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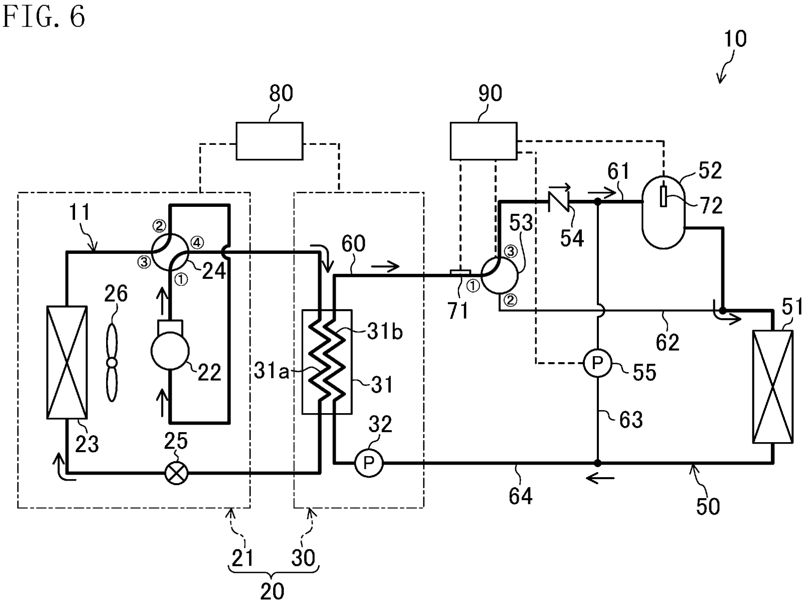
# (54) HEATING DEVICE

(57) Disclosed herein is a heating device including a controller (90) configured to switch operation modes of the heating device from a first mode to a second mode, or vice versa. The first mode of operation includes an operation of allowing, while a heat source unit (20) is running, a heating medium heated by a heating heat exchanger (31) to flow through a heat storage tank (52) and then return to the heating heat exchanger (31). The second mode of operation includes an operation of allowing, while the heat source unit (20) is not running, the heating medium in the heat storage tank (52) to flow through an air-heating heat exchanger (51), be bypassed around the heating heat exchanger (31), and then return to the heat storage tank (52).

FIG. 6

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## Description

### TECHNICAL FIELD

**[0001]** The present invention generally relates to a heating device configured to heat room air, and more particularly relates to a heating device with a heat storage tank.

### BACKGROUND ART

**[0002]** Heating devices for heating room air have been well known in the art. For example, Patent Document 1 discloses an exemplary heating device of this type which includes a heat source unit and a heat storage tank and which heats room air with hot water subjected to heat storage by the heat storage tank.

**[0003]** More specifically, the heating device includes: a heat source unit including a refrigerant circuit in which a compressor and other members are connected together; and a circulation circuit connected to a heating heat exchanger of the heat source unit. The heat storage tank and an air-heating heat exchanger are connected together in the circulation circuit.

**[0004]** This heating device performs a mode of operation of storing hot water in the heat storage tank (hereinafter referred to as a "heat storage mode of operation") as shown in FIGS. 1 and 2 and a mode of operation of using the hot water stored in the heat storage tank for heating room air (hereinafter referred to as a "heat radiation mode of operation") as shown in FIG. 3 while switching the operation modes from the former to the latter, or vice versa. Specifically, during the heat storage mode of operation shown in FIGS. 1 and 2, a refrigeration cycle is performed by the refrigerant circuit, and a pump of the circulation circuit is operated. In the circulation circuit, the water transferred to the pump is heated by the refrigerant of the heating heat exchanger. The hot water thus heated is stored in the heat storage tank. On the other hand, during the heat radiation mode of operation shown in FIG. 3, the pump is operated in the circulation circuit while the heat source unit stops running. In the circulation circuit, the hot water of the heat storage tank flows through the air-heating heat exchanger (radiator) and is used for heating the room air. This hot water flows through the heating heat exchanger in the non-running state and then is returned to the heat storage tank.

### CITATION LIST

### PATENT DOCUMENT

**[0005]** PATENT DOCUMENT 1: Japanese Unexamined Patent Publication No. 2012-13346

### SUMMARY OF INVENTION

### TECHNICAL PROBLEM

**[0006]** According to Patent Document 1, while the heat radiation mode of operation is being performed, the heating medium (i.e., hot water) in the heat storage tank is returned to the heat storage tank via the heating heat exchanger. Thus, during the heat radiation mode of operation, the pressure loss caused on the flow channel of the heating medium flowing increases so much as to cause a significant rise in the power to be consumed to operate the pump, which is not beneficial.

**[0007]** It is therefore an object of the present invention to reduce such an increase in the pressure loss caused on the flow channel of the heating medium during the mode of operation in which the heating medium stored in the heat storage tank is used to heat room air.

### SOLUTION TO THE PROBLEM

**[0008]** A first aspect of the present invention is directed to a heating device comprising: a heat source unit (20) including a heating heat exchanger (31); and a circulation circuit (50) in which an air-heating heat exchanger (51) and a heat storage tank (52) are connected together and through which a heating medium heated by the heating heat exchanger (31) circulates. The heating device further includes a controller (90) configured to switch operation modes of the heating device from a first mode to a second mode, or vice versa. The first mode of operation includes an operation of allowing, while the heat source unit (20) is running, the heating medium heated by the heating heat exchanger (31) to flow through the heat storage tank (52) and then return to the heating heat exchanger (31). The second mode of operation includes an operation of allowing, while the heat source unit (20) is not running, the heating medium in the heat storage tank (52) to flow through the air-heating heat exchanger (51), be bypassed around the heating heat exchanger (31), and then return to the heat storage tank (52).

**[0009]** The heating device according to the first aspect of the present invention is instructed by the controller (90) to selectively perform the first mode of operation or the second mode of operation while switching the operation modes from one to the other. The first mode of operation is performed while the heat source unit (20) is running. On the other hand, the second mode of operation is performed while the heat source unit (20) is not running. During the first mode of operation, the heating medium heated by the heating heat exchanger (31) flows through the heat storage tank (52) and then returns to the heating heat exchanger (31). Thus, hot water will be stored in this manner in the heat storage tank (52). During the second mode of operation, the heating medium in the heat storage tank (52) flows through the air-heating heat exchanger (51), is bypassed around the heating heat exchanger (31), and then returns to the heat storage tank

(52). As a result, the heat stored in the heat storage tank (52) may be used for heating room air. Since the heating medium is bypassed around the heating heat exchanger (31) during this second mode of operation, the pressure loss caused on the flow channel of the heating medium may be reduced compared to the conventional configuration.

**[0010]** A second aspect of the invention is an embodiment of the first aspect of the invention. In the second aspect, the controller (90) is configured to instruct the heating device to perform alternately and repeatedly a first operation and a second operation during the first mode of operation. The first operation is allowing, while the heat source unit (20) is running, the heating medium heated by the heating heat exchanger (31) to be bypassed around the heat storage tank (52), flow through the air-heating heat exchanger (51), and then return to the heating heat exchanger (31). The second operation is allowing, while the heat source unit (20) is running, the heating medium heated by the heating heat exchanger (31) to flow through both the heat storage tank (52) and the air-heating heat exchanger (51) and then return to the heating heat exchanger (31).

**[0011]** According to the second aspect of the present invention, during the first mode of operation, the first and second operations are performed alternately and repeatedly. These operations are performed while the heat source unit (20) is running. In the first operation, the heating medium heated by the heating heat exchanger (31) is allowed to be bypassed around the heat storage tank (52), and flow through the air-heating heat exchanger (51). As a result, the heat of the refrigerant flowing through the heating heat exchanger (31) is used for heating room air. In the second operation, the heating medium heated by the heating heat exchanger (31) is allowed to flow through both the heat storage tank (52) and the air-heating heat exchanger (51). Consequently, hot water will be stored in this manner in the heat storage tank (52). During this second operation, the quantity of heat radiated by the heating medium flowing through the air-heating heat exchanger (51) decreases compared to during the first operation. According to the present invention, however, the first and second operations are performed alternately and repeatedly during the first mode of operation, and therefore, the heating capacity of the air-heating heat exchanger (51) does not deteriorate so significantly during the first mode of operation. Thus, during the second mode of operation, hot water may be stored in the heat storage tank (52) with the heating capacity of the air-heating heat exchanger (51) maintained at a relatively high level.

**[0012]** A third aspect of the invention is an embodiment of the second aspect of the invention. In the third aspect, the circulation circuit (50) includes: a first flow channel (61) leading from an outlet of the heating heat exchanger (31) to an inlet of the air-heating heat exchanger (51); a second flow channel (62) provided in parallel with the first flow channel (61) and connected to the heat storage tank (52); a third flow channel (63) leading from an outlet of the air-heating heat exchanger (51) to a point on the second flow channel (62) upstream of the heat storage tank (52); a flow channel switching mechanism (53) configured to allow the outlet of the heating heat exchanger (31) to communicate with the first flow channel (61) during the first operation and communicate with the second flow channel (62) during the second operation; and a pump (55) connected to the third flow channel (63) and operated during the second mode of operation.

**[0013]** According to the third aspect of the present invention, a mechanism for carrying out the first and second modes of operation is provided. In the first operation, the outlet of the heating heat exchanger (31) communicates with the first flow channel (61). As a result, the heating medium heated by the heating heat exchanger (31) is bypassed around the heat storage tank (52) and flows into the air-heating heat exchanger (51). In the second operation, on the other hand, the outlet of the heating heat exchanger (31) communicates with the second flow channel (62). Consequently, the heating medium heated by the heating heat exchanger (31) flows into the air-heating heat exchanger (51) via the heat storage tank (52). Also, during the second mode of operation, the pump (55) connected to the third flow channel (63) is operated. Thus, the heating medium that has flowed out of the air-heating heat exchanger (51) is bypassed around the heating heat exchanger (31) and flows into the heat storage tank (52).

**[0014]** A fourth aspect of the invention is an embodiment of the second or third aspect of the invention. In the fourth aspect, the heating device further includes a temperature sensor (71) configured to sense a temperature of the heating medium on the outlet side of the heating heat exchanger (31). The controller (90) instructs the heating device to perform the first mode of operation if the temperature of the heating medium sensed by the temperature sensor (71) becomes greater than a predetermined value.

**[0015]** According to the fourth aspect of the present invention, the temperature sensor (71) senses the temperature of the heating medium on the outlet side of the heating heat exchanger (31). If this temperature becomes greater than a predetermined value, the room air may be heated, and hot water may be generated in the heat storage tank (52), with this heating medium used. Thus, if the temperature of the heating medium sensed by the temperature sensor (71) becomes greater than a predetermined value, the controller (90) instructs the heating device to perform the first mode of operation. As a result of the first mode of operation, hot water will be stored in the heat storage tank (52) while the room air is being heated.

**[0016]** A fifth aspect of the invention is an embodiment of the fourth aspect of the invention. In the fifth aspect, the controller (90) is configured to instruct the heating device to perform the second mode of operation if the temperature of the heating medium sensed by the temperature sensor (71) becomes less than a predetermined value during the first mode of operation.

**[0017]** According to the fifth aspect of the present invention, the temperature sensor (71) senses the temperature of the heating medium on the outlet side of the heating heat exchanger (31). If this temperature becomes less than the predetermined value during the first mode of operation, then a determination may be made that the heat source unit (20) has stopped running. Thus, if the temperature of the heating medium sensed by the temperature sensor (71) becomes less than the predetermined value, the controller (90) instructs the heating device to perform the second mode of operation. As a result, the room air may be heated continuously with the hot water stored in the heat storage tank (52).

**[0018]** A sixth aspect of the invention is an embodiment of the fifth aspect of the invention. In the sixth aspect, the heating device further includes an in-tank temperature sensor (72) configured to sense a temperature of the heating medium in the heat storage tank (52). The controller (90) is configured to increase a ratio of the duration of the first operation to the duration of the second operation if the temperature sensed by the in-tank temperature sensor (72) becomes greater than a predetermined value during the first mode of operation.

**[0019]** According to the sixth aspect of the present invention, the in-tank temperature sensor (72) senses the temperature of the heating medium in the heat storage tank (52). If this temperature becomes greater than a predetermined value during the first mode of operation, then a determination may be made that hot water having a sufficiently high temperature has been stored in the heat storage tank (52). Thus, if the temperature sensed by the in-tank temperature sensor (72) becomes greater than the predetermined value, the controller (90) increases the ratio of the duration of the first operation to that of the second operation. Then, the first operation of transferring the heating medium heated to the air-heating heat exchanger (51) with the heating medium bypassed around the heat storage tank (52) may be performed for a longer duration, thus improving the heating capacity. Meanwhile, although the second operation is performed for a shorter duration as a result, there is no problem even if the operation modes are switched to the second operation mode after that, because hot water having a sufficiently high temperature has already been stored in the heat storage tank (52).

## ADVANTAGES OF THE INVENTION

**[0020]** According to the present invention, since the heating medium is bypassed around the heating heat exchanger (31) while circulating during the second mode of operation, the pressure loss caused on the flow channel of the heating medium may be reduced. As a result, the power to be consumed to operate a pump in order to circulate the heating medium may be cut down, thus contributing to energy saving. In addition, the dissipation of heat from the heating medium in the heating heat exchanger (31) in the non-running state may be reduced significantly as well.

**[0021]** In addition, according to the present invention, even if the heat source unit (20) is brought into a stop compulsorily to cut down power consumption, the room air may still continue to be heated by the use of the heat stored in the heat storage tank (52).

**[0022]** According to the second aspect of the present invention, the hot water may be stored in the heat storage tank (52) with the heating capacity of the air-heating heat exchanger (51) maintained at a relatively high level. According to the third aspect of the present invention, a circuit may be provided as an implementation of the second aspect of the present invention. Optionally, this circuit may be added afterward to a circulation circuit (50) that has already been installed.

**[0023]** According to the fourth aspect of the present invention, the first mode of operation may be performed automatically based on the temperature sensed by the temperature sensor (71). Meanwhile, according to the fifth aspect of the present invention, the second mode of operation may be performed automatically based on the temperature sensed by the temperature sensor (71). According to the sixth aspect of the present invention, if the heating medium in the heat storage tank (52) has a high temperature, the heating device may be operated with priority given to the room heating capacity.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0024]**

[FIG. 1] FIG. 1 illustrates an overall configuration for an air conditioning system according to an embodiment.

[FIG. 2] FIG. 2 is a piping system diagram illustrating an air conditioner according to an embodiment.

[FIG. 3] FIG. 3 shows a relationship between a feed water temperature, a tank water temperature, and respective operation modes in an air conditioner according to an embodiment.

[FIG. 4] FIG. 4 is a state transition diagram showing how respective operation modes are switched in an air conditioner according to an embodiment.

[FIG. 5] FIG. 5 is a piping system diagram illustrating how an air conditioner according to an embodiment performs a first operation during a heat storage mode of operation.

[FIG. 6] FIG. 6 is a piping system diagram illustrating how an air conditioner according to an embodiment performs a second operation during the heat storage mode of operation.

[FIG. 7] FIG. 7 is a piping system diagram illustrating how an air conditioner according to an embodiment performs a heat radiation mode of operation.

[FIG. 8] FIG. 8(A) is a timing chart showing the respective durations of first and second operations during a first heat storage mode of operation, and FIG. 8(B) is a timing chart showing the respective durations of first and second operations during a second heat storage mode of operation.

DESCRIPTION OF EMBODIMENTS

**[0025]** Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. Note that the following embodiments are only exemplary embodiments in nature and are not intended to limit the scope, application, or uses of the present invention.

**[0026]** As shown in FIG. 1, an air conditioning system (S) according to an embodiment is comprised of a plurality of heat-pump-driven air conditioners (10), each of which functions as a heating device with the ability to heat room air. These air conditioners (10) are provided in a predetermined target area (A). In the target area (A), a power provider (5) issues a request to adjust a power demand to an energy saving manager (aggregator) (6), who in turn issues a request to adjust the power demand to the air conditioners (10) of respective households. That is to say, in the target area (A), the power consumption of the respective air conditioners (10) is restricted by the energy saving manager (6). For example, in the target area (A), the operation of the heat source unit (20) of each of the air conditioners (10) is restricted such that the overall power consumption of the target area (A) does not exceed a predetermined value.

**[0027]** As shown in FIG. 2, each of the air conditioners (10) includes a heat source unit (20) with a refrigerant circuit (11), and a circulation circuit (50). The refrigerant circuit (11)performs a refrigeration cycle by allowing a refrigerant to circulate through itself. The circulation circuit (50) allows water (or hot water) to circulate as a heating medium through itself.

<Heat Source Unit>

**[0028]** The heat source unit (20) is comprised of an outdoor unit (21) and an intermediate unit (30) that are connected together. The outdoor unit (21) is provided outdoors, and includes a compressor (22), an outdoor heat exchanger (23), a four-way switching valve (24), and an expansion valve (25). The intermediate unit (30) includes an intermediate heat exchanger (31) and a circulation pump (32).

**[0029]** The compressor (22) may be configured as a scroll compressor, for example. The outdoor heat exchanger (23) may be implemented as a fin-and-tube heat source side heat exchanger. An outdoor fan (26) is disposed in the vicinity of the outdoor heat exchanger (23). The outdoor heat exchanger (23) exchanges heat between the air blown by the outdoor fan (26) and a refrigerant. The four-way switching valve (24) has first, second, third and fourth ports. Specifically, the first, second, third and fourth ports of the four-way switching valve (24) are respectively connected to an outlet of the compressor (22), an inlet of the compressor (22), a gas-side terminal of the outdoor heat exchanger (23), and a first internal flow channel (31a) of the intermediate heat exchanger (31). The four-way switching valve (24) is configured so as to be switchable between a first state in which the first and fourth ports communicate with each other and the second and third ports communicate with each other (as indicated by the solid curves in FIG. 2) and a second state in which the first and third ports communicate with each other and the second and fourth ports communicate with each other (as indicated by the dashed curves in FIG. 2). The expansion valve (25) may be configured as an electronic expansion valve with an adjustable degree of opening.

**[0030]** The intermediate heat exchanger (31) functions as a heating heat exchanger, and has a first internal flow channel (31a) and a second internal flow channel (31b). The first internal flow channel (31a) is connected to the refrigerant circuit (11), while the second internal flow channel (31b) is connected to the circulation circuit (50). This intermediate heat exchanger (31) exchanges heat between the refrigerant flowing through the first internal flow channel (31a) and the water running through the second internal flow channel (31b).

<Circulation Circuit>

**[0031]** In the circulation circuit (50), the second internal flow channel (31b) of the intermediate heat exchanger (31), the air-heating heat exchanger (51), the heat storage tank (52), and a three-way switching valve (53) are connected together. The air-heating heat exchanger (51) may be configured as a floor heating unit embedded under the floor of a room or a panel heater for heating room air with radiant heat, for example. The heat storage tank (52) may be implemented as a hollow closed container in which hot water is stored. The three-way switching valve (53) has first, second and third ports, and functions as a flow channel switching mechanism. The three-way switching valve (53) is configured to be switchable between a first state in which the first and second ports communicate with each other and the third port is closed (as indicated by the solid curves in FIG. 2) and a second state in which the first and third ports communicate with each other and the second port is closed (as indicated by the dashed curve in FIG. 2).

**[0032]** The circulation circuit (50) is provided with an inflow channel (60), a first divergent flow channel (corresponding to the first flow channel (61)), a second divergent flow channel (corresponding to the second flow channel (62)), an outflow channel (64), and a bypass flow channel (corresponding to the third flow channel (63)).

**[0033]** The flow channel (60) has its inflow end connected to an outflow end of the second internal flow channel (31b) of the intermediate heat exchanger (31), and has its outflow end connected to the first port of the three-way switching valve (53). The first divergent flow channel

(61) has its inflow end connected to the third port of the three-way switching valve (53), and has its outflow end connected to the second divergent flow channel (62). A check valve (54) and the heat storage tank (52) are connected in this order to the first divergent flow channel (61) such that the check valve (54) is located upstream of the heat storage tank (52) (i.e., the heat storage tank (52) is located downstream of the check valve (54)). The check valve (54) allows the refrigerant to flow toward the heat storage tank (52) but prevents the refrigerant from flowing in the opposite direction.

**[0034]** The second divergent flow channel (62) has its inflow end connected to the second port of the three-way switching valve (53) and has its outflow end connected to the inflow end (i.e., the inlet) of the air-heating heat exchanger (51). The outflow channel (64) has its inflow end connected to the outflow end (i.e., the outlet) of the air-heating heat exchanger (51) and has its outflow end connected to the inflow end of the second internal flow channel (31b) of the intermediate heat exchanger (31). The circulation pump (32) is connected to the outflow channel (64).

**[0035]** The bypass flow channel (63) has its inflow end connected to a point on the outflow channel (64) upstream of the circulation pump (32) and has its outflow end connected to a point on the first divergent flow channel (61) between the check valve (54) and the heat storage tank (52). An auxiliary pump (55) is connected to the bypass flow channel (63).

**[0036]** In this embodiment, the first divergent flow channel (61), second divergent flow channel (62), bypass flow channel (63), heat storage tank (52), three-way switching valve (53), and check valve (54) described above are added afterward to a circulation circuit (50) that has already been installed. That is to say, the circulation circuit (50) that has already been installed is configured as a closed circuit in which the inflow channel (60) and the outflow channel (64) are connected between the second internal flow channel (31b) of the intermediate heat exchanger (31) and the air-heating heat exchanger (51). The circulation circuit (50) according to this embodiment may be formed by additionally including the first divergent flow channel (61), second divergent flow channel (62), bypass flow channel (63), heat storage tank (52), three-way switching valve (53), and check valve (54) afterward to this closed circuit.

<Temperature Sensor>

**[0037]** The air conditioner (10) further includes a first temperature sensor (71) and a second temperature sensor (72). The first temperature sensor (71) senses the temperature of water (feed water) running through the inflow channel (60). That is to say, the first temperature sensor (71) functions as a temperature sensor for sensing the temperature of a heating medium on the outlet side of the intermediate heat exchanger (31). The second temperature sensor (72) functions as an in-tank temperature sensor for sensing the temperature of water inside the heat storage tank (52). The first and second temperature sensors (71, 72) are also added afterward to the air conditioner (10) that has already been installed.

<Controller>

**[0038]** As shown in FIGS. 1 and 2, the air conditioner (10) further includes a demand controller (80) and a heat storage controller (90).

**[0039]** The demand controller (80) receives a signal to turn the heat source unit (20) ON/OFF from the energy saving manager (aggregator) (6). On receiving a signal to turn the heat source unit (20) OFF, the demand controller (80) performs control to bring the heat source unit (20) to a stop compulsorily. As a result, in the heat source unit (20), the compressor (22), the outdoor fan (26), and the circulation pump (32) stop running.

**[0040]** The heat storage controller (90) functions as a controller that switches the operation modes from a heat storage operation mode (a first operation mode) to a heat radiation operation mode (a second operation mode), or vice versa, by performing control independently of the demand controller (80). Specifically, during the heat storage mode of operation, the heat storage controller (90) controls the state of the three-way switching valve (53) such that the heating device performs alternately and repeatedly first and second operations. The first operation is allowing the water heated by the intermediate heat exchanger (31) to be bypassed around the heat storage tank (52), flow through the air-heating heat exchanger (51), and then return to the intermediate heat exchanger (31). On the other hand, the second operation is allowing the water heated by the intermediate heat exchanger (31) to flow through both the heat storage tank (52) and the air-heating heat exchanger (51) and then return to the intermediate heat exchanger (31).

**[0041]** The heat storage controller (90) controls the three-way switching valve (53) and the auxiliary pump (55) such that the heating device performs a heat radiation mode of operation in which the hot water in the heat storage tank (52) flows through the air-heating heat exchanger (51), is bypassed around the intermediate heat exchanger (31), and then returns to the heat storage tank (52). In addition, the heat storage controller (90) is also configured such that the heating device performs selectively either the heat storage mode of operation or the heat radiation mode of operation according to the temperatures sensed by the first and second temperature sensors (71, 72). The heat storage controller (90) is added afterward to the air conditioner (10) that has already been provided.

- Operation -

**[0042]** Next, it will be described in detail with reference to FIGS. 3 through 8 exactly how the air conditioner (10) according to this embodiment performs various modes of operation. Specifically, each of the air conditioners (10) is configured to selectively perform a first heat storage mode of operation, a second heat storage mode of operation, or a heat radiation mode of operation according to the temperatures sensed by the two temperature sensors (71, 72) that vary as the operating state of the heat source unit (20) changes.

<Stopped State>

**[0043]** If the heat source unit (20) is in the stopped state, then the compressor (22), the outdoor fan (26), and the circulation pump (32) are also in the stopped state. In this state, if the temperature of the water detected by the first temperature sensor (71) (hereinafter referred to as a "feed water temperature T1") is lower than a predetermined temperature T0 - D (where T0 may be 40°C and D may be 2°C, for example) and if the temperature of the water detected by the second temperature sensor (72) (hereinafter referred to as a "tank water temperature T2") is lower than the predetermined temperature T0 - D (where T0 may be 40°C and D may be 2°C, for example), then the auxiliary pump (55) turns OFF (i.e., stops running) and the three-way switching valve (53) turns into a "normal" state (a first state). In this state, no refrigeration cycle is carried out by the refrigerant circuit (11) and no water circulates, either, through the circulation circuit (50).

<From Stopped State into First Heat Storage Operation Mode>

**[0044]** Suppose the heat source unit (20) in the stopped state makes a state transition to a running state (to perform a heating mode of operation). In that case, a refrigeration cycle is carried out in the refrigerant circuit (11) as shown in FIG. 5. Specifically, the refrigerant compressed by the compressor (22) flows through the first internal flow channel (31a) of the intermediate heat exchanger (31) to dissipate heat (i.e., be condensed) and then has its pressure reduced by the expansion valve (25). Next, the refrigerant that has had its pressure reduced evaporates from the indoor heat exchanger (23) and then is sucked into the compressor (22).

**[0045]** In addition, if the heat source unit (20) in the stopped state makes a state transition to a running state (to perform a heating mode of operation), the circulation pump (32) of the intermediate unit (30) starts running. Then, in the circulation circuit (50), the water flows through the intermediate heat exchanger (31) and exchanges heat with the refrigerant. As a result, the temperature of the water circulating through the circulation circuit (50) rises gradually.

**[0046]** As this mode of operation continues, the feed water temperature T1 rises gradually. Then, when the feed water temperature T1 exceeds T0 + D, the heat storage controller (90) instructs the heating device to start performing a mode of operation in which the state of the three-way switching valve (53) is changed as appropriate (i.e., the first heat storage mode of operation). In this first heat storage mode of operation, the state of the three-way switching valve (53) switches such that the first operation shown in FIG. 5 and the second operation shown in FIG. 6 are performed repeatedly as appropriate (i.e., "short-period switching" is performed). Also, in the first heat storage mode of operation, the auxiliary pump (55) stops running. During the first heat storage mode of operation, the first operation having a duration Δt1 and the second operation having a duration Δt2 are performed alternately and repeatedly as shown in FIG. 8(A).

**[0047]** During the first operation shown in FIG. 5, the water heated in the second internal flow channel (31 b) of the intermediate heat exchanger (31) passes through the inflow channel (60), the three-way switching valve (53), and the second divergent flow channel (62) in this order and is delivered to the air-heating heat exchanger (51). That is to say, in the first operation, the water heated by the intermediate heat exchanger (31) flows through the air-heating heat exchanger (51) such that the water is bypassed around the heat storage tank (52). In the air-heating heat exchanger (51), the hot water is used for heating the room air by radiating heat into the room air. The water that has radiated heat in the air-heating heat exchanger (51) passes through the inflow channel (60) and then returns to the second internal flow channel (31 b) of the intermediate heat exchanger (31).

**[0048]** When a time interval Δt1 passes since the first operation was started, the second operation shown in FIG. 6 starts to be performed. During the second operation, the water heated by the intermediate heat exchanger (31) passes through the inflow channel (60), the three-way switching valve (53), and the first divergent flow channel (61) in this order and is delivered to the heat storage tank (52). That is to say, during the second operation, hot water will be stored in the heat storage tank (52). The water that has flowed out of the heat storage tank (52) flows through the air-heating heat exchanger (51). In the air-heating heat exchanger (51), the hot water is used for heating room air by radiating heat into the room air. The water that has radiated heat in the air-heating heat exchanger (51) passes through the inflow channel (60) and then returns to the second internal flow channel (31b) of the intermediate heat exchanger (31).

**[0049]** When a time interval Δt2 passes since the second operation started to be performed, the first operation shown in FIG. 5 starts to be performed all over again. In this embodiment, while the first heat storage mode of operation is performed, the duration Δt1 of the first operation is set to be as long as the duration Δt2 of the second operation and may be both 30 seconds, for example (see FIG. 8). However, Δt1 and Δt2 may also be durations of mutually different lengths and the ratio of these durations may be changed appropriately according to the operating condition as well.

**[0050]** As can be seen, during the first heat storage mode of operation, the first operation of allowing the hot water heated to be bypassed around the heat storage tank (52) and delivered to the air-heating heat exchanger (51) and the second operation of allowing the hot water heated to be delivered to the air-heating heat exchanger (51) via the heat storage tank (52) are performed alternately. Thus, during the first heat storage mode of operation, the hot water may be stored in the heat storage tank (52) without deteriorating the heating capacity of the air-heating heat exchanger (51) so significantly.

<From First Heat Storage Operation Mode to Second Heat Storage Operation Mode>

**[0051]** As the first heat storage mode of operation is performed continuously for a longer period of time, not only the feed water temperature T1 but also the tank water temperature T2 rise gradually. During the first heat storage mode of operation, when the tank water temperature T2 exceeds T0 + D, the heat storage controller (90) changes the timing of switching the three-way switching valve (53) (i.e., "long-period switching" starts to be performed) such that the second heat storage mode of operation is performed. During the second heat storage mode of operation, the auxiliary pump (55) stops running.

**[0052]** In the second heat storage mode of operation, the ratio of the duration $\Delta t1$ of the first operation to the duration $\Delta t2$ of the second operation is set to be larger than in the first heat storage mode of operation as shown in FIG. 8(B). As a result, during the second heat storage mode of operation, the duration of the first operation is longer than that of the second operation. Consequently, the heating capacity of the air-heating heat exchanger (51) improves substantially.

<From Second Heat Storage Operation Mode to Heat Radiation Operation Mode>

**[0053]** Suppose the heat source unit (20) has stopped running in response to a request from the energy saving manager (6) while the second heat storage mode of operation is being performed. Then, in the heat source unit (20), the compressor (22), the outdoor fan (26), and the circulation pump (32) stop running and the water stops being heated by the intermediate heat exchanger (31). As a result, in the circulation circuit (50), the feed water temperature T1 falls gradually. When the feed water temperature T1 becomes lower than the predetermined temperature T0 - D in this manner during the second heat storage mode of operation, the heat radiation mode of operation shown in FIG. 7 starts to be performed.

**[0054]** During the heat radiation mode of operation shown in FIG. 7, no refrigeration cycle is carried out in the refrigerant circuit (11), and the circulation pump (32) stops running as well. On the other hand, in the heat radiation mode of operation, the auxiliary pump (55) turns ON (i.e., starts running) and the three-way switching valve (53) turns into the "bypass" state (i.e., the second state). As a result, in the circulation circuit (50), the hot water in the heat storage tank (52) flows through the air-heating heat exchanger (51). In the air-heating heat exchanger (51), the hot water is used for heating the room air by radiating heat into the room air. The water that has radiated heat in the air-heating heat exchanger (51) passes through the bypass channel (63) and then returns to the heat storage tank (52).

**[0055]** As can be seen, during the heat radiation mode of operation, the room air is heated by the hot water stored in the heat storage tank (52). In the meantime, the hot water is bypassed around the intermediate heat exchanger (31) while circulating between the heat storage tank (52) and the air-heating heat exchanger (51). Consequently, in the heat radiation mode of operation, an increase in pressure loss on the hot water flow channel may be reduced, and therefore, the power to be consumed to operate the auxiliary pump (55) may be cut down as well.

<From Heat Radiation Operation Mode to Stopped State>

**[0056]** As the heat radiation mode of operation is performed continuously for a longer period of time, the temperature of the hot water in the heat storage tank (52) falls gradually. In the heat radiation operation mode, when the tank water temperature becomes lower than T0 - D, the heat storage controller (90) stops the auxiliary pump (55) and turns the three-way switching valve (53) to the first state. As a result, the water stops circulating through the circulation circuit (50).

<Switches to Other Operation Modes>

**[0057]** If the tank water temperature T2 becomes higher than T0 + D while the air conditioner (10) is not running (under the stoppage control), then the operation mode changes into the heat radiation operation mode. If the feed water temperature T1 becomes higher than T0 + D during the heat radiation mode of operation, then the operation mode changes into the second heat storage operation mode. If the tank water temperature T2 becomes lower than T0 - D during the second heat storage mode of operation, then the operation mode changes into the first heat storage operation mode. If the feed water temperature T1 becomes lower than T0 - D during the first heat storage mode of operation, then the operation mode changes into the stoppage control mode.

- Advantages of This Embodiment -

**[0058]** According to the embodiment described above, in the heat radiation operation mode shown in FIG. 7, the hot water is bypassed around the heating heat exchanger (31) while circulating, and therefore, the pressure loss caused on the hot water flow channel may be reduced. As a result, the power to be dissipated to operate the auxiliary pump (55) may also be cut down so much as to contribute to energy saving. In addition, an unwanted situation where the hot water flows through the heating heat exchanger (31) in the non-running state to dissipate heat in vain is also avoidable.

**[0059]** In addition, according to this embodiment, when the heat source unit (20) is brought to a stop compulsorily at a power saving request from the energy saving manager (6), the heat radiation mode of operation may be started automatically to continue the room-heating mode of operation. As a result, the room air may be kept comfortable with the power saving request satisfied.

**[0060]** Furthermore, during the heat storage mode of operation according to this embodiment, the first operation shown in FIG. 5 and the second operation shown in FIG. 6 are performed alternately and repeatedly. Thus, hot water may be stored in the heat storage tank (52) with the room-heating capacity maintained at a relatively high level. Besides, during the heat storage mode of operation, if the tank water temperature T2 exceeds a predetermined value T0 + D, the ratio of the duration $\Delta t1$ of the first operation to the duration $\Delta t2$ of the second operation is increased. As a result, hot water may be stored in the heat storage tank (52) with priority given to the room heating.

<<Other Embodiments>>

**[0061]** Optionally, the embodiments described above may be modified as follows.

**[0062]** Although water is used in the embodiment described above as a heating medium for the circulation circuit (50), a heat storage medium, of which the phase changes when heated by the heating heat exchanger (31), may also be used.

**[0063]** Also, the heating heat exchanger (31) used in the embodiment described above may be accompanied with any other additional heating means for heating the heating medium for the circulation circuit (50). Examples of such additional heating means include a gas boiler and a heater.

INDUSTRIAL APPLICABILITY

**[0064]** As can be seen from the foregoing description, the present invention is useful for a heating device for heating room air.

DESCRIPTION OF REFERENCE CHARACTERS

**[0065]**

10 Heating Device
20 Heat Source Unit
31 Intermediate Heat Exchanger (Heating Heat Exchanger)
51 Air-Heating Heat Exchanger
52 Heat Storage Tank
55 Auxiliary Pump
71 Temperature Sensor
72 In-Tank Temperature Sensor
90 Heat Storage Controller (Controller)

**Claims**

**1.** A heating device comprising:

a heat source unit (20) including a heating heat exchanger (31); and
a circulation circuit (50) in which an air-heating heat exchanger (51) and a heat storage tank (52) are connected together and through which a heating medium heated by the heating heat exchanger (31) circulates,

**characterized in that**
the heating device further includes a controller (90) configured to switch operation modes of the heating device from a first mode to a second mode, or vice versa,
the first mode of operation including an operation of allowing, while the heat source unit is running, the heating medium heated by the heating heat exchanger (31) to flow through the heat storage tank (52) and then return to the heating heat exchanger (31),
the second mode of operation including an operation of allowing, while the heat source unit (20) is not running, the heating medium in the heat storage tank (52) to flow through the air-heating heat exchanger (51), be bypassed around the heating heat exchanger (31), and then return to the heat storage tank (52).

**2.** The heating device of claim 1, **characterized in that** the controller (90) is configured to instruct the heating device to perform alternately and repeatedly a first operation and a second operation during the first mode of operation,
the first operation being allowing, while the heat source unit (20) is running, the heating medium heated by the heating heat exchanger (31) to be bypassed around the heat storage tank (52), flow through the air-heating heat exchanger (51), and then return to the heating heat exchanger (31),
the second operation being allowing, while the heat source unit (20) is running, the heating medium heated by the heating heat exchanger (31) to flow through both the heat storage tank (52) and the air-heating heat exchanger (51) and then return to the heating heat exchanger (31).

**3.** The heating device of claim 2, **characterized in that** the circulation circuit (50) includes:

a first flow channel (61) leading from an outlet of the heating heat exchanger (31) to an inlet of

the air-heating heat exchanger (51);
a second flow channel (62) provided in parallel with the first flow channel (61) and connected to the heat storage tank (52);
a third flow channel (63) leading from an outlet of the air-heating heat exchanger (51) to a point on the second flow channel (62) upstream of the heat storage tank (52);
a flow channel switching mechanism (53) configured to allow the outlet of the heating heat exchanger (31) to communicate with the first flow channel (61) during the first operation and communicate with the second flow channel (62) during the second operation; and
a pump (55) connected to the third flow channel (63) and operated during the second mode of operation.

**4.** The heating device of claim 2 or 3, **characterized by** further comprising
a temperature sensor (71) configured to sense a temperature of the heating medium on an outlet side of the heating heat exchanger (31), wherein
the controller (90) instructs the heating device to perform the first mode of operation if the temperature of the heating medium sensed by the temperature sensor (71) becomes greater than a predetermined value.

**5.** The heating device of claim 4, **characterized in that** the controller (90) is configured to instruct the heating device to perform the second mode of operation if the temperature of the heating medium sensed by the temperature sensor (71) becomes less than a predetermined value during the first mode of operation.

**6.** The heating device of claim 5, **characterized by** further comprising:

an in-tank temperature sensor (72) configured to sense a temperature of the heating medium in the heat storage tank (52), wherein
the controller (90) is configured to increase a ratio of the duration of the first operation to the duration of the second operation if the temperature sensed by the in-tank temperature sensor (72) becomes greater than a predetermined value during the first mode of operation.

FIG. 1

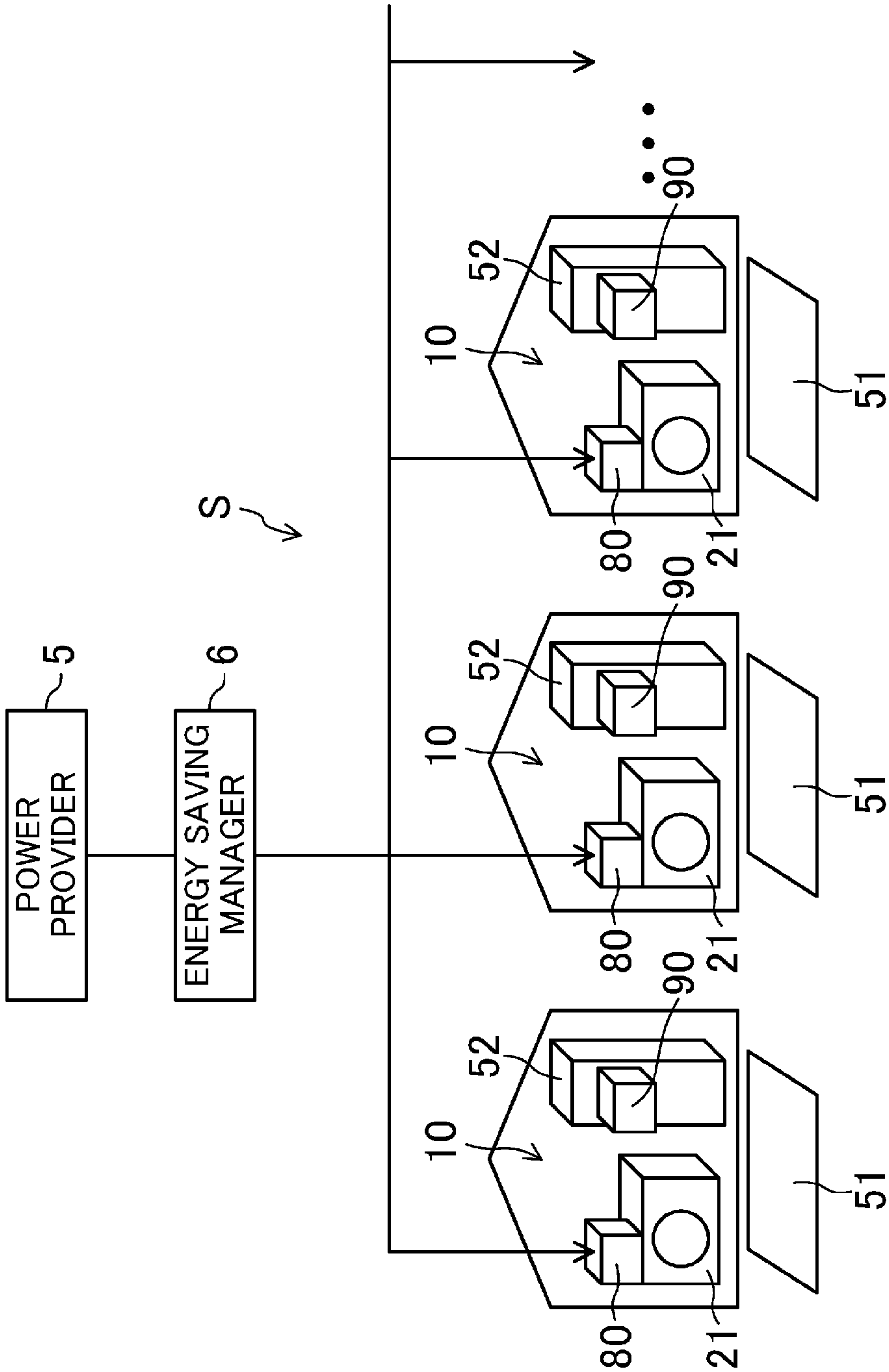

FIG. 2

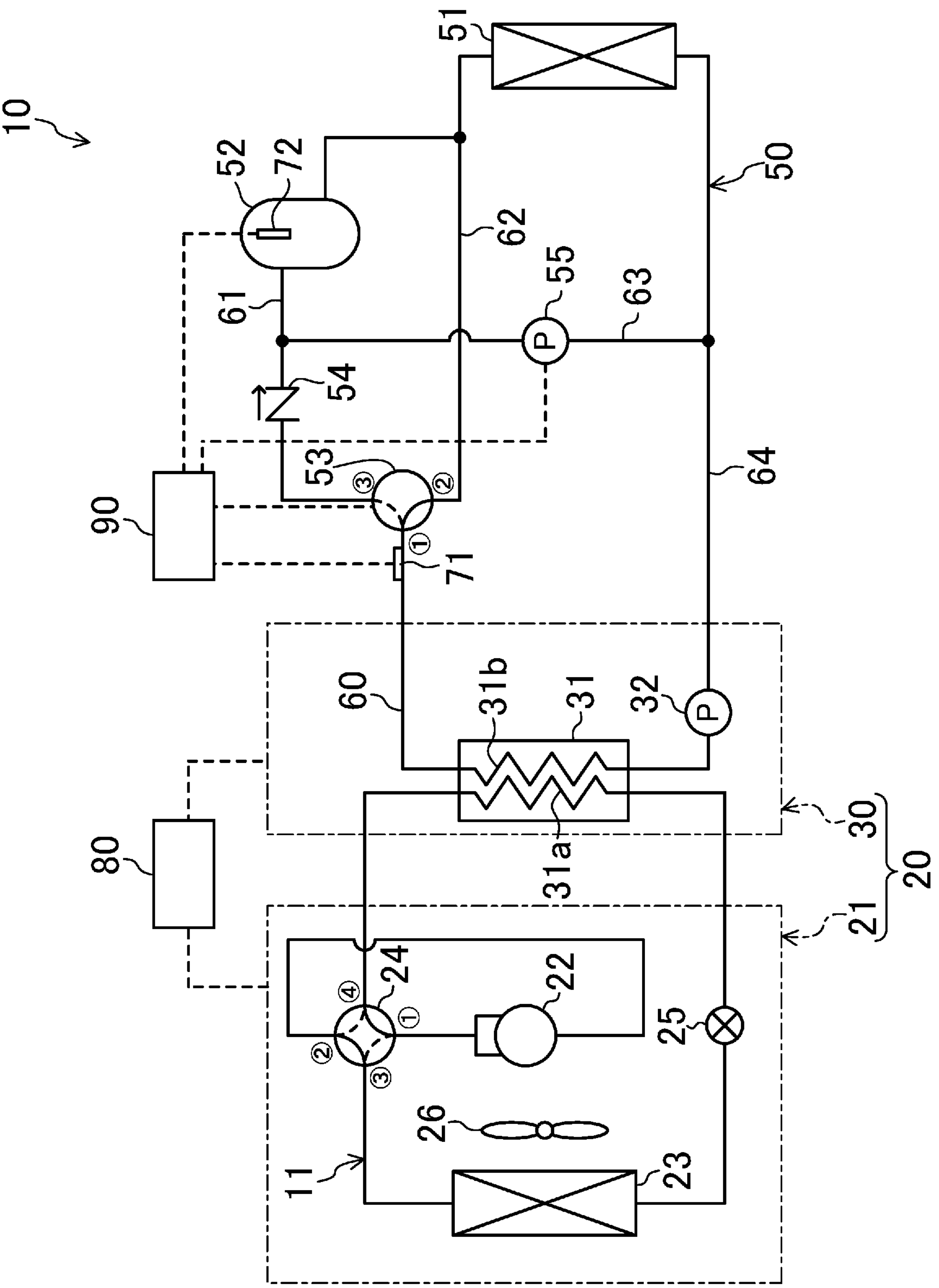
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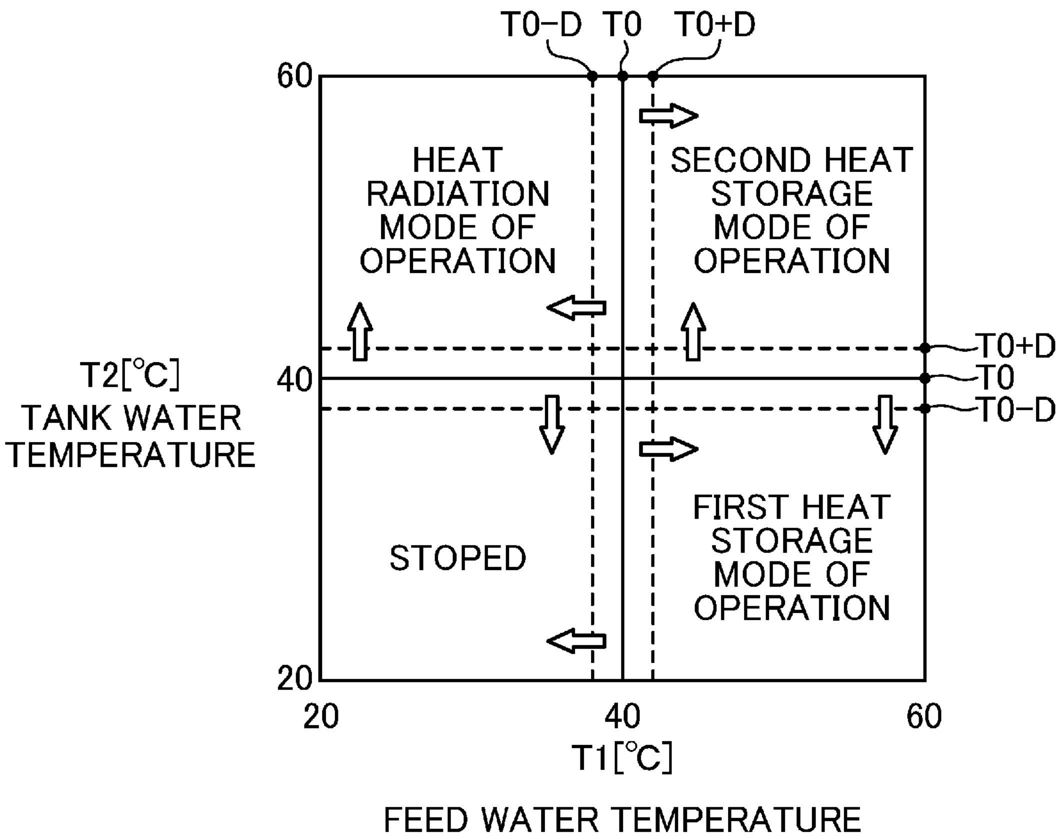
FIG. 3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T0
T0+D
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STOPED
FIRST HEAT STORAGE MODE OF OPERATION
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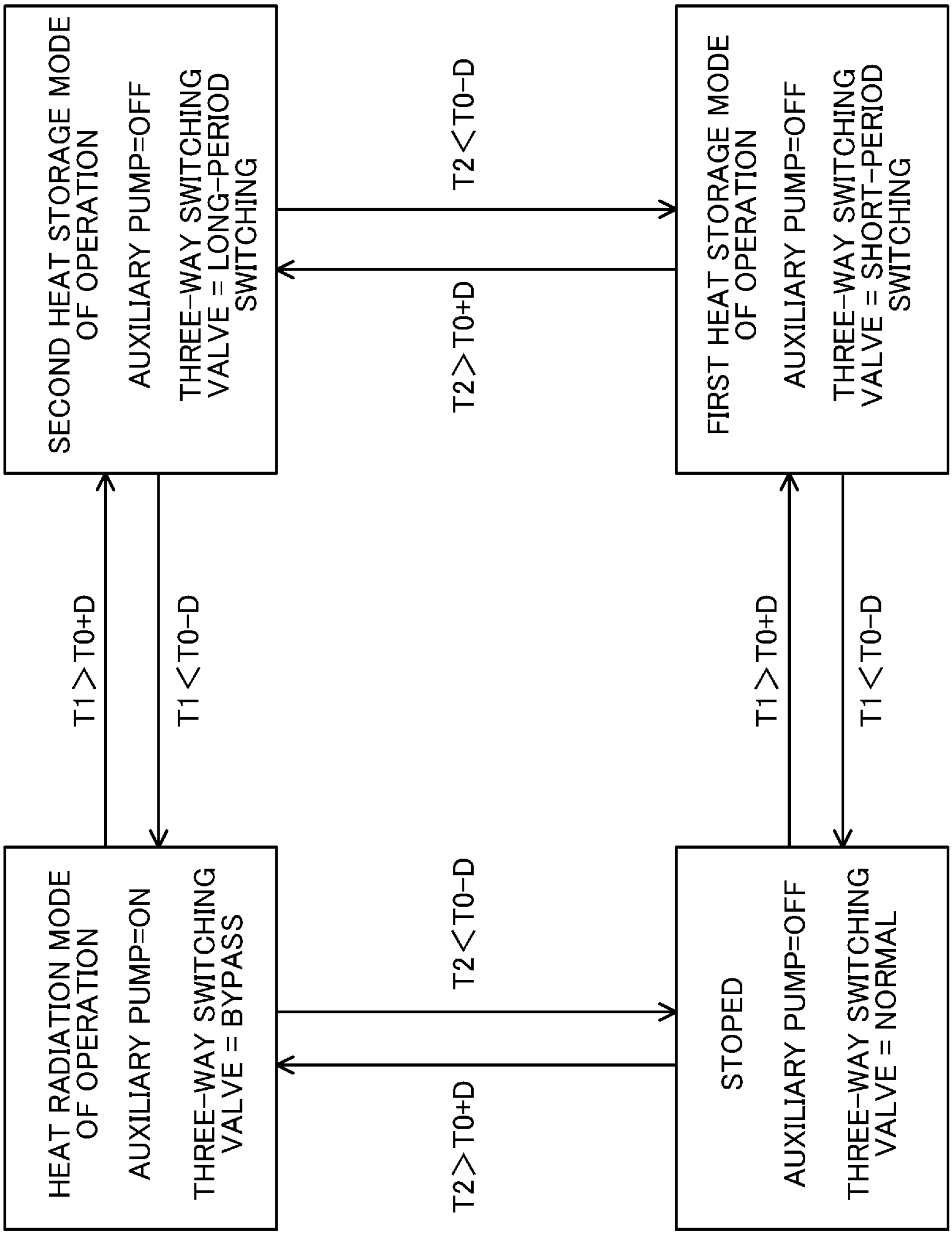
T0
T0−D
T2[°C]
TANK WATER TEMPERATURE
T1[°C]
FEED WATER TEMPERATURE


SECOND HEAT STORAGE MODE OF OPERATION
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FIRST HEAT STORAGE MODE OF OPERATION
AUXILIARY PUMP=OFF
THREE-WAY SWITCHING VALVE = SHORT-PERIOD SWITCHING
HEAT RADIATION MODE OF OPERATION
AUXILIARY PUMP=ON
THREE-WAY SWITCHING VALVE = BYPASS
STOPED
AUXILIARY PUMP=OFF
THREE-WAY SWITCHING VALVE = NORMAL
T2＜T0-D
T2＞T0+D
T1＞T0+D
T1＜T0-D
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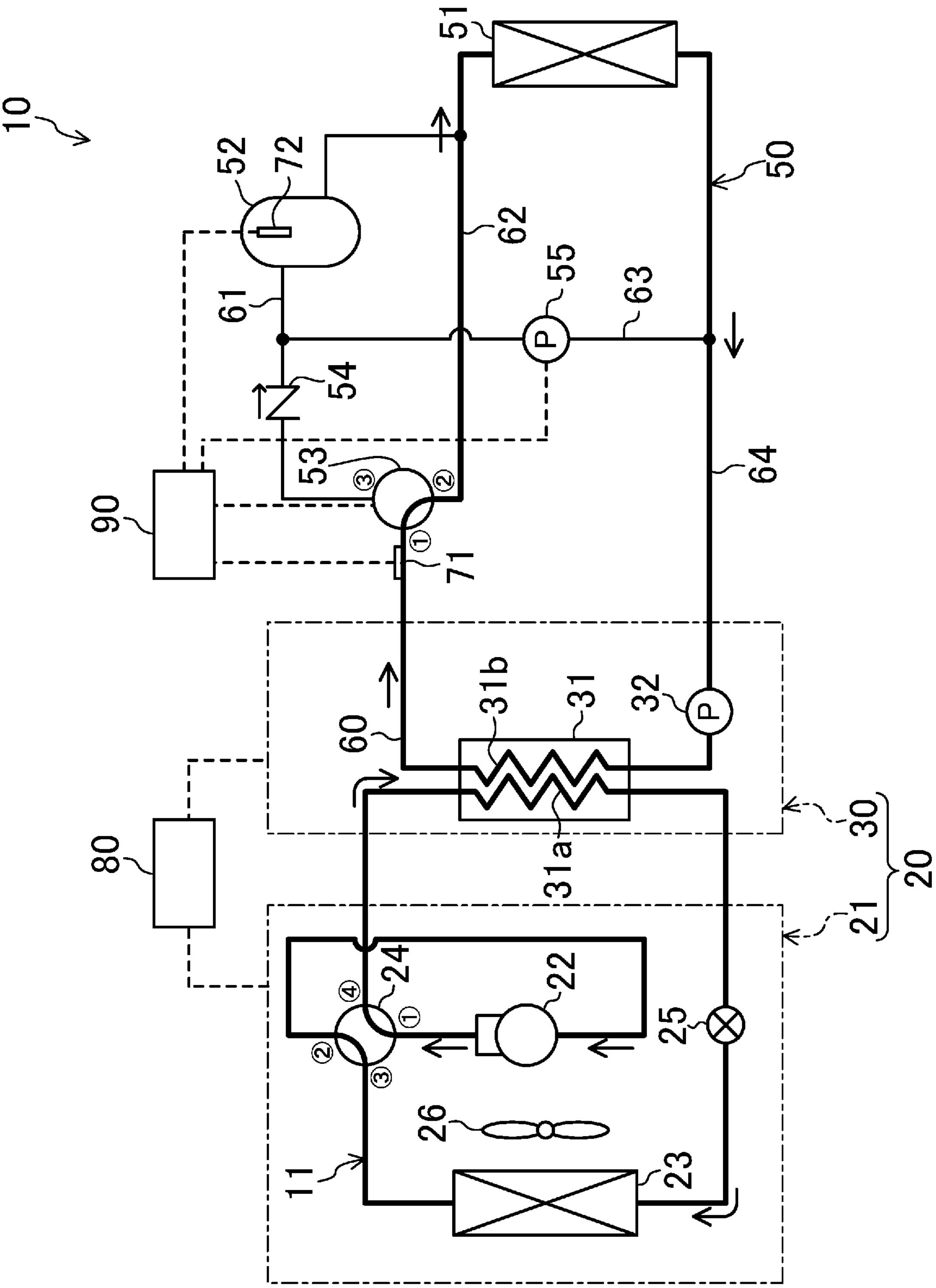
T1＜T0-D
T2＜T0-D
T2＞T0+D

FIG. 4

FIG. 5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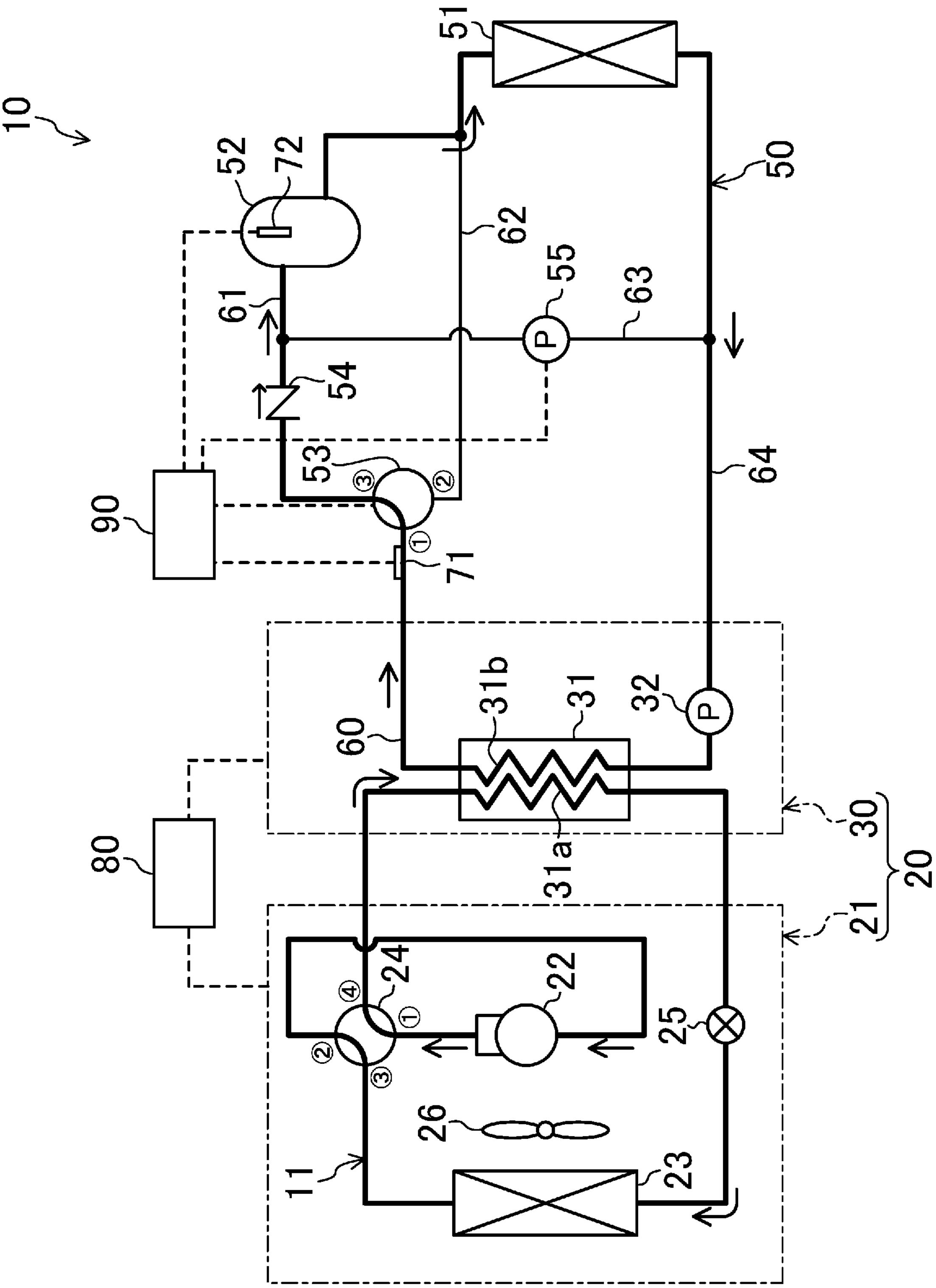
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FIG. 6

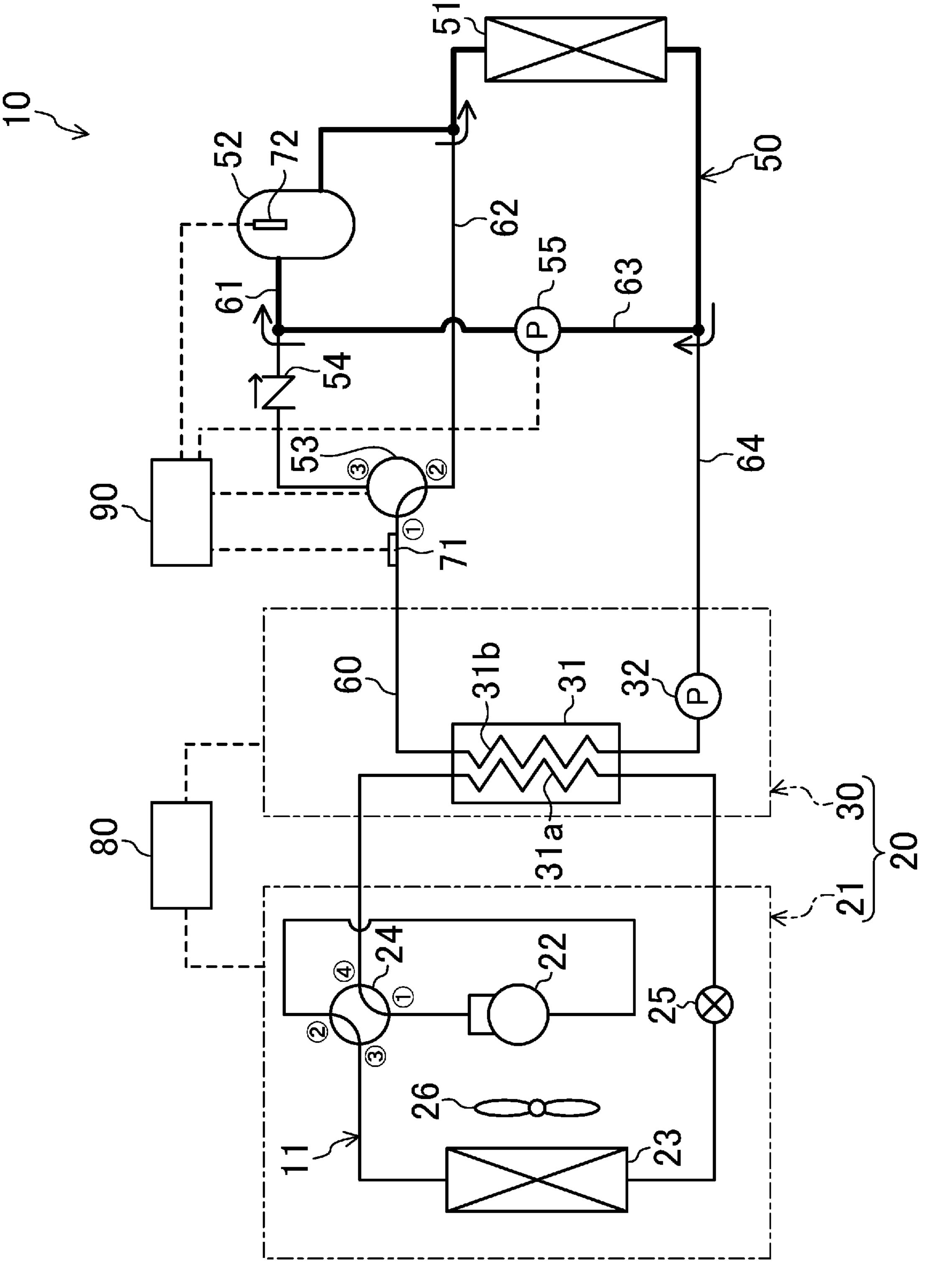
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FIG. 7

FIG. 8A

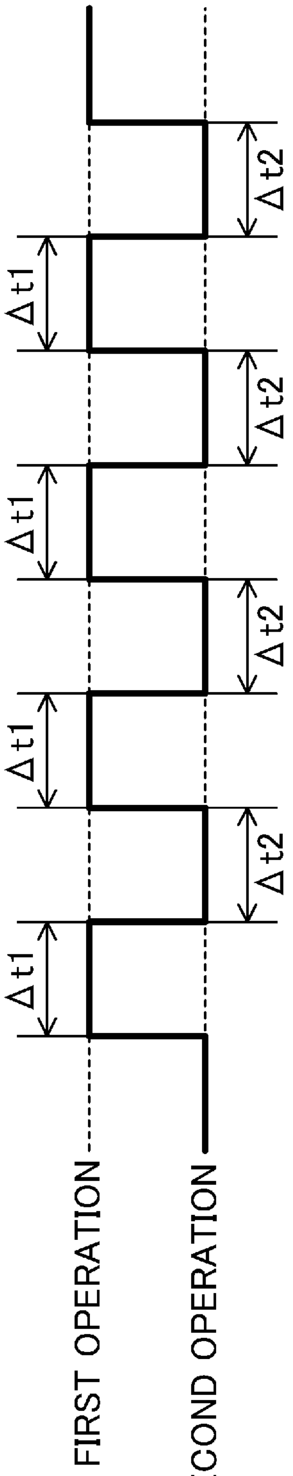
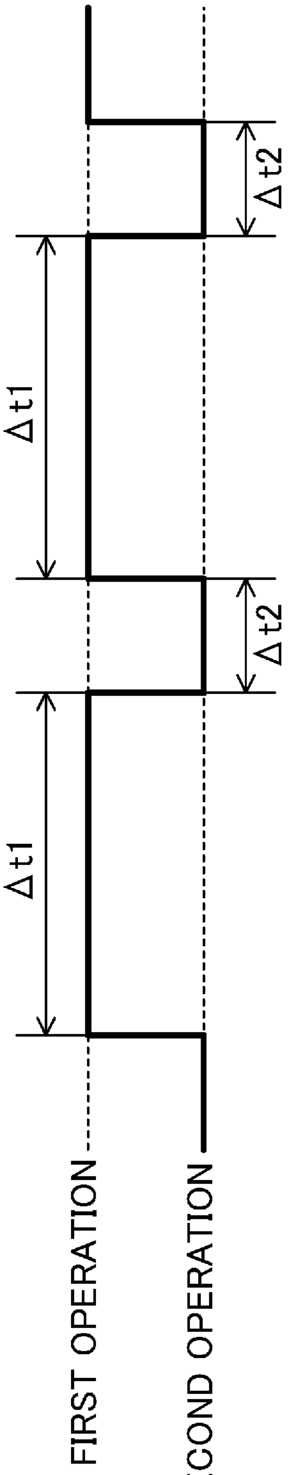

Δt1
Δt2
FIRST OPERATION
ECOND OPERATION

FIG. 8B


Δt1
Δt2
FIRST OPERATION
ECOND OPERATION

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2013/007516

A. CLASSIFICATION OF SUBJECT MATTER
*F24D3/00*(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)
F24D3/00

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 | 1996-2014 |
| Kokai Jitsuyo Shinan Koho | 1971-2014 | Toroku Jitsuyo Shinan Koho | 1994-2014 |

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<br>Y<br>A | JP 2004-218909 A (Matsushita Electric Industrial Co., Ltd.), 05 August 2004 (05.08.2004), paragraphs [0013], [0016]; fig. 3, 6 (Family: none) | 1<br>2<br>3-6 |
| Y<br>A | JP 2010-175164 A (Panasonic Corp.), 12 August 2010 (12.08.2010), paragraphs [0008] to [0033]; fig. 1 (Family: none) | 2<br>3-6 |
| A | JP 2006-10188 A (Corona Corp.), 12 January 2006 (12.01.2006), paragraphs [0022] to [0026] (Family: none) | 1-6 |

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"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

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|---|---|
| Date of the actual completion of the international search<br>27 February, 2014 (27.02.14) | Date of mailing of the international search report<br>11 March, 2014 (11.03.14) |
| Name and mailing address of the ISA/<br>Japanese Patent Office<br>Facsimile No. | Authorized officer<br><br>Telephone No. |

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

## REFERENCES CITED IN THE DESCRIPTION



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