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(54) WATER HEATER

(57) A controller includes an operation control unit that controls operations of a compressor, an expansion device, and a feeding device. When the operation control unit starts heating operation for storing heated water in a tank, the operation control unit starts operating both the compressor and the feeding device together. The operation control unit operates the compressor at a first compressor rotation speed until a preset first time period elapses from when the heating operation is started. After a lapse of the first time period, the operation control unit operates the compressor at a second compressor rotation speed higher than the first compressor rotation speed.

FIG. 1A

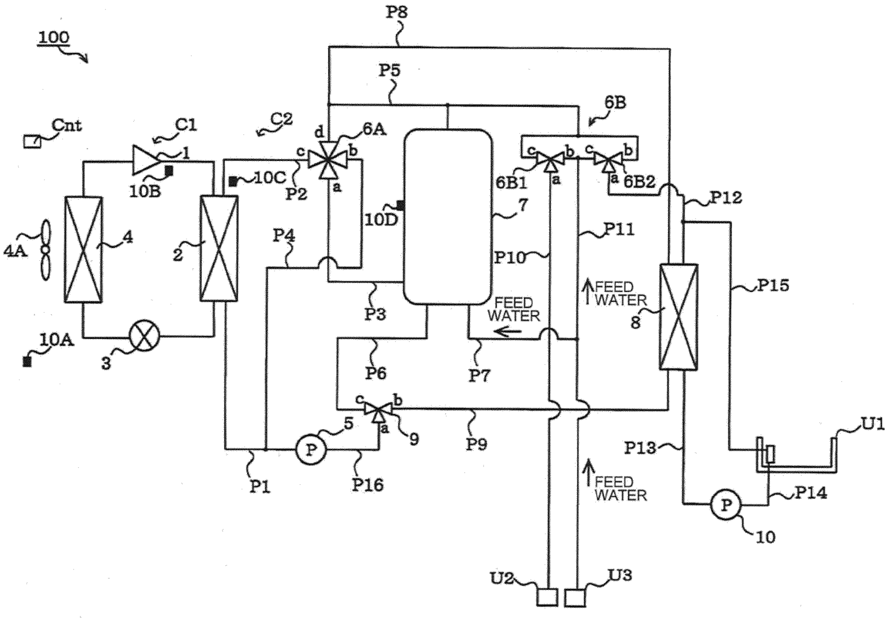

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FIG. 1B

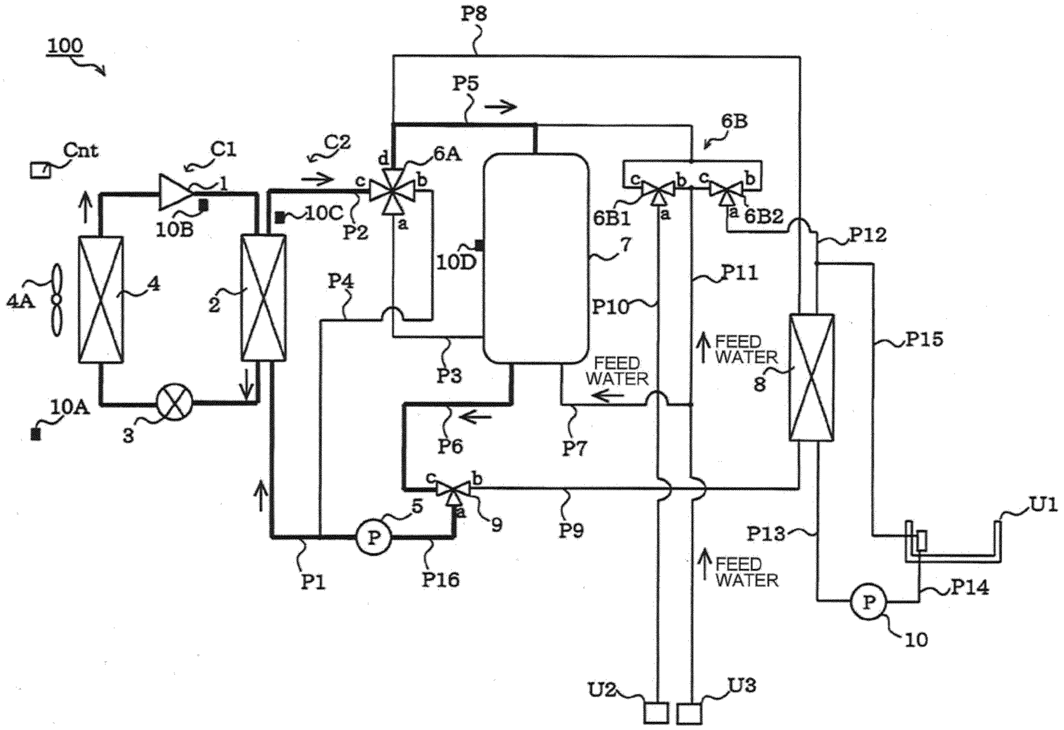
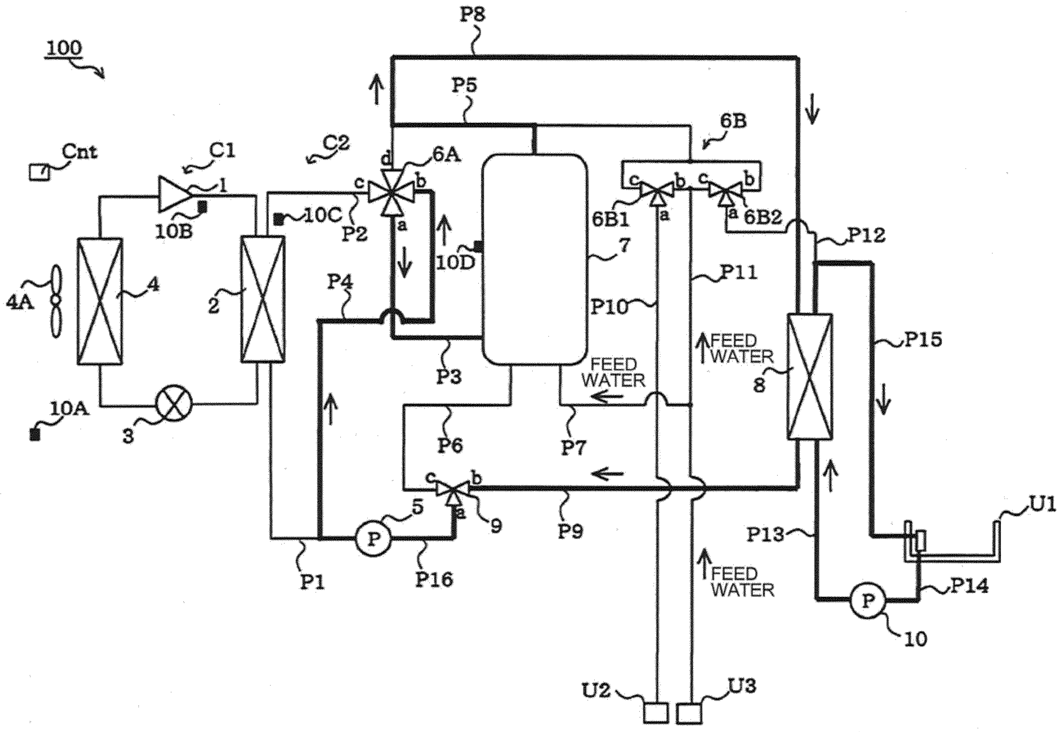

100
P8
P5
6B
Cnt
C1
C2
6A
d
c
b
a
1
10B
10C
P2
6B1
6B2
P12
10D
7
4A
4
2
P4
P11
P10
P15
FEED WATER
8
P3
10A
3
P6
P7
5
9
P9
P13
U1
P1
P16
P14
P
10
U2
U3

FIG. 1C


100
P8
P5
6B
Cnt
C1
C2
6A
d
c
b
a
1
10B
10C
P2
6B1
6B2
P12
10D
7
4A
4
2
P4
P11
P10
P15
FEED WATER
8
P3
10A
3
P6
P7
5
9
P9
P13
U1
P1
P16
P14
P
10
U2
U3

Description

Technical Field

[0001] The present invention relates to a water heater and, more particularly, to control of a water heater including a refrigerant circuit to which a water circulation circuit is connected.

Background Art

[0002] For example, there has been suggested a heat pump water heater that executes control for increasing in a stepwise manner the rotation speed of a pump provided in a water circulation circuit as the heat pump water heater starts heating operation (see, for example, Patent Literature 1). The heat pump water heater of Patent Literature 1 shortens time to reach a target tapping water temperature and prevents tapping water temperature from overshooting the target tapping water temperature by executing this control.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2005-140439

Summary of Invention

Technical Problem

[0004] When the heating operation is started, the temperature of refrigerant, the operations of devices, and the like, are not stable, so the coefficient of performance (COP) of a water heater easily deteriorates. When the heating operation is started, a decrease in COP may further increase depending on the operations of various devices provided in the water heater. When the heating operation is started, and, for example, when the rotation speed of the pump decreases too much, a decrease in COP may further increase.

[0005] The present invention has been made to solve the above-described problem, and an object thereof is to provide a water heater that is able to suppress a decrease in COP.

Solution to Problem

[0006] A water heater according to an embodiment of the present invention includes a refrigerant circuit, a tank, a feeding device, a first detecting unit, and a controller. The refrigerant circuit includes a compressor, a condenser, an expansion device, and an evaporator. The condenser is connected to a water circulation circuit. The tank is provided in the water circulation circuit. The tank stores water heated in the condenser. The feeding device is provided in the water circulation circuit. The feeding device feeds water to the tank in the water circulation circuit. The first detecting unit detects an outside air temperature. The controller controls the compressor, the expansion device, and the feeding device based on a detected outside air temperature of the first detecting unit. The controller includes an operation control unit that controls operations of the compressor, the expansion device, and the feeding device. When the operation control unit starts heating operation for storing heated water in the tank, the operation control unit starts operating both the compressor and the feeding device together. The operation control unit operates the compressor at a first compressor rotation speed until a predetermined first time period elapses from when the heating operation is started. After a lapse of the first time period, the operation control unit operates the compressor at a second compressor rotation speed higher than the first compressor rotation speed.

Advantageous Effects of Invention

[0007] With the water heater according to the embodiment of the present invention, due to the above-described configuration, a decrease in COP can be suppressed.

Brief Description of Drawings

[0008]

Fig. 1A is a schematic configuration example view of a water heater 100 according to Embodiment.

Fig. 1B is a view illustrating a heating operation of the water heater 100 according to Embodiment.

Fig. 1C is a view illustrating a reheating operation of the water heater 100 according to Embodiment.

Fig. 2 is a functional block diagram of a controller Cnt.

Fig. 3 is a table that the controller Cnt includes and in which compressor rotation speeds are specified.

Fig. 4A is a table that the controller Cnt includes and in which feeding rotation speeds are specified.

Fig. 4B is a table that the controller includes and in which second time periods are specified.

Fig. 5A is a table that the controller Cnt includes and in which target tapping water temperatures are specified.

Fig. 5B is a table that the controller Cnt includes and in which third time periods are specified.

Fig. 6A is a view illustrating changes over time in the operation of a compressor 1.

Fig. 6B is a view illustrating changes over time in the operation of a feeding device 5.

Fig. 6C is a view illustrating changes over time in target tapping water temperature.

Fig. 7 is an alternative embodiment when a set rotation speed of the compressor 1 is shifted from a first compressor rotation speed to a second compressor rotation speed.

Description of Embodiments

[0009] Hereinafter, Embodiment of the present invention will be described with reference to the drawings as needed. In the following drawings including Fig. 1, the relations in size among components can be different from the actual ones. In the following drawings including Fig. 1, similar reference signs denote the same or corresponding components, and this commonly applies to the entire text of the specification. The modes of elements described in the full text of the specification are only illustrative, and should not be construed as limiting the scope of the invention.

Embodiment

[0010] Fig. 1A is a schematic configuration example view of a water heater 100 according to Embodiment. The configuration of the water heater 100 will be described with reference to Fig. 1A.

Description of Configuration

[Explanation of Configuration]

[0011] The water heater 100 includes a refrigerant circuit C1, a water circulation circuit C2, a controller Cnt, and various detecting units. In addition, the water heater 100 is connected to a hot water supply using unit U1, a hot water supply using unit U2, and a water supply unit U3. The hot water supply using unit U1 corresponds to, for example, a bathtub of a bath. In addition, the hot water supply using unit U2 corresponds to, for example, a shower, a faucet, a tap in a kitchen, or the like. Furthermore, the water supply unit U3 corresponds to, for example, a hydrant connected to a pipe for water supply.

[0012] Refrigerant circulates through the refrigerant circuit C1. For example, carbon dioxide refrigerant may be employed as refrigerant. The refrigerant circuit C1 includes a compressor 1, a heat exchanger 2, an expansion device 3, and a heat exchanger 4. The compressor 1 compresses refrigerant. The heat exchanger 2 operates as a condenser. The expansion device 3 has the function of decompressing refrigerant. The heat exchanger 4 operates as an evaporator. A fan 4A is provided together with the heat exchanger 4. The fan 4A supplies air to the heat exchanger 4.

[0013] The heat exchanger 2 includes a refrigerant flow passage and a water flow passage. Refrigerant flows through the refrigerant flow passage. Water flows through the water flow passage. The heat exchanger 2 is configured to exchange heat between refrigerant flowing through the refrigerant flow passage and water flowing through the water flow passage. The refrigerant circuit C1 is connected to the refrigerant flow passage of the heat exchanger 2. The water circulation circuit C2 is connected to the water flow passage of the heat exchanger 2. The heat exchanger 2 condenses refrigerant flowing through the refrigerant flow passage. The heat exchanger 2 may be, for example, a double pipe heat exchanger.

[0014] Water circulates through the water circulation circuit C2. The water circulation circuit C2 includes the water flow passage of the heat exchanger 2, a flow switching device 6A, a mixing circuit 6B, a tank 7, a heat exchanger 8, and a flow switching device 9. The tank 7 stores water. In addition, the water circulation circuit C2 includes a feeding device 5 and a feeding device 10. The feeding device 5 feeds water to the tank 7. The feeding device 10 feeds water to the hot water supply using unit U1. Furthermore, the water circulation circuit C2 includes pipes P1 to P16. The feeding device 5 and the feeding device 10 each may be, for example, a pump that feeds water.

[0015] The flow switching device 6A may be, for example, a four-way valve. The flow switching device 6A includes four ports through which water flows. The flow switching device 6A includes a first port a, a second port b, a third port c, and a fourth port d. The first port a of the flow switching device 6A is connected to the pipe P3. The second port b of the flow switching device 6A is connected to the pipe P4. The third port c of the flow switching device 6A is connected to the pipe P2. The fourth port d of the flow switching device 6A is connected to the pipe P8. The flow switching device 6A is able to form a first flow passage that connects the third port c to the fourth port d. In addition, the flow switching device 6A is able to form a second flow passage that connects the first port a to the second port b. That is, the flow switching device 6A is configured to be able to selectively switch between the first flow passage and the second flow passage.

[0016] The mixing circuit 6B is a circuit that has the function of mixing heated water with water that is supplied from the water supply unit U3. The mixing circuit 6B includes a flow switching device 6B1 and a flow switching device 6B2. The flow switching device 6B1 and the flow switching device 6B2 each may be, for example, a three-way valve.

[0017] The flow switching device 6B1 includes a first port a, a second port b, and a third port c. In addition, the flow switching device 6B2 includes a first port a, a second port b, and a third port c.

[0018] The first port a of the flow switching device 6B1 is connected to the pipe P10. The second port b of the flow switching device 6B1 is connected to the third port c of the flow switching device 6B2. The third port c of the flow switching device 6B1 is connected to the second port b of the flow switching device 6B2. The first port a of the flow switching device 6B2 is connected to the pipe P12. The pipe P11 is connected to the pipe that connects the second port b of the flow switching device 6B1 to the third port c of the flow switching device 6B2.

[0019] The tank 7 stores water heated in the heat exchanger 2. The tank 7 is connected to the pipe P3, the pipe P5, the pipe P6, and the pipe P7.

[0020] The heat exchanger 8 includes a first water flow passage and a second water flow passage. The pipe P8 and the pipe P9 are connected to the first water flow passage. The pipe P12 and the pipe P13 are connected to the second water flow passage. The heat exchanger 2 is configured to be able to exchange heat between water flowing through the first water flow passage and water flowing through the second water flow passage.

[0021] The flow switching device 9 may be, for example, a three-way valve. The flow switching device 9 includes a first port a, a second port b, and a third port c. The first port a of the flow switching device 9 is connected to the pipe P16. The second port b of the flow switching device 9 is connected to the pipe P9. The third port c of the flow switching device 9 is connected to the pipe P6. The flow switching device 9 is able to form a third flow passage that connects the first port a to the second port b. In addition, the flow switching device 9 is able to form a fourth flow passage that connects the first port a to the third port c. That is, the flow switching device 9 is configured to be able to selectively switch between the third flow passage and the fourth flow passage.

[0022] The pipe P1 connects a water discharge side of the feeding device 5 to the water flow passage of the heat exchanger 2.

[0023] The pipe P2 connects the water flow passage of the heat exchanger 2 to the third port c of the flow switching device 6A.

[0024] The pipe P3 connects the first port a of the flow switching device 6A to the tank 7.

[0025] The pipe P4 connects the second port b of the flow switching device 6A to the pipe P1.

[0026] The pipe P5 connects the pipe P8 to the tank 7. In addition, the pipe P5 connects the pipe P8 to the mixing circuit 6B.

[0027] The pipe P6 connects the tank 7 to the third port c of the flow switching device 9.

[0028] The pipe P7 connects the tank 7 to the pipe P11.

[0029] The pipe P8 connects the fourth port d of the flow switching device 6A to the pipe P5. In addition, the pipe P8 connects the fourth port d of the flow switching device 6A to the first water flow passage of the heat exchanger 8.

[0030] The pipe P9 connects the first water flow passage of the heat exchanger 8 to the second port b of the flow switching device 9.

[0031] The pipe P10 connects the hot water supply using unit U2 to the first port a of the flow switching device 6B1 of the mixing circuit 6B.

[0032] The pipe P11 connects the water supply unit U3 to the pipe between the second port b of the flow switching device 6B1 of the mixing circuit 6B and the third port c of the flow switching device 6B2 of the mixing circuit 6B. In addition, the pipe P11 is connected to the pipe P7. Water is supplied to the mixing circuit 6B and the tank 7 via the pipe P11.

[0033] The pipe P12 connects the first port a of the flow switching device 6B2 of the mixing circuit 6B to the second water flow passage of the heat exchanger 8. In addition, the pipe P12 connects the first port a of the flow switching device 6B2 of the mixing circuit 6B to the pipe P15.

[0034] The pipe P13 connects a water discharge side of the feeding device 10 to the second water flow passage of the heat exchanger 8.

[0035] The pipe P14 connects a water suction side of the feeding device 10 to the hot water supply using unit U1.

[0036] The pipe P15 connects the pipe P12 to the hot water supply using unit U1.

[0037] The pipe P16 connects a water suction side of the feeding device 5 to the first port a of the flow switching device 9.

[0038] The first detecting unit 10A is a temperature sensor that detects an outside air temperature. The second detecting unit 10B is a temperature sensor that detects a refrigerant temperature at a discharge side of the compressor 1. The third detecting unit 10C is a temperature sensor that detects a heat medium temperature at an outlet of the heat exchanger 2.

[0039] The fourth detecting unit 10D is a temperature sensor that detects the temperature of water stored in the tank 7. The fourth detecting unit 10D may also be used to calculate the quantity of water stored in the tank 7. The fourth detecting unit 10D may be, for example, temperature sensors vertically disposed on the tank 7 at multiple locations.

[0040] Detection results of the first detecting unit 10A to fourth detecting unit 10D are output to the controller Cnt. The controller Cnt controls the compressor 1, the feeding device 5, the feeding device 10, and other devices.

[0041] Functional units included in the controller Cnt are implemented by exclusive hardware or a micro processing unit (MPU) that executes programs stored in a memory. When the controller Cnt is exclusive hardware, for example, a single circuit, a multiple circuit, an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or a combination of these corresponds to the controller Cnt. Each of the functional units that the controller Cnt implements may be implemented by a separate piece of hardware. Alternatively, the functional units may be implemented by a single piece of hardware. When the controller Cnt is an MPU, functions that the controller Cnt executes are implemented by software, firmware, or a combination of software and firmware. The software and/or the firmware is described as a program, and is stored in the memory. The MPU implements the functions of the controller Cnt by reading out and executing the programs stored in the memory. The memory is, for example, a nonvolatile or volatile semiconductor memory, such as a RAM, a ROM, a flash memory, an EPROM, and an EEPROM.

[Description of Operation]

[0042] Fig. 1B is a view illustrating a heating operation of the water heater 100 according to Embodiment.

[0043] The water heater 100 is able to perform heating operation for heating water in the heat exchanger 2 and storing the water in the tank 7. During the heating operation, the controller Cnt causes the refrigerant circuit C1 to circulate refrigerant by operating the compressor 1. When the heating operation is started, the controller Cnt sets the rotation speed of the compressor 1 to a first compressor rotation speed (described later).

[0044] In addition, during the heating operation, the controller Cnt operates the feeding device 5. When the heating operation is started, the controller Cnt sets the rotation speed of the feeding device 5 to a first feeding rotation speed (described later). During the heating operation, the controller Cnt switches the flow switching device 6A into the first flow passage, and switches the flow switching device 9 into the fourth flow passage. Thus, water in the water circulation circuit C2 flows in order of the feeding device 5, the heat exchanger 2, the flow switching device 6A, the tank 7, and the flow switching device 9, and returns to the feeding device 5.

[0045] Fig. 1C is a view illustrating a reheating operation of the water heater 100 according to Embodiment.

[0046] The water heater 100 is also able to perform an operation other than the heating operation. As an example, the reheating operation will be described.

[0047] The reheating operation is an operation for reheating water filled in the hot water supply using unit U1 (bath). In the reheating operation, the controller Cnt may stop the compressor 1 or may operate the compressor 1. In addition, in the reheating operation, the controller Cnt operates the feeding device 5 and the feeding device 10. In addition, in the reheating operation, the controller Cnt switches the flow switching device 6A into the second flow passage, and also switches the flow switching device 9 into the third flow passage. Thus, water flowing out from the feeding device 5 of the water circulation circuit C2 flows through the flow switching device 6A, the tank 7, the heat exchanger 8, and the flow switching device 9, and returns to the feeding device 5. On the other hand, water flowing out from the feeding device 10 of the water circulation circuit C2 is heated by water flowing through the first water flow passage of the heat exchanger 8 and then supplied to the hot water supply using unit U1 via the pipe P15.

[Regarding Functions of Controller Cnt]

[0048] Fig. 2 is a functional block diagram of the controller Cnt.

[0049] The controller Cnt includes a heat quantity acquisition unit 90A, a heat storage quantity acquisition unit 90B, a first rotation speed acquisition unit 90C, and a second rotation speed acquisition unit 90D. In addition, the controller Cnt includes a time period acquisition unit 90E, a tapping water temperature information acquisition unit 90F, and an opening degree acquisition unit 90G. Furthermore, the controller Cnt includes an operation control unit 90H and a storage unit 90I.

[0050] The heat quantity acquisition unit 90A of the controller Cnt acquires data on the quantity of heat of water stored in the tank 7. The data on the quantity of heat of water corresponds to a remaining hot water heat quantity that is the quantity of heat of water in the tank 7. The heat quantity acquisition unit 90A acquires a remaining hot water heat quantity based on a detected temperature of the fourth detecting unit 10D.

[0051] The heat storage quantity acquisition unit 90B of the controller Cnt acquires data on a target value of the total heat storage quantity (total heat quantity) of water stored in the tank 7 (target heat storage quantity). The data on a target value of the total heat storage quantity of water corresponds to a target quantity of heat stored in the tank 7. The heat storage quantity acquisition unit 90B calculates a target value of the total heat storage quantity of water stored in the tank 7 based on, for example, the quantity of heat of water used by the hot water supply using unit U1, the hot water supply using unit U2, and the like. The heat storage quantity acquisition unit 90B acquires the data on the calculated target value as the target heat storage amount.

[0052] The first rotation speed acquisition unit 90C of the controller Cnt acquires a first compressor rotation speed and a second compressor rotation speed based on a remaining hot water heat quantity, a target heat storage quantity, and a detected outside air temperature. The first rotation speed acquisition unit 90C acquires a remaining hot water heat quantity from the heat quantity acquisition unit 90A, acquires a target heat storage quantity from the heat storage quantity acquisition unit 90B, and acquires a detected outside air temperature from the first detecting unit 10A. The first compressor rotation speed and the second compressor rotation speed are preset constant values. In addition, the second compressor rotation speed is higher than the first compressor rotation speed. Specific acquisition units for the first compressor rotation speed and the second compressor rotation speed will be described with reference to Fig. 3 (described later).

[0053] The second rotation speed acquisition unit 90D of the controller Cnt acquires a first feeding rotation speed and a second feeding rotation speed based on a remaining hot water heat quantity, a target heat storage quantity, and a detected outside air temperature. The second rotation speed acquisition unit 90D acquires a remaining hot water heat quantity from the heat quantity acquisition unit 90A, acquires a target heat storage quantity from the heat storage quantity acquisition unit 90B, and acquires a detected outside air temperature from the first detecting unit 10A. The first feeding rotation speed is a preset constant value. On the other hand, the second feeding rotation speed is not limited to a preset constant value, and may be a variable value that varies with time. In addition, the first feeding rotation speed is lower than the second feeding rotation speed. This magnitude relation is satisfied irrespective of whether the second feeding rotation speed is a constant value or a variable value. Specific acquisition units for the first feeding rotation speed and the second feeding rotation speed will be described with reference to Fig. 4A (described later).

[0054] The time period acquisition unit 90E of the controller Cnt is able to acquire a first time period from the storage unit 901. The first time period is pre-stored in the storage unit 901.

[0055] In addition, the time period acquisition unit 90E acquires a second time period based on a remaining hot water heat quantity, a target heat storage quantity, and a detected outside air temperature. The time period acquisition unit 90E acquires a remaining hot water heat quantity from the heat quantity acquisition unit 90A, acquires a target heat storage quantity from the heat storage quantity acquisition unit 90B, and acquires a detected outside air temperature from the first detecting unit 10A. A specific acquisition unit for the second time period will be described with reference to Fig. 4B (described later).

[0056] The tapping water temperature information acquisition unit 90F of the controller Cnt acquires a first target tapping water temperature and a second target tapping water temperature based on a remaining hot water heat quantity, a target heat storage quantity, and a detected outside air temperature. For example, when the detected outside air temperature is low as in the winter, the first target tapping water temperature and the second target tapping water temperature are increased accordingly. The tapping water temperature information acquisition unit 90F acquires a detected outside air temperature from the first detecting unit 10A. In addition, the tapping water temperature information acquisition unit 90F acquires a third time period based on a remaining hot water heat quantity, a target heat storage quantity, and a detected outside air temperature. During the third time period, the target tapping water temperature is set to the first target tapping water temperature.

[0057] When the heating operation is started, the opening degree acquisition unit 90G of the controller Cnt acquires a first opening degree based on a first compressor rotation speed and a target tapping water temperature. The first opening degree is a target opening degree of the expansion device 3. The opening degree acquisition unit 90G acquires a first compressor rotation speed from the first rotation speed acquisition unit 90C, and acquires a target tapping water temperature from the tapping water temperature information acquisition unit 90F. When a preset period of time has elapsed from when the heating operation is started, the opening degree acquisition unit 90G acquires a second opening degree based on the temperature of refrigerant that is discharged from the compressor 1. The second opening degree is a target opening degree of the expansion device 3. That is, the opening degree acquisition unit 90G acquires a second opening degree based on a detected temperature of the second detecting unit 10B.

[0058] The operation control unit 90H of the controller Cnt controls the rotation speed of the compressor 1, the opening degree of the expansion device 3, the rotation speed of the feeding device 5, and the rotation speed of the feeding device 10. In addition, the operation control unit 90H controls the rotation speed of the fan 4A, switching of the flow passage of the flow switching device 6A, switching of the flow passage of the mixing circuit 6B (the flow switching device 6B1 and the flow switching device 6B2), and switching of the flow passage of the flow switching device 9.

[0059] Various kinds of data are stored in the storage unit 901 of the controller Cnt.

[Regarding First Compressor Rotation Speed and Second Compressor Rotation Speed]

[0060] Fig. 3 is a table that the controller Cnt includes and in which compressor rotation speeds are specified.

[0061] The controller Cnt includes a first table in which first compressor rotation speeds are specified and a second table in which second compressor rotation speeds are specified. In the first table and the second table, compressor rotation speeds that satisfy the following relations are specified.

[0062] In the first table, a plurality of heat quantity differences each corresponding to a difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 is specified. As the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 increases, the heat quantity difference also increases. The heat quantity difference may be defined as a numeric value that is determined based on the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7. For example, when the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 is a numeric value within a preset first range, the heat quantity difference is zero. That is, in this case, the controller Cnt consults cells in "0" Column of the first table in Fig. 3. In addition, for example, when the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 is a numeric value within a preset second range larger than the first range, the heat quantity difference is 100. That is, in this case, the controller Cnt consults cells of "100"Column of the first table in Fig. 3. As an example, five different heat quantity differences are specified.

[0063] In addition, in the first table, a plurality of outside air temperature values each corresponding to a detected outside air temperature is specified. An outside air temperature value may be defined as a numeric value that is determined based on a detected outside air temperature. For example, when the detected outside air temperature is lower than or equal to 40 degrees C and higher than 25 degrees C, the outside air temperature value is 40. That is, in this case, the controller Cnt consults cells of "40" Row of the first table in Fig. 3. In addition, for example, when the detected outside air temperature is lower than or equal to 25 degrees C and higher than 16 degrees C, the outside air temperature value is 25. That is, in this case, the controller Cnt consults cells of "25" Row of the first table in Fig. 3. As an example, six different outside air temperature values are specified. Therefore, in the first table, five times six, that is, 30 first compressor rotation speeds are specified. A third table, a fourth table, a fifth table, a sixth table, a seventh table, and an eighth table that will be described based on Fig. 4A, Fig. 4B, Fig. 5A, and Fig. 5B (described later) also have a format similar to that of the first table. That is, in these tables as well, a plurality of (for example, five) heat quantity differences each corresponding to a difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 is specified, and a plurality of (for example, six outside air temperature values) each corresponding to a detected outside air temperature is specified. In addition, the definition of a heat quantity difference and an outside air temperature value and the description of a heat quantity difference and an outside air temperature value, described with reference to Fig. 3, are applicable to the tables shown in Fig. 4A, Fig. 4B, Fig. 5A, and Fig. 5B as well.

[0064] The first compressor rotation speed increases as the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 increases. That is, where the outside air temperature value is constant, the first compressor rotation speed increases as the heat quantity difference increases. Where the outside air temperature value is constant, as the specified first compressor rotation speed shifts rightward in the first table, the value increases.

[0065] In addition, the first compressor rotation speed increases as the detected outside air temperature decreases. That is, where the heat quantity difference is constant, the first compressor rotation speed increases as the outside air temperature value reduces. Where the heat quantity difference is constant, as the specified first compressor rotation speed shifts downward in the first table, the value increases.

[0066] In the second table as well, the second compressor rotation speed is specified in a manner similar to that of the first table. In the second table, a plurality of heat quantity differences each corresponding to a difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 is specified. As an example, five different heat quantity differences are specified. In addition, in the second table, a plurality of outside air temperature values each corresponding to a detected outside air temperature is specified. As an example, eight different outside air temperature values are specified. Therefore, in the second table, five times eight, that is, 40 second compressor rotation speeds are specified.

[0067] The second compressor rotation speed increases as the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 increases. That is, where the outside air temperature value is constant, the second compressor rotation speed increases as the heat quantity difference increases.

[0068] In addition, the second compressor rotation speed increases as the detected outside air temperature decreases. That is, where the heat quantity difference is constant, the second compressor rotation speed increases as the outside air temperature value reduces.

[0069] During a time period soon after the start of the heating operation, it is difficult to increase the efficiency of converting the work of the compressor 1 to the quantity of heat of water stored in the tank 7. This is because, in the initial stage of the start of the heating operation, the temperature of refrigerant, the operations of various devices, and the like, are not stable. Therefore, when the controller Cnt starts heating operation, the controller Cnt executes control for keeping the rotation speed of the compressor 1 at the first compressor rotation speed and, after a lapse of the first time period, increasing the rotation speed of the compressor 1 to the second compressor rotation speed. Thus, it is possible to reduce a decrease in COP.

[0070] Numeric values at which the COP of the water heater 100 is improved are employed as compressor rotation speeds that are specified in the first table and the second table in various situations. In Embodiment, various situations are determined based on a detected outside air temperature and a difference between a target heat storage quantity and a remaining hot water heat quantity. In Embodiment, five times eight, that is, 40 situations are assumed. When the controller Cnt operates the compressor 1 at a compressor rotation speed depending on each situation, the water heater 100 is able to perform heating operation of which the COP is high in various situations.

[Regarding First Feeding Rotation Speed and Second Feeding Rotation Speed]

[0071] Fig. 4A is a table that the controller Cnt includes and in which feeding rotation speeds are specified.

[0072] The controller Cnt includes a third table in which first feeding rotation speeds are specified and a fourth table in which second feeding rotation speeds are specified. In the third table and the fourth table, feeding rotation speeds that satisfy the following relations are specified.

[0073] The first feeding rotation speed increases as the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 reduces. That is, where the outside air temperature value is constant, the first feeding rotation speed increases as the heat quantity difference reduces.

[0074] In addition, the first feeding rotation speed increases as the detected outside air temperature increases. That is, where the heat quantity difference is constant, the first feeding rotation speed increases as the outside air temperature value increases.

[0075] The second feeding rotation speed increases as the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 reduces. That is, where the outside air temperature value is constant, the second feeding rotation speed increases as the heat quantity difference reduces.

[0076] In addition, the second feeding rotation speed increases as the detected outside air temperature increases. That is, where the heat quantity difference is constant, the second feeding rotation speed increases as the outside air temperature value increases.

[0077] Fig. 4B is a table that the controller Cnt includes and in which second time periods are specified.

[0078] The controller Cnt includes a fifth table in which second time periods are specified. In the fifth table, second time periods that satisfy the following relations are specified.

[0079] The second time period shortens as the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 reduces. That is, where the outside air temperature value is constant, the second time period shortens as the heat quantity difference reduces.

[0080] The second time period shortens as the detected outside air temperature increases. That is, where the heat quantity difference is constant, the second time period shortens as the outside air temperature value increases.

[0081] Where the second feeding rotation speed is a variable value, the controller Cnt acquires an initial value of the second feeding rotation speed based on a remaining hot water heat quantity, a target heat storage quantity, and a detected outside air temperature. Then, when a preset condition is satisfied, the controller Cnt, for example, executes variation control for varying the feeding rotation speed to vary the second feeding rotation speed. For example, proportional-integral-differential controller (PID control) may be employed as variation control. The variation control is not limited to PID control. The variation control may be P control or may be PI control. The preset condition may be, for example, a condition that a detected temperature (tapping water temperature) of the third detecting unit 10C exceeds a preset target tapping water temperature. That is, the controller Cnt shifts into variation control as the detected temperature (tapping water temperature) of the third detecting unit 10C exceeds a first target tapping water temperature or a second target tapping water temperature. As a result, the rotation speed of the feeding device 5 changes from the initial value of the second feeding rotation speed.

[0082] In a time period soon after the start of the heating operation, when the rotation speed of the feeding device 5 is kept low or the feeding device 5 remains stopped, the efficiency of gaining the quantity of heat that is supplied from the refrigerant circuit C1 may reduce. That is, it is difficult to increase the efficiency of converting the work of the compressor 1 to the quantity of heat of water stored in the tank 7. Therefore, when the controller Cnt starts heating operation, the controller Cnt starts the operation of the compressor 1, and starts the operation of the feeding device 5. Thus, it is possible to suppress a decrease in the COP of the water heater 100.

[0083] Numeric values at which the COP of the water heater 100 is improved are employed as pump rotation speeds that are specified in the third table and the fourth table in various situations. Numeric values at which the COP of the water heater 100 is improved are employed as time periods that are specified in the fifth table in various situations. In Embodiment, various situations are determined based on a detected outside air temperature and a difference between a target heat storage quantity and a remaining hot water heat quantity. In Embodiment, five times eight, that is, 40 situations are assumed. When the controller Cnt operates the feeding device 5 at a pump rotation speed depending on each situation during a second time period depending on each situation, the water heater 100 is able to perform heating operation of which the COP is high in various situations.

[Regarding First Target Tapping water temperature and Second Target Tapping water temperature]

[0084] Fig. 5A is a table that the controller Cnt includes and in which target tapping water temperatures are specified.

[0085] The controller Cnt includes a sixth table in which first target tapping water temperatures are specified and a seventh table in which second target tapping water temperatures are specified. In the sixth table and the seventh table, first target tapping water temperatures and second target tapping water temperatures that satisfy the following relations are specified.

[0086] The first target tapping water temperature increases as the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 increases. That is, where the outside air temperature value is constant, the first target tapping water temperature increases as the heat quantity difference increases.

[0087] In addition, the first target tapping water temperature increases as the detected outside air temperature decreases. That is, where the heat quantity difference is constant, the first target tapping water temperature increases as the outside air temperature value reduces.

[0088] The second target tapping water temperature increases as the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 increases. That is, where the outside air temperature value is constant, the second target tapping water temperature increases as the heat quantity difference increases.

[0089] In addition, the second target tapping water temperature increases as the detected outside air temperature decreases. That is, where the heat quantity difference is constant, the second target tapping water temperature increases as the outside air temperature value reduces.

[0090] Fig. 5B is a table that the controller Cnt includes and in which third time periods are specified.

[0091] The controller Cnt includes an eighth table in which third time periods are specified. In the eighth table, third time periods that satisfy the following relations are specified.

[0092] The third time period extends as the difference between a target heat storage quantity in the tank 7 and a remaining hot water heat quantity that is the quantity of heat of water in the tank 7 increases. That is, where the outside air temperature value is constant, the third time period extends as the heat quantity difference increases.

[0093] The third time period extends as the detected outside air temperature decreases. That is, where the heat quantity difference is constant, the third time period extends as the outside air temperature value reduces.

[0094] Advantageous effects will be described by taking winter as an example. In a time period soon after the heating operation is started, when the target tapping water temperature (corresponding to the first target tapping water temperature) is kept low, the opening degree of the expansion device 3 excessively increases, and the temperature of refrigerant that is discharged from the compressor 1 is hard to increase, with the result that the COP of the water heater 100 may decrease. Therefore, when the controller Cnt starts heating operation, the controller Cnt sets the target tapping water temperature in consideration of a detected outside air temperature. Thus, it is possible to reduce a decrease in the COP of the water heater 100. In addition, when the controller Cnt starts heating operation, the controller Cnt sets the target tapping water temperature in consideration of a difference between a target heat storage quantity and a remaining hot water heat quantity. Thus, it is possible to reduce a decrease in the COP of the water heater 100.

[0095] Numeric values at which the COP of the water heater 100 is improved are employed as target tapping water temperatures that are specified in the sixth table and the seventh table in various situations. Numeric values at which the COP of the water heater 100 is improved are employed as time periods that are specified in the eighth table in various situations. In Embodiment, various situations are determined based on a detected outside air temperature and a difference between a target heat storage quantity and a remaining hot water heat quantity. In Embodiment, five times eight, that is, 40 situations are assumed. When the controller Cnt sets a target tapping water temperature depending on each situation during a third time period depending on each situation, the water heater 100 is able to perform heating operation of which the COP is high in various situations.

[Operation of Compressor 1 in Heating Operation]

[0096] Fig. 6A is a view illustrating changes over time in the operation of the compressor 1.

[0097] Time t = 0 in Fig. 6A corresponds to the start of the heating operation.

[0098] In addition, time t = t1 in Fig. 6A corresponds to the end of the first time period in the heating operation.

[0099] The compressor 1 operates at the first compressor rotation speed during the first time period. Then, as the first time period elapses, the compressor 1 operates at the second compressor rotation speed higher than the first compressor rotation speed.

[Operation of Feeding Device 5 in Heating Operation]

[0100] Fig. 6B is a view illustrating changes over time in the operation of the feeding device 5.

[0101] Time t = 0 in Fig. 6B corresponds to the start of the heating operation.

[0102] In addition, time t = t2-1 in Fig. 6B corresponds to the end of the second time period in the heating operation.

[0103] In addition, time t = t2-2 in Fig. 6B corresponds to a time at which the detected temperature (tapping water temperature) of the third detecting unit 10C exceeds the first target tapping water temperature. Fig. 6B shows an example in which the second time period is shorter than the third time period.

[0104] The feeding device 5 operates at the first feeding rotation speed during the second time period. Then, as the second time period elapses, the feeding device 5 starts operating at the second feeding rotation speed lower than the first feeding rotation speed. Then, when the detected temperature (tapping water temperature) of the third detecting unit 10C exceeds the first target tapping water temperature, the rotation speed of the feeding device 5 changes from the second feeding rotation speed.

[Changes over Time in Target Tapping water temperature in Heating Operation]

[0105] Fig. 6C is a view illustrating changes over time in target tapping water temperature.

[0106] Time t = 0 in Fig. 6C corresponds to the start of the heating operation.

[0107] In addition, time t = t3 in Fig. 6C corresponds to the end of the third time period in the heating operation.

[0108] The controller Cnt sets a setting value of the target tapping water temperature to the first target tapping water temperature during the third time period. Then, as the third time period elapses, the controller Cnt sets the setting value of the target tapping water temperature to the second target tapping water temperature higher than the first target tapping water temperature.

[0109] Fig. 7 is an alternative embodiment when a set rotation speed of the compressor 1 is shifted from the first compressor rotation speed to the second compressor rotation speed. At the end of the first time period, the controller Cnt may bring the set rotation speed of the compressor 1 to the second compressor rotation speed by increasing the set rotation speed from the first compressor rotation speed in a stepwise manner. The operation of the feeding device 5 is also similar.

Reference Signs List

[0110] 1 compressor 2 heat exchanger 3 expansion device 4 heat exchanger 4A fan 5 feeding device 6A flow switching device 6B mixing circuit 6B1 flow switching device 6B2 flow switching device 7 tank 8 heat exchanger 9 flow switching device 10 feeding device 10A first detecting unit 10B second detecting unit 10C third detecting unit 10D fourth detecting unit 90A heat quantity acquisition unit 90B heat storage quantity acquisition unit 90C first rotation speed acquisition unit 90D second rotation speed acquisition unit 90E period acquisition unit 90F tapping water temperature information acquisition unit 90G opening degree acquisition unit 90H operation control unit 901 storage unit 100 water heater C1 refrigerant circuit C2 water circulation circuit Cnt controller P1 pipe P2 pipe P3 pipe P4 pipe P5 pipe P6 pipe P7 pipe P8 pipe P9 pipe P10 pipe P11 pipe P12 pipe P13 pipe P14 pipe P15 pipe P16 pipe U1 hot water supply using unit U2 hot water supply using unit U3 water supply unit

Claims

1. A water heater comprising:

a refrigerant circuit including a compressor, a condenser connected to a water circulation circuit, an expansion device, and an evaporator;
a tank provided in the water circulation circuit, the tank storing water heated in the condenser;
a feeding device provided in the water circulation circuit, the feeding device feeding water to the tank of the water circulation circuit;
a first detecting unit configured to detect an outside air temperature; and
a controller configured to control the compressor, the expansion device, and the feeding device based on a detected outside air temperature of the first detecting unit, wherein
the controller includes an operation control unit configured to control operations of the compressor, the expansion device, and the feeding device,
when the operation control unit starts heating operation for storing heated water in the tank, the operation control unit starts operating both the compressor and the feeding device together,
the operation control unit operates the compressor at a first compressor rotation speed until a preset first time period elapses from when the heating operation is started, and
after a lapse of the first time period, the operation control unit operates the compressor at a second compressor rotation speed higher than the first compressor rotation speed.

2. The water heater of claim 1, wherein
the first compressor rotation speed increases as a difference between a target storage heat quantity in the tank and a remaining hot water heat quantity that is a quantity of heat of water in the tank increases.

3. The water heater of claim 1 or 2, wherein
the second compressor rotation speed increases as a difference between a storage heat quantity in the tank and a remaining hot water heat quantity in the tank increases.

4. The water heater of any one of claims 1 to 3, wherein the first compressor rotation speed increases as the detected outside air temperature decreases.

5. The water heater of any one of claims 1 to 4, wherein the second compressor rotation speed increases as the detected outside air temperature decreases.

6. The water heater of any one of claims 1 to 5, wherein the operation control unit operates the feeding device at a first feeding rotation speed until a preset second time period elapses from when the heating operation is started, and
after a lapse of the second time period, the operation control unit operates the feeding device at a second feeding rotation speed lower than the first feeding rotation speed.

7. The water heater of claim 6, wherein
the first compressor rotation speed increases as a difference between a target heat storage quantity in the tank and a remaining hot water heat quantity that is a quantity of heat of water in the tank reduces.

8. The water heater of claim 6 or 7, wherein
the second feeding rotation speed increases as a difference between a target heat storage quantity in the tank and a remaining hot water heat quantity that is a quantity of heat of water in the tank reduces.

9. The water heater of any one of claims 6 to 8, wherein the first feeding rotation speed increases as the detected outside air temperature increases.

10. The water heater of any one of claims 6 to 9, wherein the second feeding rotation speed increases as the detected outside air temperature increases.

11. The water heater of any one of claims 6 to 10, wherein
the second time period shortens as a difference between a target heat storage quantity in the tank and a remaining hot water heat quantity that is a quantity of heat of water in the tank reduces.

12. The water heater of any one of claims 6 to 11, wherein
the second time period shortens as the detected outside air temperature increases.

13. The water heater of any one of claims 1 to 12, wherein
the controller further includes a heat quantity acquisition unit that acquires a remaining hot water heat quantity in the tank that is a quantity of heat of water in the tank.

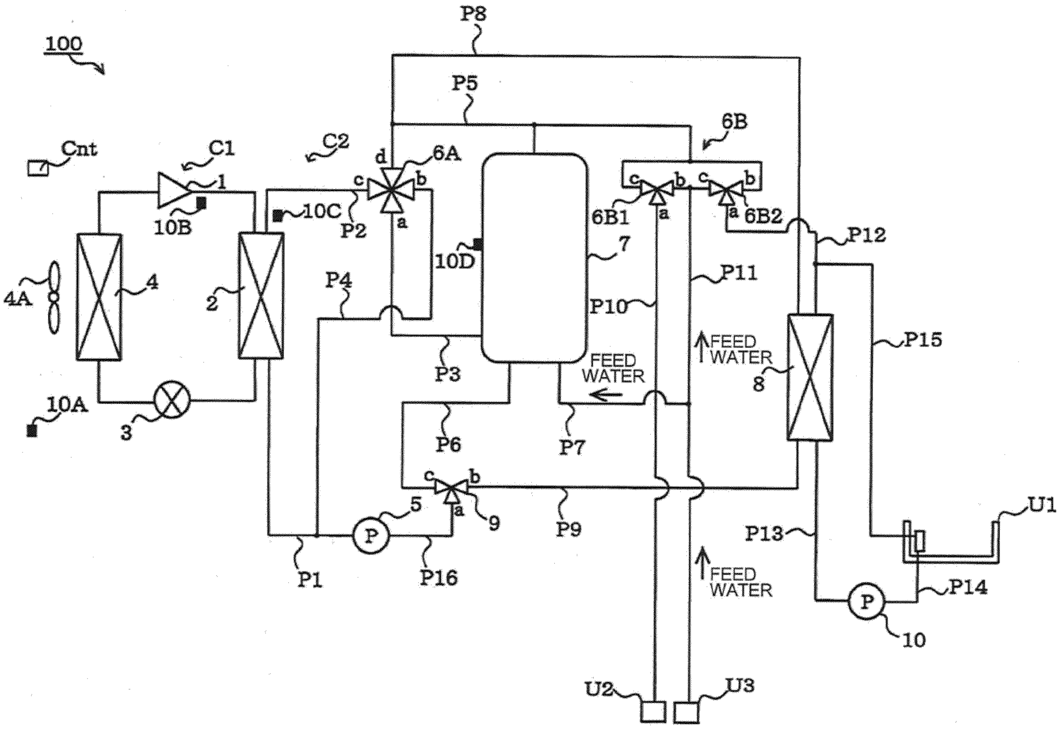
14. The water heater of any one of claims 1 to 13, wherein
the controller further includes a storage heat acquisition unit that acquires a target heat storage quantity in the tank.

15. The water heater of any one of claims 1 to 14, wherein
the controller further includes a first rotation speed acquisition unit that acquires the first compressor rotation speed and the second compressor rotation speed based on a remaining hot water heat quantity in the tank that is a quantity of heat of water in the tank, a target heat storage quantity in the tank, and the detected outside air temperature.

16. The water heater of any one of claims 6 to 12, and claims 13 to 15 as dependent on claims 6 to 12, wherein
the controller further includes a second rotation speed acquisition unit that acquires the first feeding rotation speed and the second feeding rotation speed based on a remaining hot water heat quantity in the tank that is a quantity of heat of water in the tank, a target heat storage quantity in the tank, and the detected outside air temperature.

17. The water heater of any one of claims 6 to 12, claim 16, and claims 13 to 15 as dependent on claims 6 to 12, wherein
the controller further includes a time period acquisition unit that acquires the second time period, during which the feeding device is operated at the first feeding rotation speed, based on a remaining hot water heat quantity in the tank that is a quantity of heat of water in the tank, a target heat storage quantity in the tank, and the detected outside air temperature.

FIG. 1A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P5
6B
Cnt
C1
C2
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c
b
c
b
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P2
a
6B1
a
a
6B2
P12
10D
7
P11
4A
4
2
P4
P10
P15
FEED WATER
P3
FEED WATER
8
10A
3
P6
P7
c
b
5
a
9
P9
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P1
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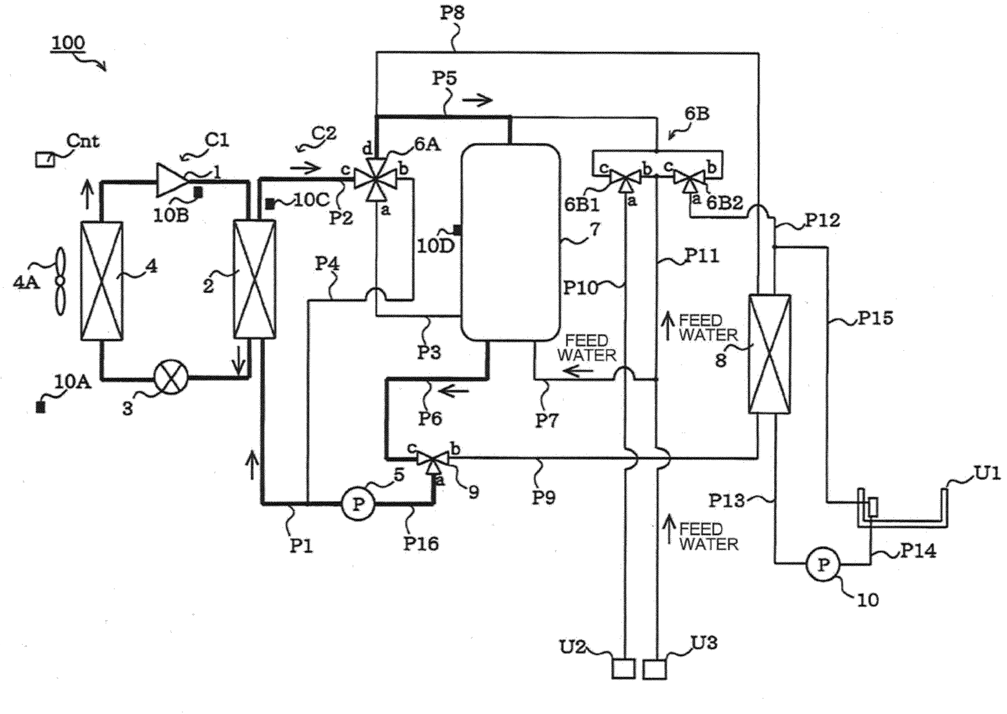
FEED WATER
P14
10
U2
U3
P
P
P

FIG. 1B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C1
C2
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d
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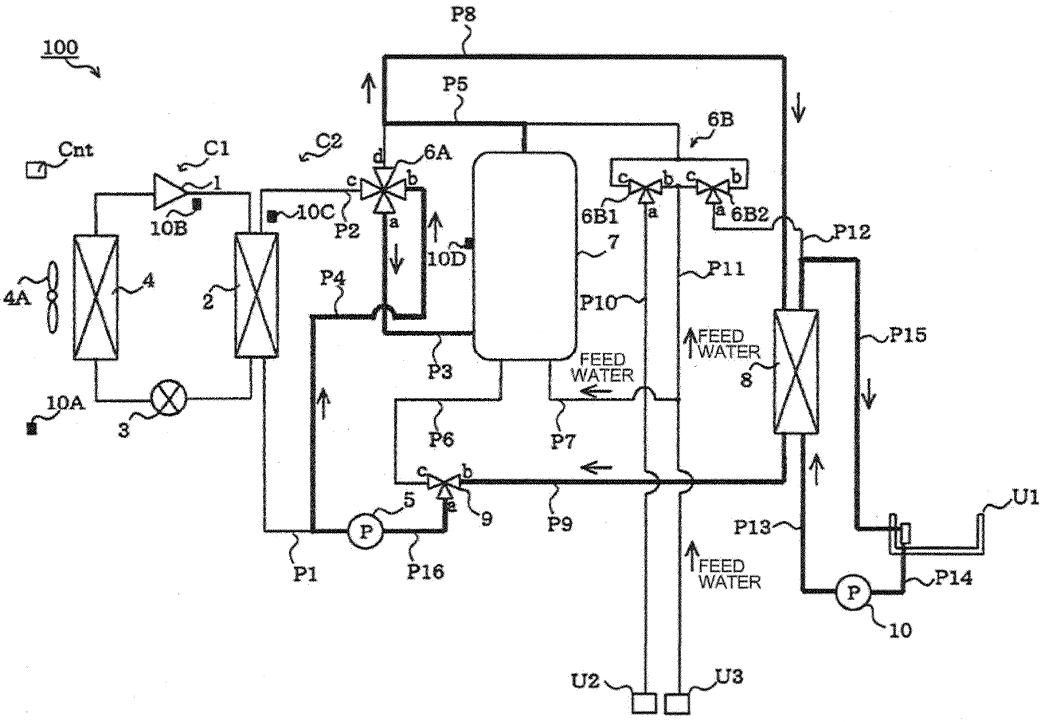
P2
a
6B1
a
a
6B2
P12
4A
4
2
P4
10D
7
P11
P10
P15
P3
FEED WATER
FEED WATER
8
10A
3
P6
P7
c
b
5
a
9
P9
U1
P13
P1
P16
FEED WATER
P14
P
P
10
U2
U3

FIG. 1C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P5
6B
Cnt
C1
C2
6A
d
c
b
a
1
10B
10C
P2
10D
6B1
6B2
P12
4A
4
2
P4
7
P11
P10
P15
FEED WATER
FEED WATER
8
P3
10A
3
P6
P7
5
9
P9
P13
U1
P1
P16
FEED WATER
P14
P
10
U2
U3

FIG. 2

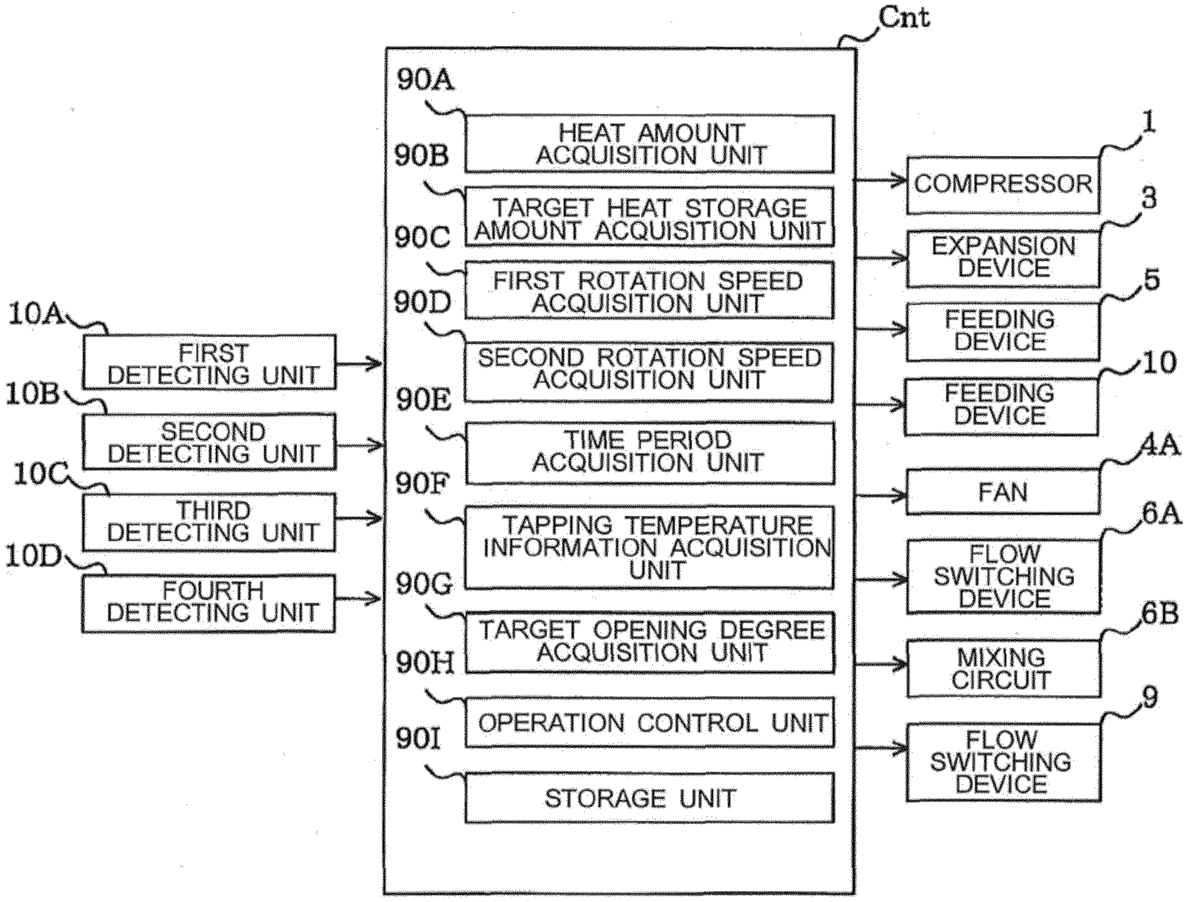


FIG. 3

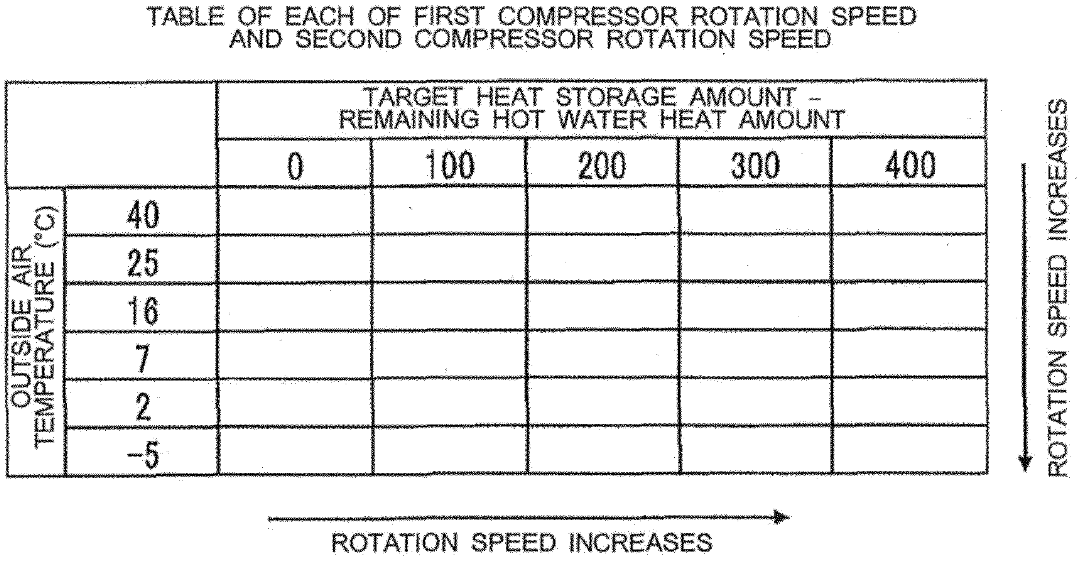


TABLE OF EACH OF FIRST COMPRESSOR ROTATION SPEED AND SECOND COMPRESSOR ROTATION SPEED

		TARGET HEAT STORAGE AMOUNT − REMAINING HOT WATER HEAT AMOUNT				
		0	100	200	300	400
OUTSIDE AIR TEMPERATURE (°C)	40					
	25					
	16					
	7					
	2					
	-5					

ROTATION SPEED INCREASES

ROTATION SPEED INCREASES

FIG. 4A

TABLE OF EACH OF FIRST PUMP ROTATION SPEED AND SECOND PUMP ROTATION SPEED

		TARGET HEAT STORAGE AMOUNT – REMAINING HOT WATER HEAT AMOUNT				
		0	100	200	300	400
OUTSIDE AIR TEMPERATURE (°C)	40					
	25					
	16					
	7					
	2					
	-5					

ROTATION SPEED INCREASES

ROTATION SPEED INCREASES

FIG. 4B

TABLE OF SECOND TIME PERIOD

		TARGET HEAT STORAGE AMOUNT – REMAINING HOT WATER HEAT AMOUNT				
		0	100	200	300	400
OUTSIDE AIR TEMPERATURE (°C)	40					
	25					
	16					
	7					
	2					
	-5					

TIME PERIOD SHORTENS

TIME PERIOD SHORTENS

FIG. 5A

TABLE OF EACH OF FIRST TARGET TAPPING TEMPERATURE VALUE AND SECOND TARGET TAPPING TEMPERATURE VALUE

		TARGET HEAT STORAGE AMOUNT – REMAINING HOT WATER HEAT AMOUNT				
		0	100	200	300	400
OUTSIDE AIR TEMPERATURE (°C)	40					
	25					
	16					
	7					
	2					
	-5					

TEMPERATURE INCREASES

TEMPERATURE INCREASES

FIG. 5B

TABLE OF THIRD TIME PERIOD

		TARGET HEAT STORAGE AMOUNT – REMAINING HOT WATER HEAT AMOUNT				
		0	100	200	300	400
OUTSIDE AIR TEMPERATURE (°C)	40					
	25					
	16					
	7					
	2					
	-5					

TIME PERIOD EXTENDS →

TIME PERIOD EXTENDS ↓

FIG. 6A

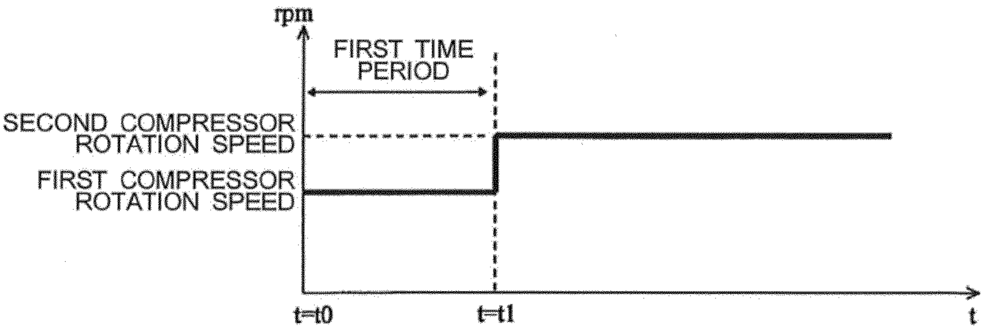


FIG. 6B

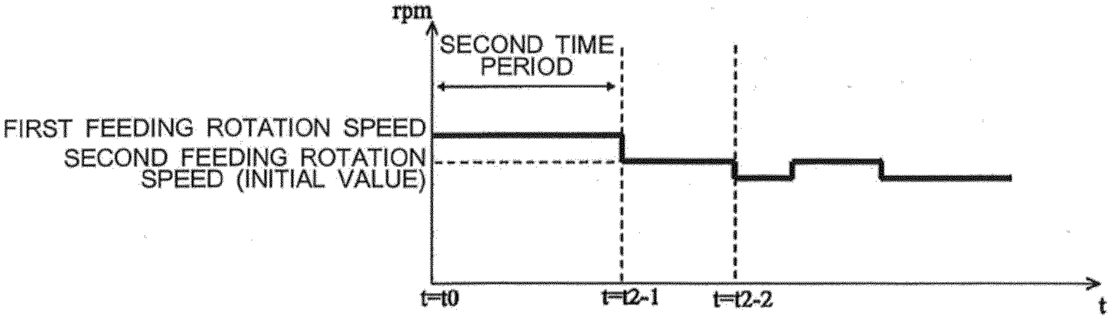


FIG. 6C

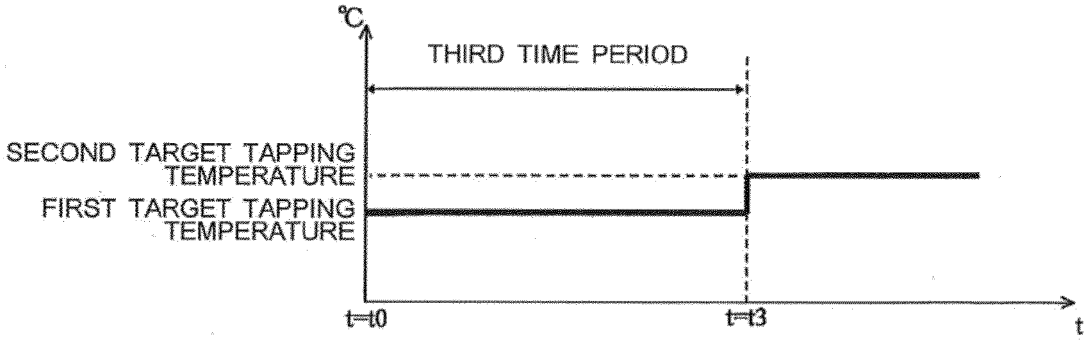
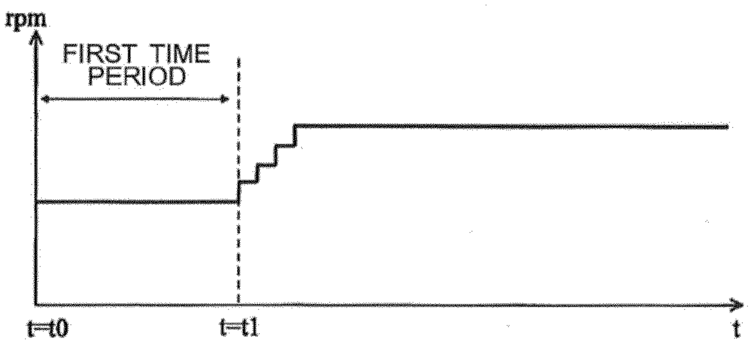

℃
THIRD TIME PERIOD
SECOND TARGET TAPPING TEMPERATURE
FIRST TARGET TAPPING TEMPERATURE
t=t0
t=t3
t

FIG. 7


rpm
FIRST TIME PERIOD
t=t0
t=t1
t

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/085099

A. CLASSIFICATION OF SUBJECT MATTER
F24H4/02(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)
F24H4/02, F24H1/00

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	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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.
X Y	JP 2013-137169 A (Daikin Industries, Ltd.), 11 July 2013 (11.07.2013), paragraphs [0015] to [0041]; fig. 1 to 3 (Family: none)	1 2-17
X Y	JP 2011-075257 A (Hitachi Appliances, Inc.), 14 April 2011 (14.04.2011), paragraphs [0014] to [0031]; fig. 1 to 4 (Family: none)	1 2-17
Y	JP 2010-261665 A (Mitsubishi Electric Corp.), 18 November 2010 (18.11.2010), paragraphs [0012] to [0074]; fig. 1 to 9 (Family: none)	2-17

☒ 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
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"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 15 February 2017 (15.02.17)	Date of mailing of the international search report 28 February 2017 (28.02.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/085099

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2013-224767 A (Rinnai Corp.), 31 October 2013 (31.10.2013), claims 4 to 6; paragraphs [0018] to [0053]; fig. 1 to 4 & KR 10-2013-0118772 A	2-17
A	JP 2013-160490 A (Hitachi Appliances, Inc.), 19 August 2013 (19.08.2013), paragraphs [0012] to [0115]; fig. 1 to 5 (Family: none)	1-17
A	JP 2012-241944 A (Hitachi Appliances, Inc.), 10 December 2012 (10.12.2012), paragraphs [0012] to [0096]; fig. 4A (Family: none)	1-17
A	JP 2005-140439 A (Matsushita Electric Industrial Co., Ltd.), 02 June 2005 (02.06.2005), paragraphs [0019] to [0027]; fig. 1 to 5 (Family: none)	1-17

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005140439 A **[0003]**