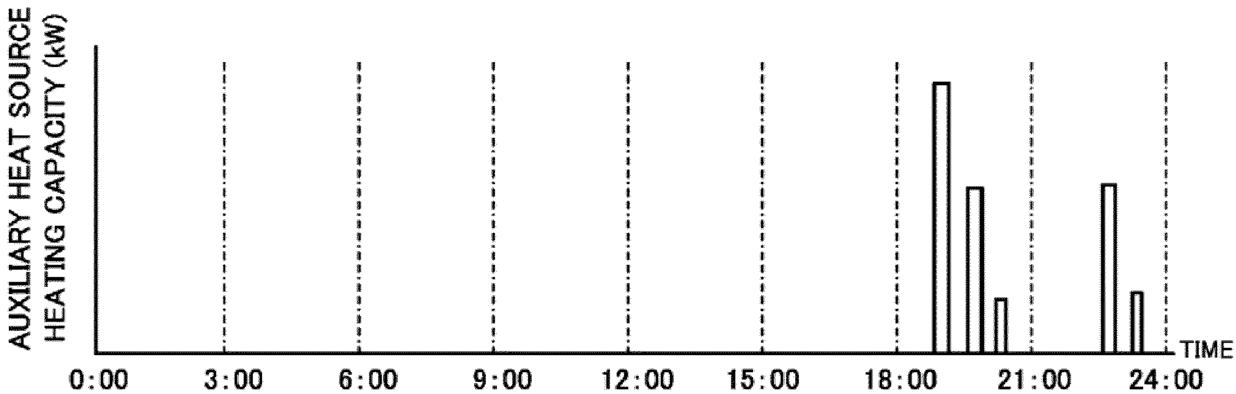
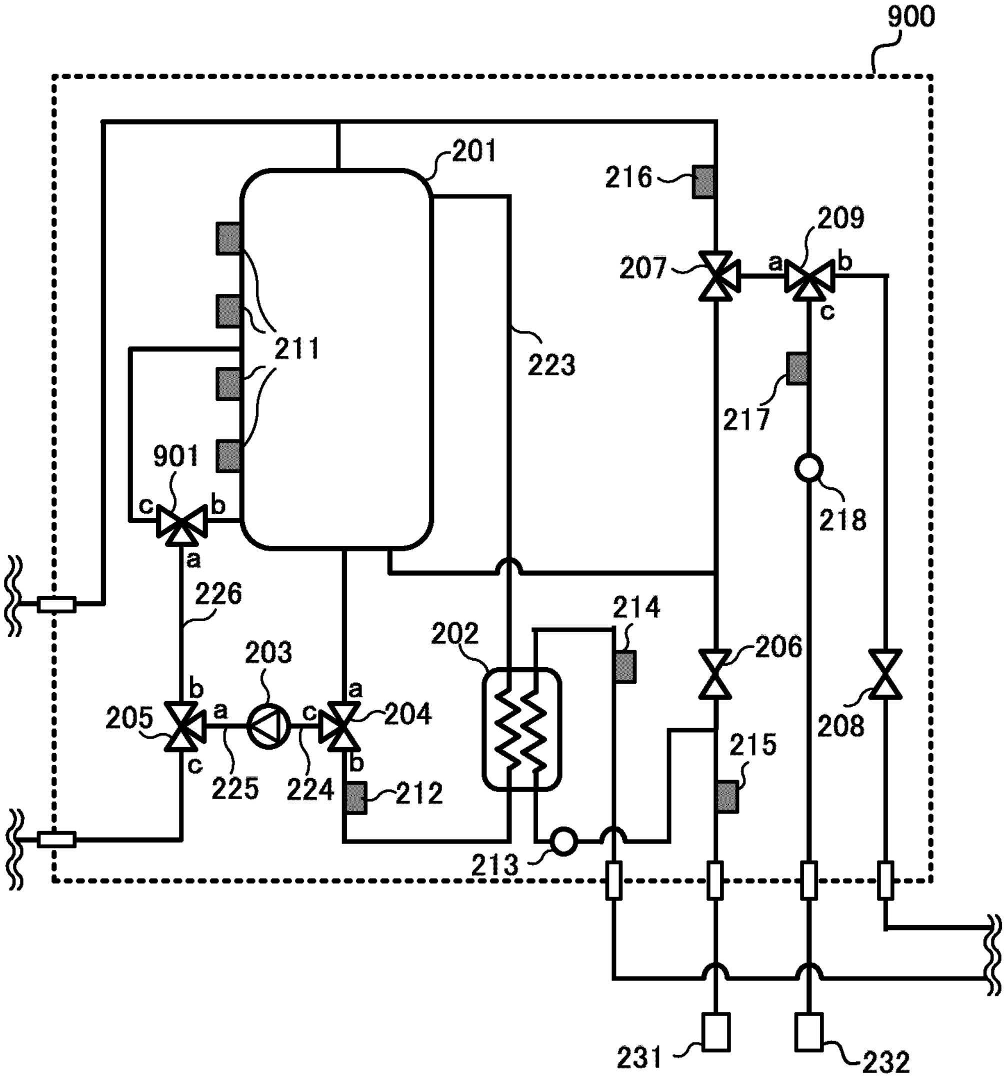


FIG. 17



900
201
216
209
207
a
b
c
211
223
217
901
c
b
a
218
226
214
202
203
206
208
b
a
c
a
205
204
215
c
225
224
b
212
213
231
232

FIG. 18

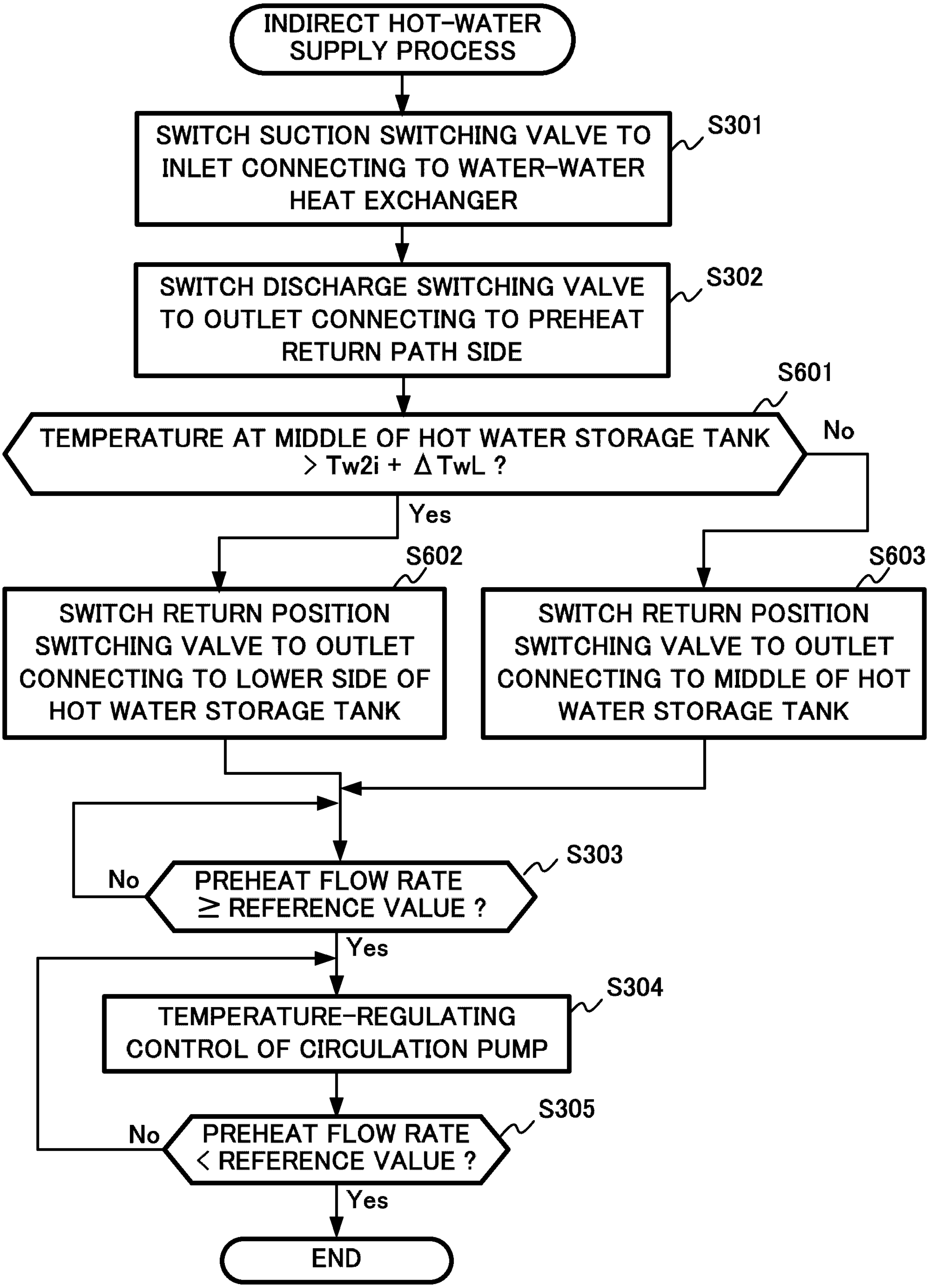

INDIRECT HOT-WATER SUPPLY PROCESS
SWITCH SUCTION SWITCHING VALVE TO INLET CONNECTING TO WATER-WATER HEAT EXCHANGER
S301
SWITCH DISCHARGE SWITCHING VALVE TO OUTLET CONNECTING TO PREHEAT RETURN PATH SIDE
S302
S601
TEMPERATURE AT MIDDLE OF HOT WATER STORAGE TANK > Tw2i + ΔTwL ?
No
Yes
S602
SWITCH RETURN POSITION SWITCHING VALVE TO OUTLET CONNECTING TO LOWER SIDE OF HOT WATER STORAGE TANK
S603
SWITCH RETURN POSITION SWITCHING VALVE TO OUTLET CONNECTING TO MIDDLE OF HOT WATER STORAGE TANK
No
PREHEAT FLOW RATE ≥ REFERENCE VALUE ?
S303
Yes
TEMPERATURE-REGULATING CONTROL OF CIRCULATION PUMP
S304
No
PREHEAT FLOW RATE < REFERENCE VALUE ?
S305
Yes
END

FIG. 19A

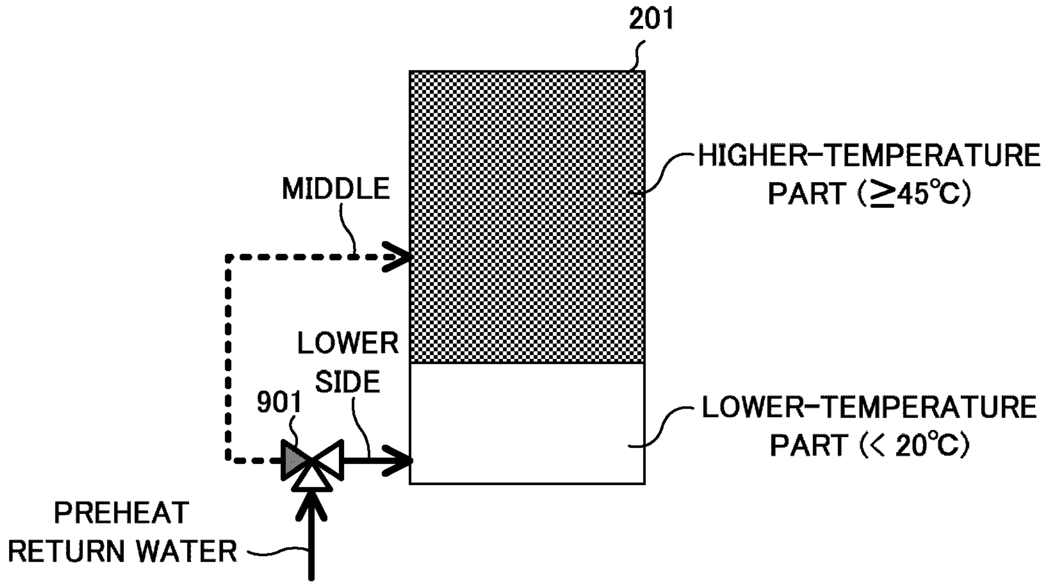


FIG. 19B

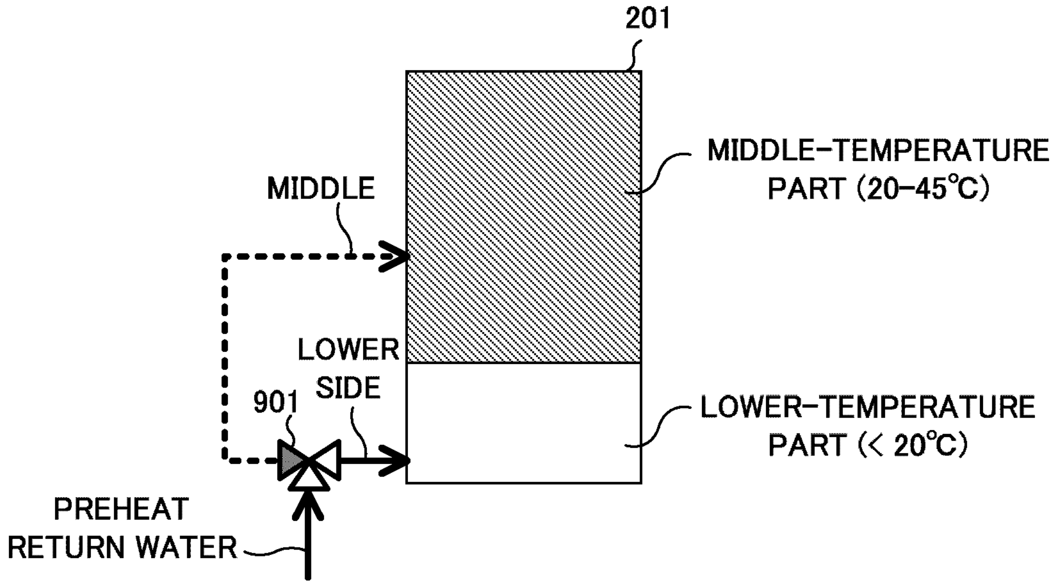
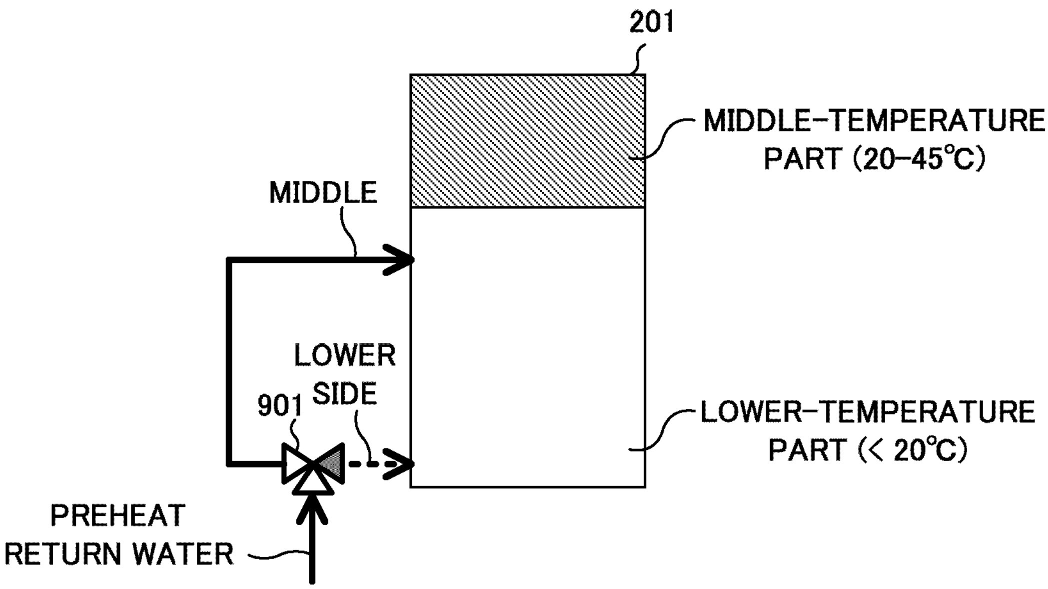


FIG. 19C


201
MIDDLE-TEMPERATURE PART (20-45°C)
MIDDLE
LOWER SIDE
901
LOWER-TEMPERATURE PART (< 20°C)
PREHEAT RETURN WATER

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2016/079308

A. CLASSIFICATION OF SUBJECT MATTER
F24H1/18(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24H1/18, F24H1/00, F24H1/20

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2012-127628 A (Panasonic Corp.), 05 July 2012 (05.07.2012), paragraphs [0014] to [0030]; fig. 1 to 7 (Family: none)	1-10,13-18 11,12
Y	JP 2011-214793 A (Takagi Industrial Co., Ltd.), 27 October 2011 (27.10.2011), paragraphs [0024] to [0033]; fig. 1 (Family: none)	1-10,13-18
Y	JP 2010-203686 A (The Tokyo Electric Power Co., Inc.), 16 September 2010 (16.09.2010), paragraph [0081]; fig. 1 (Family: none)	10

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 November 2016 (22.11.16)	06 December 2016 (06.12.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/079308

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-91196 A (Denso Corp.), 22 April 2010 (22.04.2010), paragraphs [0033] to [0049]; fig. 1, 7 (Family: none)	1-18
A	JP 2012-13301 A (Panasonic Electric Works Co., Ltd.), 19 January 2012 (19.01.2012), entire text; all drawings (Family: none)	1-18
A	JP 2013-228150 A (Toho Gas Co., Ltd.), 07 November 2013 (07.11.2013), entire text; all drawings (Family: none)	1-18
A	JP 2013-164173 A (Tokyo Gas Co., Ltd.), 22 August 2013 (22.08.2013), entire text; all drawings (Family: none)	1-18
A	JP 2010-210180 A (Rinnai Corp.), 24 September 2010 (24.09.2010), entire text; all drawings (Family: none)	1-18
A	JP 2006-170526 A (Denso Corp.), 29 June 2006 (29.06.2006), entire text; all drawings (Family: none)	1-18

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2010210180 A **[0004]**
- JP 2011214793 A **[0004]**