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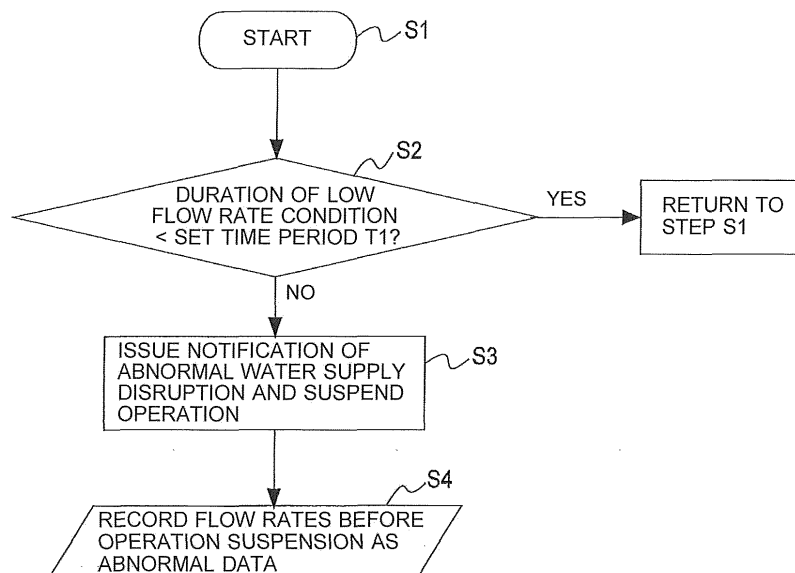
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(54) **HEAT PUMP HOT-WATER SUPPLY DEVICE AND HOT-WATER STORAGE SYSTEM EQUIPPED WITH HEAT PUMP HOT-WATER SUPPLY DEVICE**

(57) A heat pump hot water dispenser includes a heat pump cycle device 50 connecting at least a compressor 51, a refrigerant-water heat exchanger 52, a pressure reducing device 53, and an evaporator 54 by pipes, the refrigerant-water heat exchanger 52 being configured to allow refrigerant and water to exchange heat, a flow rate detection unit 40 for detecting a flow rate of water flowing through the refrigerant-water heat exchanger 52, and a

control unit 60 for controlling operation of the heat pump cycle device 50. The control unit 60 is configured to determine an occurrence of abnormal water supply disruption and suspend the operation of the heat pump cycle device 50 when a flow rate of water detected by the flow rate detection unit 40 continues to be lower than a threshold for a set time period T1 or longer.

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Description

Technical Field

[0001] The present invention relates to a heat pump hot water dispenser and a hot water storage system including the heat pump hot water dispenser.

Background Art

[0002] Heat pump devices using natural refrigerants have been actively developed in an attempt to eliminate the use of chlorofluorocarbons. In particular, heat pump devices using carbon dioxide (CO₂) as refrigerant have become popular in recent years. CO₂ has an ozone depletion potential of 0 and a global warming potential of 1, and thus has an advantage such that loads on the environment can be reduced. In addition, CO₂ has no toxicity and no flammability, and thereby is excellent in terms of safety, and has advantages such that CO₂ is easily obtained and is relatively inexpensive.

[0003] Furthermore, unlike chlorofluorocarbon-based refrigerants, CO₂ on a high-pressure side, namely, the CO₂ discharged from a compressor, has a property of being in a supercritical state. That is, the CO₂ in a supercritical state remains in the supercritical state without being condensed when imparting heat to other fluids (e.g., water, air, and refrigerant) by heat exchange. The CO₂ having such a property has less state transition loss and is suitable for use in heat pump devices that are required to achieve an especially high temperature. Consequently, various heat pump hot water dispensers that use CO₂ as refrigerant to heat water to 90 degrees C by utilizing the advantages of CO₂ have been proposed.

[0004] As an example of such a heat pump device, a hot water dispenser "provided with a water heating unit, a hot water tank for storing hot water heated by the water heating unit, a plurality of radiating units for circulating the hot water stored in the hot water tank as a heat source, selecting unit for selecting whether the plurality of radiating units are used or not, and a control unit for controlling a water heating operation that heats water by the water heating unit on the basis of a selection state selected by the selecting unit and stores the heated water in the hot water tank" is disclosed (e.g., see Patent Literature 1). This heat pump hot water dispenser uses a circulation pump to control the flow rate of supplied hot water.

[0005] In general, heat pump hot water dispensers use pumps, as described in Patent Literature 1, to feed hot water heated by the water heating units into the hot water tanks, or to circulate hot water stored in the hot water tanks through the heat pump hot water dispensers to raise the temperature of the hot water. Such a pump is embedded in a hot water dispenser or provided by connecting to a hot water dispenser.

[0006] In addition, such a hot water dispenser is required to prepare against a case where water supplied

to the heat pump hot water dispenser is disrupted or the pressure thereof is reduced. Therefore, to protect a compressor or the like during water supply disruption, a water-cooled type cooler that is provided with a water supply disruption detection unit for detecting a pressure on a discharge side of a compressor and that controls operation of the compressor on the basis of the outputs from the water supply disruption detection unit has been proposed (e.g., see Patent Literature 2).

Citation List

Patent Literature

[0007]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2004-333051 (Page 4, Fig. 1)

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 7-229653 (Page 3, Fig. 1)

Summary of Invention

Technical Problem

[0008] However, if the water supply disruption detection unit and the configuration related to the operation for controlling a compressor on the basis of the water supply disruption detection unit described in Patent Literature 2 are applied to the heat pump hot water dispenser described in Patent Literature 1, in which the flow rate of supplied hot water is controlled by a pump, the pump may be damaged when water supply is disrupted. Examples of cases where a pump is damaged in the configuration include a case where water supply disruption cannot be detected in an operation (such as a pump operation mode) in which the pressure is not increased, thereby damaging the pump, and a case where an increase in the pressure takes time due to control of a decrease in frequency, thereby damaging the pump before water supply disruption is detected. If the pump is damaged, problems occur such that, even when the operation of the heat pump is resumed after the water supply disruption, hot water heated by the water heating unit cannot be fed into and stored in the hot water tank, or that hot water stored in the hot water tank cannot be circulated through the heat pump hot water dispenser.

[0009] Furthermore, Patent Literature 2 discloses a pressure switch as a method for detecting water supply disruption; however, with such a water supply disruption detection method like a pressure switch, water supply disruption may be erroneously detected or a pump may be damaged. A specific example will be explained with reference to figures. Fig. 8 is used to explain a problem of the conventional technique. Figs. 8 (a) and 8 (b) illustrate examples of a hot water storage system in which a

hot water tank 101 and a hot water dispenser 130 are connected to each other via a water inflow pipe 131 having a valve body 134 and a water outflow pipe 132 having a valve body 135. In a case where hot water tank 101 and the hot water dispenser 130 are connected to each other via a water outflow pipe 132 having a shrine gate shape (an upwardly bent shape indicated by sign 180) as illustrated in Fig. 8 (a) or in a case where the hot water tank 101 and the hot water dispenser 130 are connected to each other via a water inflow pipe 131 having an inverse shrine gate shape (a downwardly bent shape indicated by sign 181) as illustrated in Fig. 8 (b), air in the pipe cannot be released and therefore a pump cannot suck water or hot water due to air entrainment in the pump, thereby a temporary decrease in flow rate may occur. In such a case, a water supply disruption detection unit formed of the pressure switch described in Patent Literature 2 may erroneously detect an event of a temporary decrease in flow rate, which is recovered in a few seconds, as water supply disruption. Note that, in the present invention, a temporary decrease in flow rate, such that the flow rate of water is decreased and recovered in a few seconds, is not considered as water supply disruption.

[0010] In addition, Figs. 8 (c) and 8 (d) illustrate examples of connection pipes (including water outflow pipes and water inflow pipes) to the hot water dispenser 130 and valves provided to the connection pipes. In a case where a three-way valve 182 is connected to the connection pipes of the hot water dispenser 130 as illustrated in Fig. 8 (c), or in a case where two or more two-way valves (two-way valves 183a, 183b) are connected to the connection pipes of the hot water dispenser 130 as illustrated in Fig. 8 (d), a temporary decrease in flow rate occurs when the valve is operated for switching flow passages. Fig. 9 illustrates an example of the relationship between the opening degrees of valves and the flow rate in switching of flow passages by using the two-way valves 183a and 183b illustrated in Fig. 8 (d). As illustrated in Fig. 9, when the two-way valves 183a and 183b are operated to switch the flow passages, a temporary decrease in flow rate occurs. Furthermore, in a case not shown with the three-way valve 182, a temporary decrease in flow rate occurs as with Fig. 9. In this case, the water supply disruption detection unit formed of the pressure switch described in Patent Literature 2 may erroneously detect the temporary decrease in flow rate as water supply disruption.

[0011] Moreover, a problem occurs, in which even if operation of a compressor or the like is suspended to protect devices in a case where such a temporary decrease in flow rate occurs, no repeatability is found to identify the cause of the abnormal suspension, thereby making it difficult to find out the cause.

[0012] To address the problems above, the present invention provides a heat pump hot water dispenser that can perform operations without any trouble even after a temporary decrease in flow rate occurs, and provides a

hot water storage system provided with the heat pump hot water dispenser.

Solution to Problem

[0013] A heat pump hot water dispenser of the present invention includes a heat pump cycle device connecting at least a compressor, a refrigerant-water heat exchanger, a pressure reducing device, and an evaporator by pipes, the refrigerant-water heat exchanger being configured to allow refrigerant and water to exchange heat, a flow rate detection unit for detecting a flow rate of water flowing through the refrigerant-water heat exchanger, and a control unit for controlling operation of the heat pump cycle device. The control unit is configured to determine an occurrence of abnormal water supply disruption and suspend the operation of the heat pump cycle device when a flow rate of water detected by the flow rate detection unit continues to be lower than a threshold for a set time period or longer.

Advantageous Effects of Invention

[0014] The present invention is configured in such a manner that when a condition where the flow rate of the water flowing through the refrigerant-water heat exchanger is lower than a threshold continues for a set time period or longer, the condition is determined as abnormal water supply disruption, and the operation of the heat pump cycle device is suspended. Therefore, erroneous detections of water supply disruption due to malfunction of the flow rate detection unit caused by noises and due to a temporary decrease in flow rate can be controlled. Furthermore, an advantageous effect can be obtained such that, even if a temporary decrease in flow rate occurs, operation can be performed after the temporary decrease in flow rate without any trouble within a range where a pump for circulating water through the refrigerant-water heat exchanger is not damaged.

Brief Description of Drawings

[0015]

[Fig. 1] Fig. 1 is a pipe circuit diagram illustrating a hot water storage system 100 of Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a pipe circuit diagram illustrating a hot water dispenser 30 of Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a flowchart of a determination process for water supply disruption detection of the hot water dispenser 30 of Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 illustrates graphs each indicating an example of a relationship between a flow rate of water flowing through the refrigerant-water heat exchanger 52 and an elapsed time of Embodiment 1

of the present invention.

[Fig. 5] Fig. 5 illustrates a graph indicating an example of a relationship between a temperature of a pump embedded component and an operation elapsed time.

[Fig. 6] Fig. 6 is a pipe circuit diagram illustrating a hot water storage system 100 of Embodiment 2 of the present invention.

[Fig. 7] Fig. 7 is a flowchart explaining operation of a hot water dispenser 30 of Embodiment 2 of the present invention.

[Fig. 8] Fig. 8 illustrates examples of a pipe connection configuration between a hot water dispenser 130 and a hot water tank 101.

[Fig. 9] Fig. 9 is a graph illustrating an example of a relationship between opening degrees of valves and a flow rate when an operation for switching flow passages is performed in a case where two two-way valves are connected to the hot water dispenser 130.

Description of Embodiments

[0016] Embodiments in which a heat pump hot water dispenser of the present invention is applied to a hot water storage system provided with a hot water tank will be explained below with reference to the accompanying drawings. Note that, in the drawings, the dimensional relationship among the component members may differ from an actual case. In addition, in the drawings, the features denoted by the same signs are the same or corresponding features, and this applies throughout the description. Furthermore, the configurations of the component members described throughout the description are merely examples, and are not limited to the description.

Embodiment 1

[0017] Fig. 1 is a pipe circuit diagram illustrating a hot water storage system 100 of Embodiment 1 of the present invention. Note that, in Fig. 1, the directions of water flow are also indicated by dotted arrows. The hot water storage system 100 of Embodiment 1 includes a hot water tank 1 and a heat pump hot water dispenser 30 (hereinafter referred to simply as a hot water dispenser 30) that is a unit for heating water in the hot water tank 1. Hot water heated by the hot water dispenser 30 is stored in the hot water tank 1, and the hot water is supplied from the hot water tank 1 to a faucet of a facility (e.g., bathroom or kitchen) that uses hot water.

[0018] A lower portion of the hot water tank 1 is connected to the hot water dispenser 30 via a water inflow pipe 31 for allowing water in the hot water tank 1 to flow into the hot water dispenser 30. A temperature sensor 2 is provided at a lower portion of the hot water tank 1 to detect the temperature of water located at substantially the same depth as the portion to which the water inflow pipe 31 is connected. The configuration of the temperature sensor 2 is not limited in particular as long as it can

detect a water temperature. In addition, an upper portion of the hot water tank 1, more particularly, an upper portion located above the portion to which the water inflow pipe 31 is connected, is connected to the hot water dispenser 30 via a water outflow pipe 32 in which water flowing out from the hot water dispenser 30 flows. The water inflow pipe 31 branches off between the hot water tank 1 and the hot water dispenser 30, and a pipe branching off therefrom is referred to as a water inflow pipe 31 a. The water inflow pipe 31 a is connected to a water receiving tank 3 via a water supply pipe 4. The water receiving tank 3 stores water to be supplied to the hot water storage system 100. The water supply pipe 4 is provided with a water supply valve 5 for controlling the amount of water to be supplied from the water receiving tank 3 to the hot water dispenser 30.

[0019] The water inflow pipe 31 and the water outflow pipe 32 are provided with valve bodies, such as manual valves, to block paths of the water pipes between the hot water dispenser 30 and the hot water tank 1 when the hot water dispenser 30 is maintained or replaced. Specifically, the water inflow pipe 31 is provided with valve bodies 33 and 34 in series, and the water inflow pipe 31 a branches off between the valve bodies 33 and 34. The water outflow pipe 32 is provided with a valve body 35.

[0020] One end of a hot water supply pipe 6, the other end of which is connected to a faucet not shown, is connected to an upper portion of the hot water tank 1. The hot water supply pipe 6 is provided with a hot water supply pump 7 for feeding hot water stored in the hot water tank 1 to the faucet. In addition, one end of a return pipe 8 is connected to a lower portion of the hot water tank 1, more particularly, below the portion to which the hot water supply pipe 6 is connected. Note that the hot water supply pump 7 may be provided to the return pipe 8.

[0021] Next, a configuration of the hot water dispenser 30 will be explained.

[0022] Fig. 2 is a pipe circuit diagram illustrating the hot water dispenser 30 of Embodiment 1 of the present invention. Note that, in Fig. 2, the direction of water flow is indicated by dotted arrows, and the direction of refrigerant flow is indicated by solid arrows. The hot water dispenser 30 of Embodiment 1 includes a heat pump cycle device (same as a refrigeration cycle device) 50 as a heat source. In Embodiment 1, the heat pump cycle device 50 uses CO₂ refrigerant. High-pressure CO₂ refrigerant has a property of being in a supercritical state. That is, the CO₂ refrigerant in a supercritical state remains in the supercritical state without being condensed when imparting heat to other fluids (water in Embodiment 1) by heat exchange. Therefore, state transition loss is small, thereby being suitable for heating water to a high temperature.

[0023] In the heat pump cycle device 50, a compressor 51, a refrigerant-water heat exchanger 52 as a radiator, a pressure reducing device 53, and an evaporator 54 are sequentially connected by pipes to form a refrigerant circuit. The compressor 51 is connected to the refrigerant-

water heat exchanger 52 via a refrigerant inflow pipe 55. The refrigerant-water heat exchanger 52 is connected to the pressure reducing device 53 via a refrigerant outflow pipe 56. The pressure reducing device 53 is connected to the evaporator 54 by a pipe, and the evaporator 54 is connected to the compressor 51 by a pipe. Note that the refrigerant used in the heat pump cycle device 50 is not limited to CO₂, and various refrigerants, such as hydrofluorocarbon (HFC) refrigerants such as R410A, R407C, R404A and R32, hydrochlorofluorocarbon (HCFC) refrigerants such as R22 and R134a, and natural refrigerants such as hydrocarbon and helium, can be used. In this case, the refrigerant-water heat exchanger 52 functions as a condenser.

[0024] In the heat pump cycle device 50, high-temperature, high-pressure refrigerant discharged from the compressor 51 flows into the refrigerant-water heat exchanger 52, releases heat by exchanging heat with a fluid (water, in Embodiment 1) flowing through the refrigerant-water heat exchanger 52, and then flows out from the refrigerant-water heat exchanger 52. The refrigerant that flows out from the refrigerant-water heat exchanger 52 is decompressed by the pressure reducing device 53, then flows into the evaporator 54 and the temperature of the refrigerant is raised therein, and then is sucked into the compressor 51. The number of the refrigerant-water heat exchangers 52 is not limited, and a single or a plurality of the refrigerant-water heat exchangers 52 can be provided according to a required heating amount of water.

[0025] The water inflow pipe 31 and the water outflow pipe 32 are connected to the refrigerant-water heat exchanger 52. The water flowing into the refrigerant-water heat exchanger 52 through the water inflow pipe 31 exchanges heat with the refrigerant flowing in the refrigerant-water heat exchanger 52, and then is fed into the hot water tank 1 (see Fig. 1) through the water outflow pipe 32. A water supply pump 36 for feeding water to the refrigerant-water heat exchanger 52 is provided to the water inflow pipe 31. The water supply pump 36 may be a pump of which the flow rate can be adjusted by varying the rotation speed, or a pump of which the flow rate (rotation speed) is constant. The water supply pump 36 may be provided to the water outflow pipe 32. In addition, the water supply pump 36 may be embedded in the hot water dispenser 30 as illustrated in Fig. 2, or may be provided to a portion of the water inflow pipe 31 or the water outflow pipe 32 exposed from an outer frame of the hot water dispenser 30.

[0026] The water inflow pipe 31 is provided with a flow rate detection unit 40 for detecting the flow rate of water flowing through the refrigerant-water heat exchanger 52. The flow rate detection unit 40 may be of an arbitrary flow rate sensor of, for example, an electric type, a mechanical type, an ultrasonic type, or a heat type. Note that, in the example of Fig. 2, the flow rate detection unit 40 uses a volume type flow rate detection device, and thus is provided to a portion between the water supply pump 36 of

the water inflow pipe 31 and the refrigerant-water heat exchanger 52, because the portion is one in which the pressure is the highest. The flow rate detection unit 40 is provided to neither an upstream region of the water supply pump 36 where cavitation may occur nor a downstream region of the refrigerant-water heat exchanger 52 where bubbles may generate.

[0027] Provided in a chassis of the hot water dispenser 30 is a control unit 60 to which information detected by the flow rate detection unit 40 and the temperature sensor 2 is input, and that controls operations of at least the hot water supply pump 7, valve bodies 34 and 35, and the compressor 51. When the pressure reducing device 53 is formed of an expansion valve capable of adjusting an opening degree, the operation of the pressure reducing device 53 may be controlled by the control unit 60, and when the valve bodies 34 and 35 are capable of adjusting opening degrees, these valve bodies may be controlled by the control unit 60. In Embodiment 1, the control unit 60 is provided in the chassis of the hot water dispenser 30, as illustrated in Fig. 2; however, the control unit 60 may be provided to any place. The control unit 60 may be realized by the CPU and an analysis program executed by the CPU, or may be realized as a hardware using wired logic. Note that functions to be realized by the control unit 60 may be realized by devices that are physically separated in an arbitrary unit. In addition, the control unit 60 has a memory unit 61 that is rewritable, and the flow rates detected by the flow rate detection unit 40 can be recorded in the memory unit 61 as described later.

[0028] Furthermore, the hot water dispenser 30 is provided with a notification unit 62 for notifying a user of operation conditions of the hot water dispenser 30 and information that should be notified to the user. The notification unit 62 is, for example, a display device, such as a liquid crystal monitor that visually displays information, or a sound output device, such as a speaker or a buzzer that aurally notifies information. Note that, both a display device and a sound output device, or either of them may be provided as the notification unit 62.

[0029] Next, operations will be explained.

[0030] The hot water storage system 100 of Embodiment 1 heats water stored in the hot water tank 1 or water stored in the water receiving tank 3 by the hot water dispenser 30 (refrigerant-water heat exchanger 52) and feeds the water into the hot water tank 1. The control unit 60 of Embodiment 1 has at least two operation modes, as operation modes of the hot water dispenser 30, of a circulation mode in which water is circulated between the hot water dispenser 30 (refrigerant-water heat exchanger 52) and the hot water tank 1, and a hot water storage mode in which hot water heated by the hot water dispenser 30 is stored in the hot water tank 1. The hot water storage mode differs from the circulation mode in that water supplied from the water receiving tank 3 is heated by the hot water dispenser 30 and stored in the hot water tank 1, and water is not fed to the hot water dispenser 30 from the hot water tank 1. With reference to Figs. 1

and 2, overviews of the circulation mode and the hot water storage mode will be explained below.

[0031] For the circulation mode, water to be heated by the hot water dispenser 30 (refrigerant-water heat exchanger 52) is the water stored in the hot water tank 1. In the hot water tank 1, the temperature of the water increases toward the upper portion of the hot water tank 1 and the temperature of the water decreases toward the lower portion of the hot water tank 1. In Embodiment 1, the control unit 60 operates the hot water dispenser 30 to start heating of the water stored in the hot water tank 1 when a water temperature detected by the temperature sensor 2 provided at the lower portion of the hot water tank 1 becomes a prescribed heating start temperature or lower. When starting heating of the water stored in the hot water tank 1, the control unit 60 opens the valve bodies 33, 34 and 35, and causes the water supply pump 36 to operate. The water stored at a lower portion of the hot water tank 1 is fed to the hot water dispenser 30 (refrigerant-water heat exchanger 52) via the water inflow pipe 31. Then, the water is heated by the hot water dispenser 30 (refrigerant-water heat exchanger 52) and becomes hot water. The hot water flows into the hot water tank 1 via the water outflow pipe 32. Then, a detected temperature detected by the temperature sensor 2 reaches a prescribed heating end temperature, the heating of the water stored in the hot water tank 1 is finished. The hot water stored in the hot water tank 1 is supplied to a faucet not shown via the hot water supply pipe 6 when the hot water supply pump 7 is operated.

[0032] When the hot water stored in the hot water tank 1 is supplied to a faucet not shown via the hot water supply pipe 6, the amount of the water in the hot water tank 1 is decreased. Then, the control unit 60 starts operation in the hot water storage mode. When the amount of the water in the hot water tank 1 is decreased to a prescribed amount and the operation is started in the hot water storage mode, the valve body 33 is closed and the water supply valve 5 is opened. When the water supply valve 5 is opened, the water stored in the water receiving tank 3 is fed to the hot water dispenser 30 (refrigerant-water heat exchanger 52) via the water inflow pipe 31 a. The water is then heated by the hot water dispenser 30 (refrigerant-water heat exchanger 52) and becomes hot water. The hot water flows into the hot water tank 1 via the water outflow pipe 32, and then is fed to a faucet not shown via the hot water supply pipe 6.

[0033] Next, the determination operations for water supply disruption detection of the hot water dispenser 30 will be explained.

[0034] Note that the same operations for determining abnormal water supply disruption are used in both of the circulation mode and the hot water storage mode, and the operations of the hot water storage system 100 and the hot water dispenser 30 will be explained by using the circulation mode, as an example, in which the water stored in the hot water tank 1 is heated by the hot water dispenser 30 (refrigerant-water heat exchanger 52).

[0035] Fig. 3 is a flowchart of the determination process for water supply disruption detection of the hot water dispenser 30 of Embodiment 1 of the present invention. Fig. 4 illustrates graphs each indicating an example of the relationship between the flow rate of water flowing through the refrigerant-water heat exchanger 52 of Embodiment 1 of the present invention and the elapsed time.

[0036] The control unit 60 starts operation of the hot water dispenser 30 (step S1). When the operation of the hot water dispenser 30 is started, the flow rate detection unit 40 detects periodically (e.g., every 30 seconds) a flow rate of the water flowing in the refrigerant-water heat exchanger 52. In addition, the flow rates periodically detected by the flow rate detection unit 40 are stored in the memory unit 61 in a ring buffer format, for example. Therefore, the flow rates of the water flowing in the refrigerant-water heat exchanger 52 for a prescribed period extending back from a present time are stored in the memory unit 61.

[0037] The control unit 60 determines whether or not a condition (hereinafter may be referred to as a low flow rate condition) in which the flow rate of the water flowing in the refrigerant-water heat exchanger 52 detected by the flow rate detection unit 40 is equal to or lower than a threshold continues for a set time T1 (180 seconds in Embodiment 1) or longer (step S2). When, as illustrated in Fig. 4 (a), the low flow rate condition continues for less than the set time T1 (180 seconds) (YES in step S2 of Fig. 3), the control unit 60 does not determine the condition as abnormal water supply disruption, and returns to step S1 to continue the operation of the hot water dispenser 30. Meanwhile, when, as illustrated in Fig. 4 (b), the low flow rate condition continues for the set time T1 (180 seconds) or longer (NO in step S2 of Fig. 3), the control unit 60 determines that water supply disruption occurs, and the process proceeds to step S3.

[0038] Note that, the set time T1 to be set in step S2 is variable in accordance with actual connecting pipe paths of the hot water storage system 100 or pumps used in the hot water storage system 100, and the set time T1 in Embodiment 1 is set to a range from 60 to 180 seconds inclusive. The reasons for setting the set time T1 to the range will be explained below.

[0039] First, the lower limit (60 seconds) of the range of the set time T1 is based on the following two reasons.

[0040] As a first reason, it is observed that, in a case where a three-way valve is connected to a connection pipe of the heat pump hot water dispenser as illustrated in Fig. 8 (c) or in a case where two or more two-way valves are connected to a connection pipe of the heat pump hot water dispenser as illustrated in Fig. 8 (d), a temporary decrease in flow rate occurs as illustrated in Fig. 9 when the valve is operated for switching flow paths, and the flow rate detection unit 40 may detect water supply disruption, and the detection duration of the decrease in flow rate is less than 60 seconds. Therefore, when the lower limit of the range of the set time T1 is set to 60 seconds, an erroneous determination of a temporary de-

crease in flow rate in the valve operation of the three-way valve or the two-way valves as a water supply disruption condition can be controlled.

[0041] Furthermore, as a second reason, there is a case where the flow rate detection unit 40 operates incorrectly due to the effect of noise or the like, and consequently the flow rate cannot be detected temporarily and a decrease in flow rate cannot be detected. In such a case, the duration of detection of the decrease in flow rate is less than 60 seconds.

[0042] For these two reasons, the lower limit of the range of the set time T1 is set to 60 seconds.

[0043] Next, the upper limit (180 seconds) of the range of the set time T1 is based on the following reason.

[0044] If a pump (e.g., a hot water supply pump 7 or a water supply pump 36) embedded in the hot water dispenser 30 or used in the hot water storage system 100 using the hot water dispenser 30 continues the operation in a water supply disruption condition, a cooling effect of the pump by the fluid cannot be obtained. Fig. 5 illustrates a graph indicating an example of the relationship between the temperature of a pump and the elapsed time of the operation and indicating a case where the pump is operated under a condition where the flow rate is lower than a threshold. As illustrated in Fig. 5, as the operation time of the pump in a low flow rate condition elapses, the temperature of a component (e.g., a shaft or a substrate) embedded in the pump rises, and the component may be overheated above an operation guarantee temperature and may be damaged thereby. Therefore, as the maximum time for securing a margin (e.g., twice) with respect to a time (e.g., 360 seconds in Fig. 5) until the temperature of a component embedded in the pump reaches the operation guarantee temperature, the upper limit of the range of the set time T1 is set to 180 seconds.

[0045] For the reasons above, the range of the set time T1 is set to between 60 and 180 seconds inclusive. The set time T1 is set in the range of 60 to 180 seconds in the control unit 60 by a maintenance person or the like. The setting of the set time T1 in the control unit 60 is made by an arbitrary configuration, such as rewriting a program that the CPU of the control unit 60 executes or switching a signal to the control unit 60 by using an operation switch not shown.

[0046] The explanations for Fig. 3 will resume.

[0047] In step S3 of Fig. 3, the control unit 60 allows the notification unit 62 to notify that abnormal water supply disruption is detected. In addition, for protection of the devices such as the water supply pump 36 and the compressor 51, the control unit 60 suspends operations of these devices. A suspension method may be a method in which an instruction is directly output to each device from the control unit 60 or a method of suspending via another device. For example, the compressor 51 may be provided with a high-pressure cutout device, and is suspended via the high-pressure cutout device.

[0048] Furthermore, as described above, the flow rates of the water flowing in the refrigerant-water heat ex-

changer 52 are stored periodically (e.g., every 30 seconds) in the memory unit 61. When the low flow rate condition continues for the set time T1 (180 seconds) or longer, and the control unit 60 determines the condition as abnormal water supply disruption and suspends the operation of the hot water dispenser 30, the control unit 60 stores the last ten flow rates, for example, detected before the operation suspension and stored in the memory unit 61, separately in the memory unit 61 as abnormal data (step S4). That is, in Embodiment 1, the control unit 60 and the memory unit 61 function as a recording unit of the present invention.

[0049] As described above, the control unit 60 is configured to determine whether or not water supply disruption is occurring according to the duration of a low flow rate condition when the flow rate detection unit 40 detects the decrease in flow rate, and therefore an erroneous detection of water supply disruption caused by determining a temporary low flow rate condition as water supply disruption can be controlled. A temporary low flow rate condition is not determined as water supply disruption, and therefore, even when a temporary decrease in flow rate occurs, the subsequent operation of the hot water dispenser 30 can be performed without any trouble within a range where a pump used in the hot water storage system 100 is not damaged. In addition, the control unit 60 properly determines whether or not abnormal water supply disruption is occurring according to the duration of a detected decrease in flow rate when the flow rate detection unit 40 detects the decrease in flow rate, and therefore abnormal water supply disruption can be detected in a repeatable condition.

[0050] Furthermore, in Embodiment 1, when the operation of the hot water dispenser 30 is suspended due to the determination of abnormal water supply disruption, the flow rates detected by the flow rate detection unit 40 before the suspension are recorded as abnormal data. Therefore, a maintenance person can check afterward whether the cause of the abnormal suspension of the heat pump hot water dispenser is water supply disruption, thereby facilitating cause analysis of the abnormal suspension.

Embodiment 2

[0051] Embodiment 1 explains an example of operation for suspending the operation of the hot water dispenser 30 when abnormal water supply disruption is detected.

[0052] The abnormal water supply disruption may be caused by a configuration related to the conveyance of water from the hot water tank 1 to the hot water dispenser 30, such as a case where a water level 70 in the hot water tank 1 is lower than the connection portion of the water inflow pipe 31, as illustrated in Fig. 6, or a case where the valve body 33 is failed. If the operation of the hot water dispenser 30 is suspended in such a case, the operation for storing hot water in the hot water tank 1 is

suspended, and thereby shortage of hot water is caused and therefore the user may feel inconvenience. Furthermore, if a condition where a water level in the hot water tank 1 is lower than the connection portion of the water inflow pipe 31 or a condition where the valve body 33 is failed is the cause of the abnormal water supply disruption, the operation of the hot water dispenser 30 itself does not have any trouble, and the hot water dispenser 30 may operate without problems when water supplied from the water receiving tank 3 is supplied to the hot water dispenser 30.

[0053] In Embodiment 2, operation of the hot water dispenser 30 for solving such problems will be explained. In Embodiment 2, differences from Embodiment 1 will be mainly explained.

[0054] Fig. 6 is a pipe circuit diagram illustrating a hot water storage system 100 of Embodiment 2 of the present invention. Fig. 6 shows a water level 70 in a hot water tank 1 for explanation; however, the configuration of the hot water storage system 100 illustrated in Fig. 6 is the same as the configuration of Fig. 1, and a temperature sensor 2, although not being shown, is provided to the hot water storage system 100 of Fig. 6 as with the case of Fig. 1.

[0055] Fig. 7 is a flowchart explaining operation of a hot water dispenser 30 of Embodiment 2 of the present invention. As with a case of Embodiment 1, a control unit 60 of Embodiment 2 has at least two operation modes, as operation modes of the hot water dispenser 30, of a circulation mode in which water is circulated between the hot water dispenser 30 (refrigerant-water heat exchanger 52) and the hot water tank 1, and of a hot water storage mode in which hot water heated by the hot water dispenser 30 is stored in the hot water tank 1. The operation will be explained below with reference to Fig. 7.

[0056] When the control unit 60 starts operation of the hot water dispenser 30 (step S10), the control unit 60 determines whether the operation mode is a circulation mode or not, that is, determines whether the operation mode is a hot water storage mode or not (step S11). When the hot water dispenser 30 is in a circulation mode (YES in S11), the process proceeds to step S15, or when the hot water dispenser 30 is in a hot water storage mode (NO in S11), the process proceeds to step S12.

[0057] In step S12, when a flow rate detection unit 40 detects a decrease in flow rate, the control unit 60 determines whether or not a low flow rate condition continues for a set time T1 (180 seconds in Embodiment 2) or longer. When the low flow rate condition continues for less than the set time T1 (180 seconds) (YES in step S12), the control unit 60 does not determine the condition as abnormal water supply disruption, and returns to step S10 to continue the operation. Meanwhile, when the low flow rate condition continues for the set time T1 (180 seconds) or longer (NO in step S12), the control unit 60 determines that water supply disruption occurs, and the process proceeds to step S13.

[0058] In step S13, the control unit 60 allows a noti-

cation unit 62 to notify that abnormal water supply disruption is detected. In addition, for protection of the devices such as a water supply pump 36 and a compressor 51, the control unit 60 suspends operations of these devices. A suspension method may be a method in which an instruction is directly output to each device from the control unit 60 or a method of suspending via another device. For example, the compressor 51 may be provided with a high-pressure cutout device, and is suspended via the high-pressure cutout device. In Embodiment 2, when water supply disruption is detected during operation in the hot water storage mode, the operation of the hot water dispenser 30 is suspended as with a case of Embodiment 1.

[0059] Furthermore, as described in Embodiment 1, the flow rates of the water flowing in a refrigerant-water heat exchanger 52 are stored periodically (e.g., every 30 seconds) in a memory unit 61, and the control unit 60 stores the last ten flow rates, for example, detected before the operation suspension of the hot water dispenser 30 and stored in the memory unit 61, separately in the memory unit 61 as abnormal data (step S14). That is, in Embodiment 2, the control unit 60 and the memory unit 61 function as a recording unit of the present invention.

[0060] In step S15, when the flow rate detection unit 40 detects a decrease in flow rate, the control unit 60 determines whether or not a low flow rate condition continues for a set time T1 (180 seconds). When the low flow rate condition continues for less than the set time T1 (180 seconds) (YES in step S15), the control unit 60 does not determine the condition as abnormal water supply disruption, and returns to step S10 to continue the operation. Meanwhile, when the low flow rate condition continues for the set time T1 (180 seconds) or longer (NO in step S15), the process proceeds to step S16.

[0061] In step S16, the control unit 60 allows a notification unit 62 to notify that abnormal water supply disruption is detected during operation in the circulation mode. In addition, for protection of the devices such as a water supply pump 36 and a compressor 51, the control unit 60 suspends operations of these devices. A suspension method may be a method in which an instruction is directly output to each device from the control unit 60 or a method of suspending via another device. For example, the compressor 51 may be provided with a high-pressure cutout device, and is suspended via the high-pressure cutout device.

[0062] Furthermore, as described in Embodiment 1, the flow rates of the water flowing in a refrigerant-water heat exchanger 52 are stored periodically (e.g., every 30 seconds) in a memory unit 61, and the control unit 60 stores the last ten flow rates, for example, detected before the operation suspension of the hot water dispenser 30 and stored in the memory unit 61, separately in the memory unit 61 as abnormal data (step S17).

[0063] After step S17, the control unit 60 waits until a wait time T2 (e.g., 200 seconds) elapses, and then, while not allowing operation in the circulation mode, allows and

starts operation in the hot water storage mode (step S18), and the process proceeds to step S19. At this time, the notification unit 62 keeps notifying that the water supply disruption condition is detected during operation in the circulation mode. Note that, the value (200 seconds) of the wait time T2 in step S18 is an example, and the value is set to a time period that is enough for cooling a device (e.g., water supply pump 36 or compressor 51) which is heated due to the water supply disruption down to a temperature at which operation of the device can be performed without any troubles.

[0064] In step S19, when the flow rate detection unit 40 detects a decrease in flow rate, the control unit 60 determines whether or not a low flow rate condition continues for 180 seconds while performing the operation in the hot water storage mode. When the low flow rate condition continues for less than the set time T1 (180 seconds) (YES in step S19), the control unit 60 does not determine the condition as abnormal water supply disruption, and continues the operation in the hot water storage mode in step S19. Meanwhile, when the low flow rate condition continues for the set time T1 (180 seconds) or longer (NO in step S19), the control unit 60 determines the condition as abnormal water supply disruption, and the process proceeds to step S13.

[0065] As described above, in Embodiment 2, the control unit 60 is configured to determine whether or not water supply disruption is occurring according to the duration of a low flow rate condition when the flow rate detection unit 40 detects the decrease in flow rate, and therefore the same advantages as in Embodiment 1 can be attained.

[0066] In addition, in Embodiment 2, even when water supply disruption is detected during operation in the circulation mode, in which hot water stored in the hot water tank 1 is circulated and heated in the hot water dispenser 30, and the operation of the hot water dispenser 30 is suspended, operation in the hot water storage mode, in which hot water heated by the hot water dispenser 30 is stored in the hot water tank 1, can be performed.

[0067] Note that, in Embodiments 1 and 2, examples in which the hot water dispenser 30 is applied to the hot water storage system 100 having the hot water tank 1 are explained. However, hot water may be directly supplied to a faucet from the hot water dispenser 30 without flowing through the hot water tank 1. Furthermore, numerical values used in the explanations in Embodiments 1 and 2 are merely examples, and the present invention is not limited to the values. Reference Signs List

[0068] 1 hot water tank 2 temperature sensor 3 water receiving tank 4 water supply pipe 5 water supply valve 6 hot water supply pipe 7 hot water supply pump 8 return pipe 30 heat pump hot water dispenser 31 water inflow pipe 31 a water inflow pipe 32 water outflow pipe 33 valve body 34 valve body 35 valve body 36 water supply pump 40 flow rate detection unit 50 heat pump cycle device 51 compressor 52 refrigerant-water heat exchanger 53 pressure reducing device 54 evaporator 55 refrigerant

inflow pipe 56 refrigerant outflow pipe 60 control unit 61 memory unit 62 notification unit 100 hot water storage system

Claims

1. A heat pump hot water dispenser comprising:

a heat pump cycle device connecting at least a compressor, a refrigerant-water heat exchanger, a pressure reducing device, and an evaporator by pipes, the refrigerant-water heat exchanger being configured to allow refrigerant and water to exchange heat;
a flow rate detection unit for detecting a flow rate of water flowing through the refrigerant-water heat exchanger; and
a control unit for controlling operation of the heat pump cycle device,
the control unit being configured to determine an occurrence of abnormal water supply disruption and suspend the operation of the heat pump cycle device when a flow rate of water detected by the flow rate detection unit continues to be lower than a threshold for a set time period or longer.

2. The heat pump hot water dispenser of claim 1 further comprising a recording unit for recording, as abnormal data, a flow rate of water flowing through the refrigerant-water heat exchanger detected by the flow rate detection unit before operation of the heat pump cycle device is suspended, when a flow rate of water detected by the flow rate detection unit continues to be lower than the threshold for the set time period or longer, and the operation of the heat pump cycle device is suspended.

3. The heat pump hot water dispenser of claim 1 or 2, wherein the set time period is variable.

4. The heat pump hot water dispenser of any one of claims 1 to 3,
wherein the control unit has, as operation modes of the heat pump cycle device, a circulation mode in which water is circulated between a hot water tank for storing water that exchanges heat with refrigerant at the refrigerant-water heat exchanger and the refrigerant-water heat exchanger, and a hot water storage mode in which water that exchanges heat with refrigerant at the refrigerant-water heat exchanger is stored in the hot water tank, and
wherein after the control unit determines an occurrence of abnormal water supply disruption while the heat pump cycle device is operating in the circulation mode, the control unit switches the circulation mode to the hot water storage mode.

5. The heat pump hot water dispenser of claim 4 further comprising a notification unit for issuing a notification of abnormal water supply disruption when the control unit determines an occurrence of the abnormal water supply disruption, and for continuing the notification of the abnormal water supply disruption even after the circulation mode is switched to the hot water storage mode. 5
6. The heat pump hot water dispenser of any one of claims 1 to 4 further comprising a notification unit for issuing a notification of abnormal water supply disruption when the control unit determines an occurrence of the abnormal water supply disruption. 10 15
7. The heat pump hot water dispenser of any one of claims 1 to 6, wherein the set time period is from 60 to 180 seconds.
8. A hot water storage system comprising: 20
- the heat pump hot water dispenser of any one of claims 1 to 7; and
- a hot water tank for storing water that exchanges heat with refrigerant at the refrigerant-water heat exchanger provided to the heat pump hot water dispenser. 25

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FIG. 1

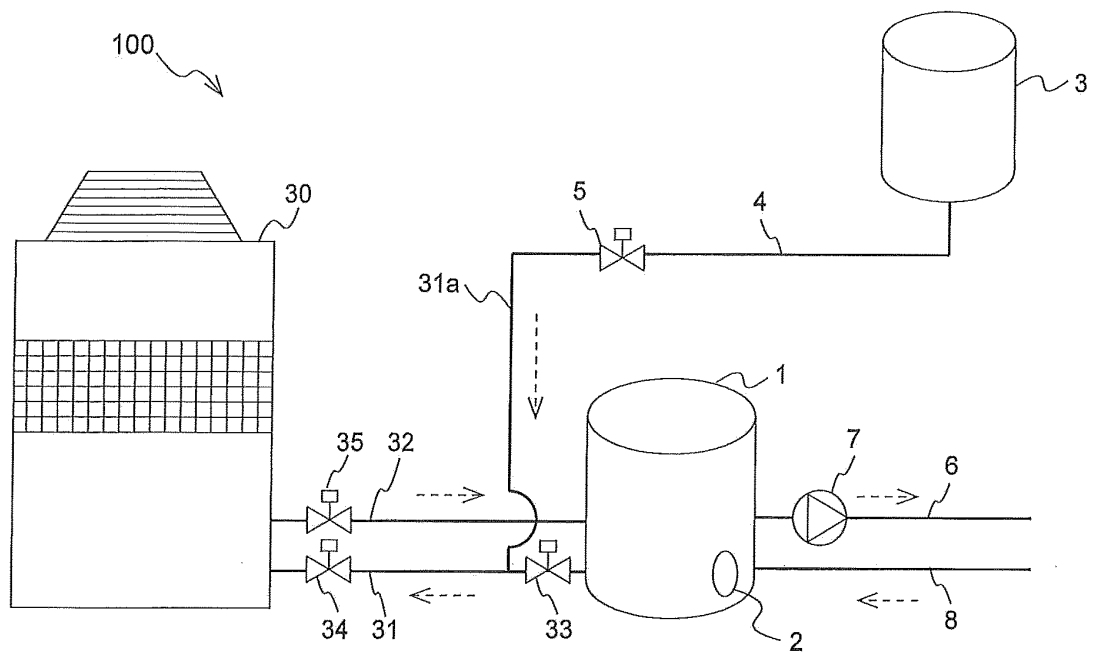


FIG. 2

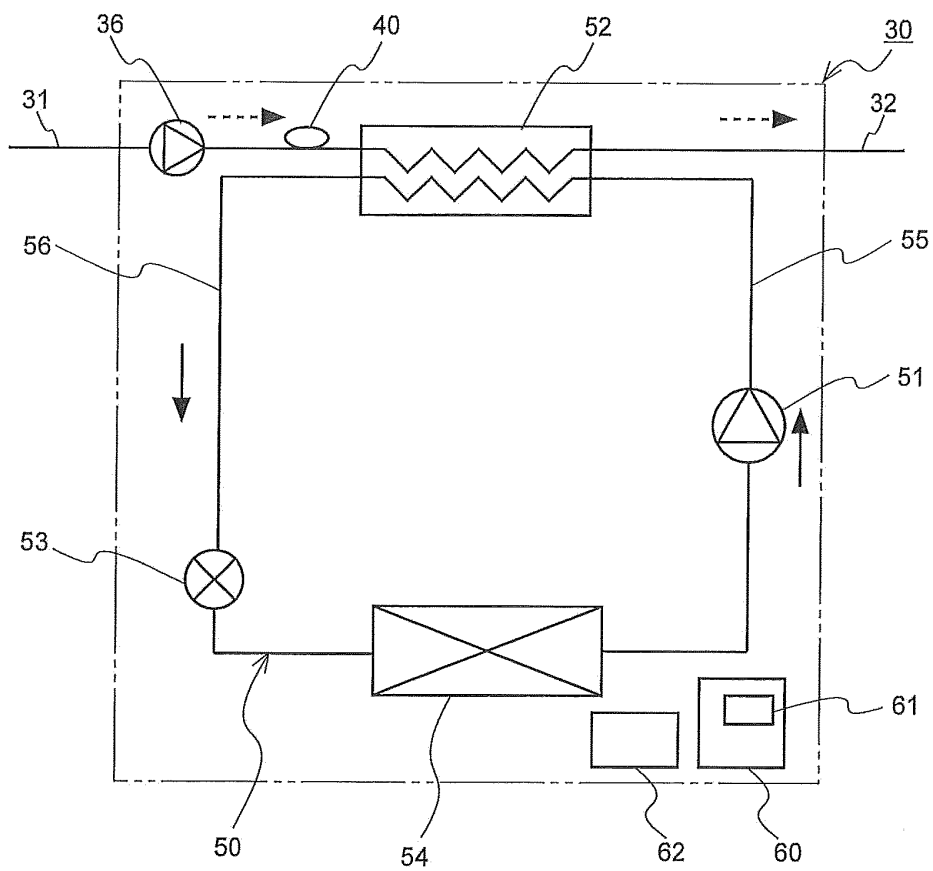


FIG. 3

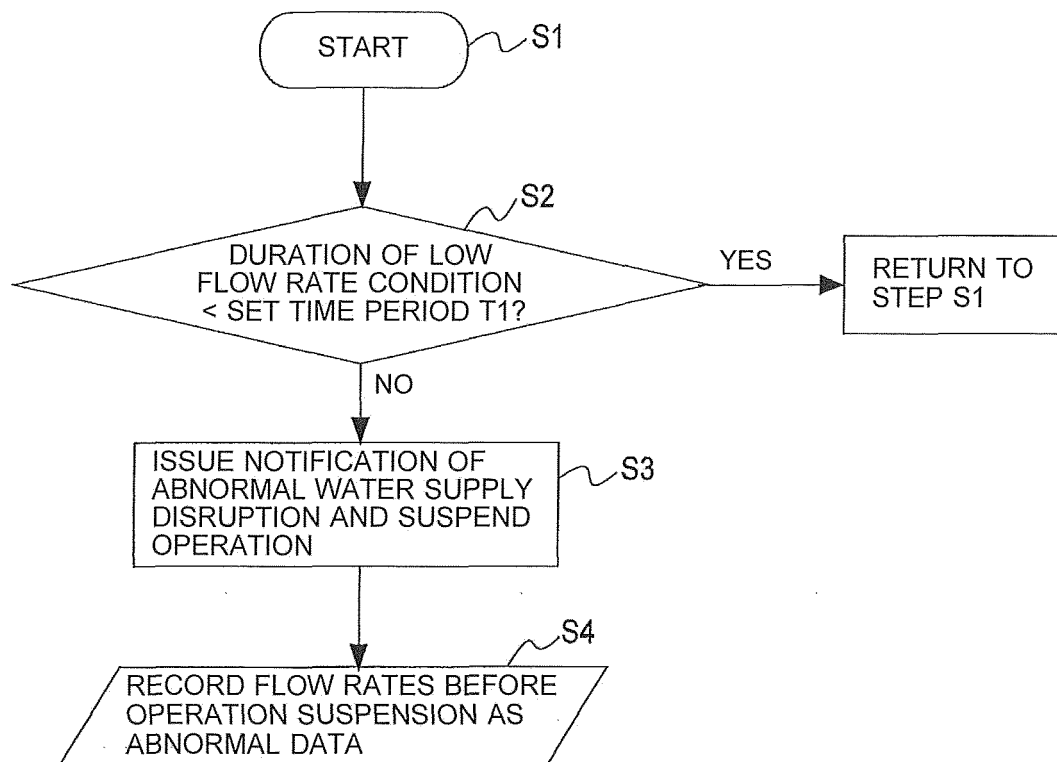


FIG. 4

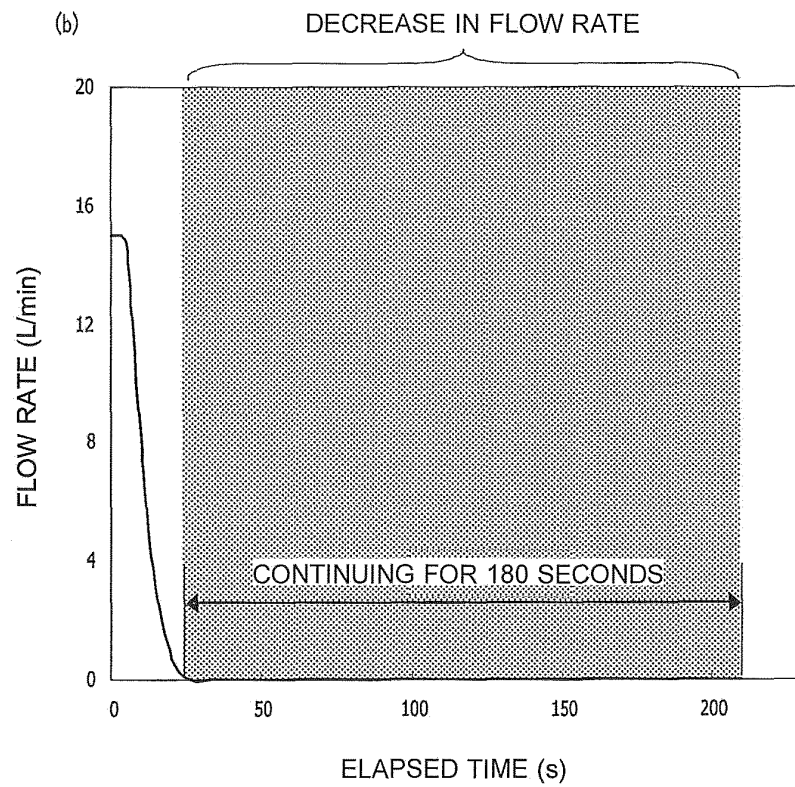
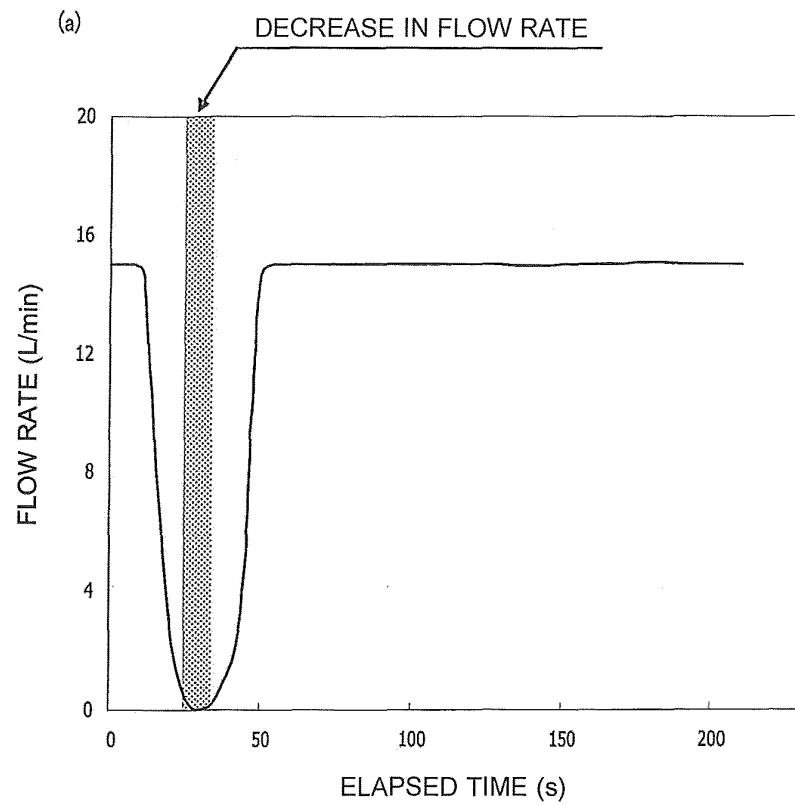


FIG. 5

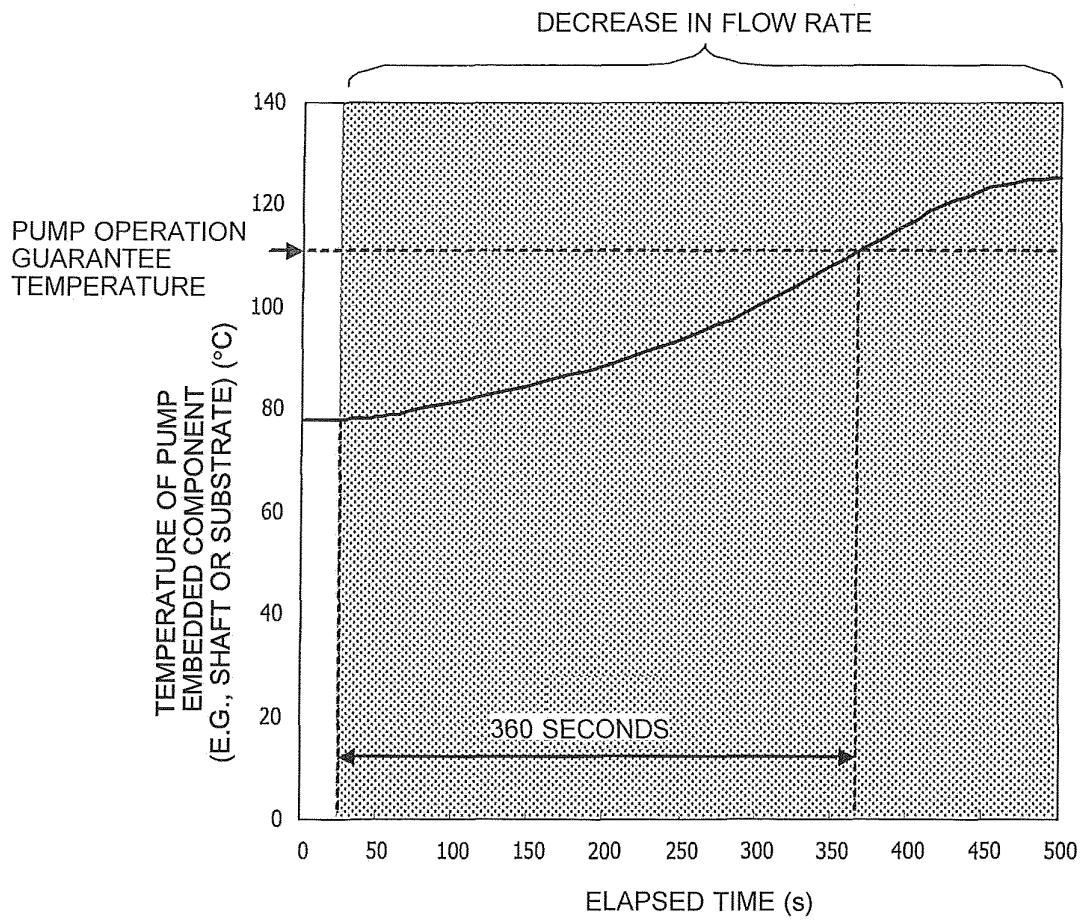


FIG. 6

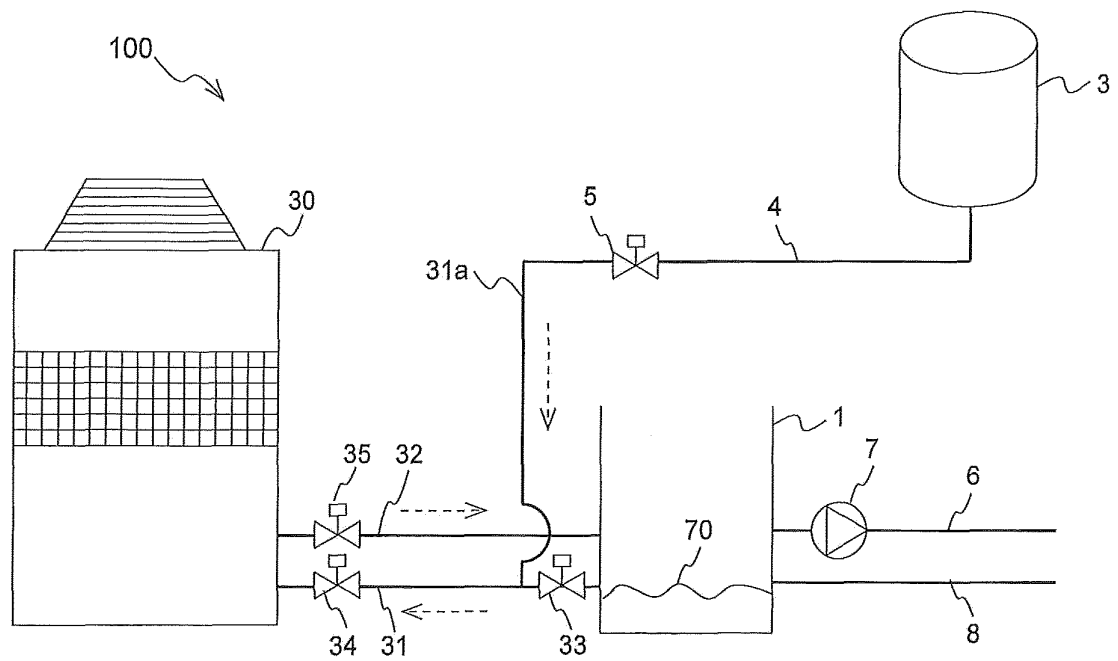


FIG. 7

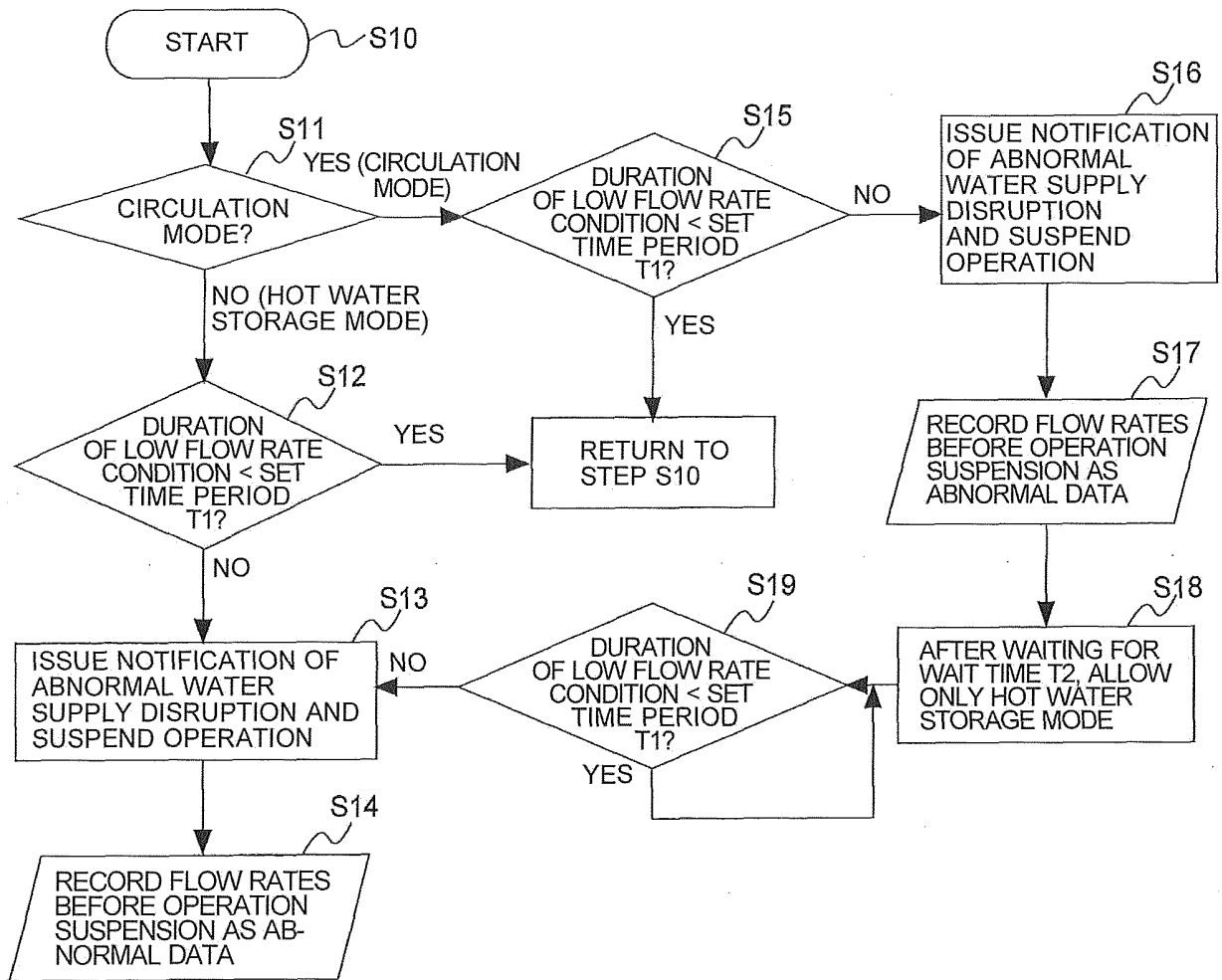


FIG. 8

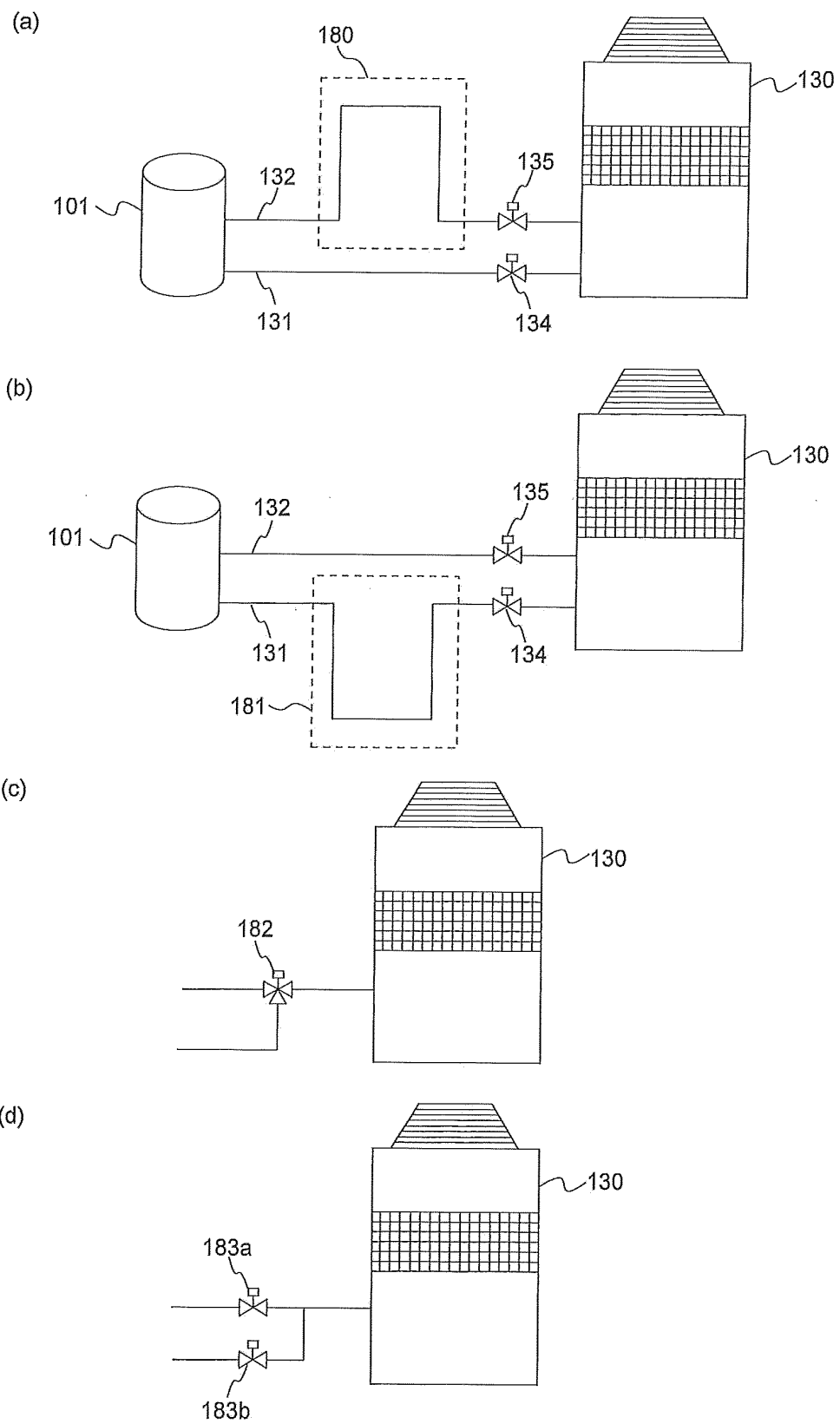
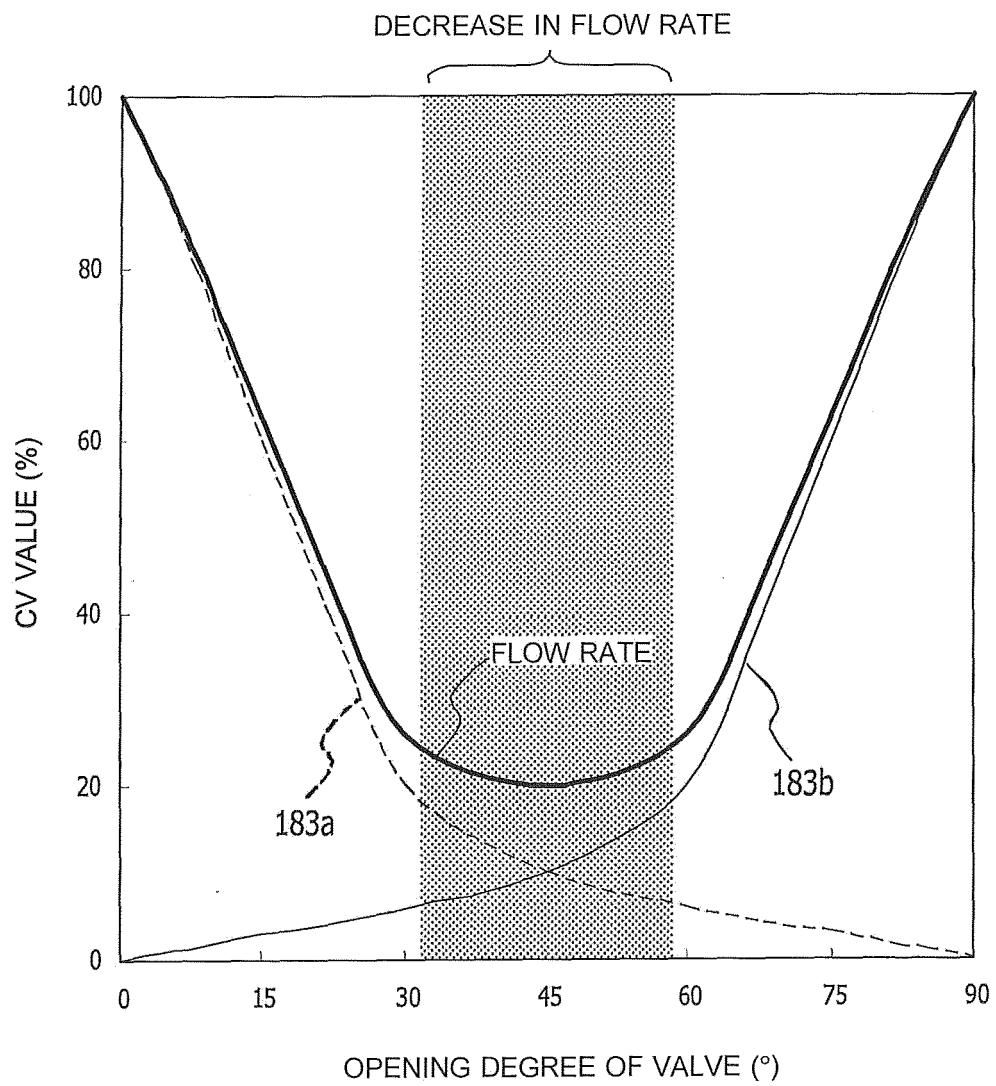


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/062452

A. CLASSIFICATION OF SUBJECT MATTER

F24H1/00 (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)

F24H1/00

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	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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 2011-220676 A (Mitsubishi Electric Corp.), 04 November 2011 (04.11.2011), entire text (Family: none)	1-3, 6-8 4, 5
Y A	JP 2006-274873 A (Noritz Corp.), 12 October 2006 (12.10.2006), entire text (Family: none)	1-3, 6-8 4, 5
A	JP 2009-257707 A (Mitsubishi Electric Corp.), 05 November 2009 (05.11.2009), entire text (Family: none)	1-8

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

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Date of the actual completion of the international search
10 June, 2013 (10.06.13)Date of mailing of the international search report
18 June, 2013 (18.06.13)Name and mailing address of the ISA/
Japanese Patent Office

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Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/062452

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2012/049820 A1 (Mitsubishi Electric Corp.), 19 April 2012 (19.04.2012), entire text & JP 2012-83084 A	1-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- JP 7229653 A [0007]