



(11) **EP 4 462 033 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.11.2024 Bulletin 2024/46

(51) International Patent Classification (IPC):
F24H 1/18 ^(2022.01) **F24H 4/02** ^(2022.01)
F24H 9/00 ^(2022.01)

(21) Application number: **24732375.1**

(86) International application number:
PCT/JP2024/012910

(22) Date of filing: **28.03.2024**

(87) International publication number:
WO 2024/204655 (03.10.2024 Gazette 2024/40)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

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(30) Priority: **31.03.2023 JP 2023058795**
31.03.2023 JP 2023058797
31.03.2023 JP 2023058796

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(54) **WATER SYSTEM**

(57) When a state in which water is not made to flow between a tank and a pipe extending from the tank continues, the pipe is cooled by the ambient temperature, which causes a temperature difference in the pipe. At this time, there is a problem where there is concern that convection may occur in the water in the pipe, causing low-temperature water to flow into the tank and disrupting the temperature stratification of the water in the tank. A hot water supply system includes a tank (21), a first water boiling pipe (B1), and a second water boiling pipe (B2).

The first water boiling pipe (B1) extends from the tank (21). The second water boiling pipe (B2) is connected to the first water boiling pipe (B1). The first water boiling pipe (B1) includes a suppressing portion (40). The suppressing portion (40) suppresses water in the second water boiling pipe (B2) from flowing into the tank (21) through the first water boiling pipe (B1) during a first state. The first state is a state in which water is not made to flow between the tank (21) and the first water boiling pipe (B1).

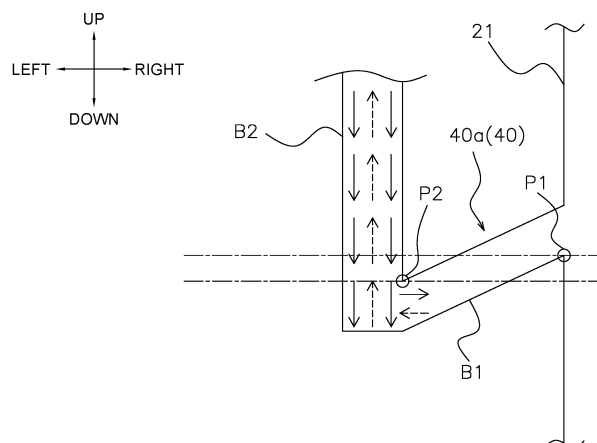


FIG. 3

Description

Technical Field

[0001] The present disclosure relates to a water system.

Background Art

[0002] As described in PTL 1 (Japanese Unexamined Patent Application Publication No. 2012-042090), there is a technology of supplying water at a predetermined temperature by forming a temperature stratification of water in a tank using a heat source device and mixing water having different temperatures in the tank, for example.

Summary of Invention

Technical Problem

[0003] When a state in which water is not made to flow between a tank and a pipe extending from the tank continues, the pipe is cooled by the ambient temperature, which causes a temperature difference in the pipe. At this time, there is a problem where there is concern that convection may occur in the water in the pipe, causing low-temperature water to flow into the tank and disrupting the temperature stratification of the water in the tank.

Solution to Problem

[0004] A water system according to a first aspect includes a tank, a first pipe, a second pipe, a heat source device, and a control unit. The tank stores water. The first pipe extends from the tank. The second pipe is connected to the first pipe. The heat source device heats water. The first pipe includes a suppressing portion. The suppressing portion suppresses water in the second pipe from flowing into the tank through the first pipe during a first state. The first state is a state in which water is not made to flow between the tank and the first pipe. The first pipe, the second pipe, and the heat source device form a water boiling circuit for heating the water in the tank.

[0005] In the water system according to the first aspect, the suppressing portion suppresses water in the second pipe from flowing into the tank through the first pipe during the first state. The first state is a state in which water is not made to flow between the tank and the first pipe. As a result, during the first state in which water is not made to flow between the tank and the first pipe, the water system can suppress low-temperature water in the second pipe from flowing into the tank through the first pipe, and can prevent the temperature stratification of the water in the tank from being disrupted.

[0006] A water system according to a second aspect is the water system according to the first aspect, in which

the suppressing portion is a gradient portion or a stepped portion. The gradient portion or the stepped portion rises toward the tank.

[0007] With such a configuration, the water system according to the second aspect can suppress the low-temperature water in the second pipe from flowing into the tank through the first pipe during the first state.

[0008] A water system according to a third aspect is the water system according to the second aspect, in which a position of a lowermost portion of a flow path at an end portion of the gradient portion or the stepped portion on a tank side is higher than a position of an uppermost portion of the flow path at an end portion of the gradient portion or the stepped portion on a side opposite to the tank.

[0009] With such a configuration, the water system according to the third aspect can more effectively suppress the low-temperature water in the second pipe from flowing into the tank through the first pipe during the first state.

[0010] A water system according to a fourth aspect is the water system according to the first aspect, in which the suppressing portion is a first valve provided in the first pipe.

[0011] With such a configuration, the water system according to the fourth aspect can suppress the low-temperature water in the second pipe from flowing into the tank through the first pipe during the first state.

[0012] A water system according to a fifth aspect is the water system according to any one of the first to fourth aspects and further includes a second valve, a fourth pipe, a fifth pipe, and an eighth pipe. The second valve adjusts a flow path of water. The fourth pipe extends from an upper surface of the tank. The fifth pipe is connected to the heat source device. The eighth pipe extends from a lower surface of the tank. The eighth pipe is connected to the heat source device. The first pipe extends from a side surface of the tank. The fourth pipe, the fifth pipe, and the second pipe are connected to each other via the second valve. The control unit controls the second valve so as to open a second pipe side of the second valve during the first state.

[0013] A water system according to a sixth aspect is the water system according to the fifth aspect, in which the control unit performs a first water boiling operation. In the first water boiling operation, the water in the tank is heated by sequentially being made to pass through the eighth pipe, the heat source device, the fifth pipe, and the fourth pipe.

[0014] A water system according to a seventh aspect is the water system according to the fifth or the sixth aspect, in which the control unit performs a second water boiling operation. In the second water boiling operation, the water in the tank is heated by sequentially being made to pass through the eighth pipe, the heat source device, the fifth pipe, the second pipe, and the first pipe.

[0015] A water system according to an eighth aspect is the water system according to any one of the fifth to seventh aspects and further includes a third pipe. The

third pipe is connected to the first pipe. The eighth pipe includes a sixth pipe and a seventh pipe. The sixth pipe extends from the lower surface of the tank. The seventh pipe is connected to the heat source device. The third pipe, the sixth pipe, and the seventh pipe are connected to each other.

[0016] A water system according to a ninth aspect is the water system according to the first aspect and further includes a second valve, a third pipe, a fourth pipe, a fifth pipe, a sixth pipe, and a seventh pipe. The second valve adjusts a flow path of water. The third pipe is connected to the first pipe. The fourth pipe extends from an upper surface of the tank. The fifth pipe is connected to the heat source device. The sixth pipe extends from a lower surface of the tank. The seventh pipe is connected to the heat source device. The first pipe extends from a side surface of the tank. The fourth pipe, the fifth pipe, and the second pipe are connected to each other via the second valve. The third pipe, the sixth pipe, and the seventh pipe are connected to each other. The suppressing portion is a third valve. The third valve is connected to an end portion of the first pipe on a side opposite to the tank. The third valve adjusts a flow path of water. The control unit controls the third valve so as to open a second pipe side and a third pipe side of the third valve and close a first pipe side of the third valve during the first state. The first pipe, the second pipe, and the third pipe are connected to each other via the third valve.

[0017] In the water system according to the ninth aspect, the control unit controls the third valve so as to open the second pipe side and the third pipe side of the third valve and close the first pipe side of the third valve during the first state. As a result, during the first state, the water system can suppress the low-temperature water in the second pipe from flowing into the tank through the first pipe, and can prevent the temperature stratification of the water in the tank from being disrupted.

[0018] A water system according to a tenth aspect is the water system according to the ninth aspect, in which the third valve is a mixing valve. An opening degree of the mixing valve is adjustable for each connected pipe.

[0019] With such a configuration, for example, the water system according to the tenth aspect can return the water from the low-temperature layer and the middle-temperature layer in the tank to the high-temperature layer in the tank for a while after the start of the water boiling operation, and thereafter, can gradually reduce the amount of water to be returned from the middle-temperature layer to the high-temperature layer. In this manner, the water system can flexibly perform the water boiling operation.

[0020] A water system according to an eleventh aspect is the water system according to the ninth aspect, in which the control unit performs a third water boiling operation. In the third water boiling operation, the water in the tank is heated by sequentially being made to pass through the first pipe, the third pipe, the seventh pipe, the heat source device, the fifth pipe, and the fourth pipe.

[0021] A water system according to a twelfth aspect is the water system according to the eighth aspect and further includes a fourth valve. The fourth valve adjusts a flow path of water. The third pipe, the sixth pipe, and the seventh pipe are connected to each other via the fourth valve.

[0022] A water system according to a thirteenth aspect is the water system according to the twelfth aspect, in which the control unit performs a third water boiling operation. In the third water boiling operation, the water in the tank is heated by sequentially being made to pass through the first pipe, the third pipe, the seventh pipe, the heat source device, the fifth pipe, and the fourth pipe.

15 Brief Description of Drawings

[0023]

[Fig. 1] Fig. 1 is a configuration diagram of a hot water supply system in a first embodiment.

[Fig. 2] Fig. 2 is a view illustrating an example of a pipe of related art extending from a tank.

[Fig. 3] Fig. 3 is an enlarged view of a vicinity of a first water boiling pipe in the first embodiment.

[Fig. 4] Fig. 4 is an enlarged view of a vicinity of a first water boiling pipe in a modification 1A.

[Fig. 5] Fig. 5 is an enlarged view of a vicinity of a first water boiling pipe in a modification 1B.

[Fig. 6] Fig. 6 is an enlarged view of a vicinity of a first water boiling pipe in a modification 1C.

[Fig. 7] Fig. 7 is an enlarged view of a vicinity of a fourth water boiling pipe in a modification 1E.

[Fig. 8] Fig. 8 is a configuration diagram of a hot water supply system in a second embodiment.

[Fig. 9] Fig. 9 is a view illustrating an example of a pipe of related art extending from a tank.

[Fig. 10] Fig. 10 is an enlarged view of a vicinity of a first water boiling pipe in the second embodiment.

[Fig. 11] Fig. 11 is a configuration diagram of a hot water supply system in a third embodiment.

[Fig. 12] Fig. 12 is an enlarged view of a vicinity of a first water boiling pipe in the third embodiment.

[Fig. 13] Fig. 13 is a configuration diagram of a hot water supply system in a fourth embodiment.

45 Description of Embodiments

<First Embodiment>

50 (1) Configuration of Hot Water Supply System

[0024] Fig. 1 is a configuration diagram of a hot water supply system 100 (water system) in the present embodiment. As illustrated in Fig. 1, the hot water supply system 100 mainly includes a heat pump unit 110 (heat source device), a hot water storage unit 120, a hot water supply section 140, a water stop valve 160, and a control unit 190.

[0025] The heat pump unit 110 heats water supplied from the hot water storage unit 120 and supplies the heated water to the hot water storage unit 120. The hot water storage unit 120 stores the heated water supplied from the heat pump unit 110 and supplies, for example, the stored high-temperature water, to the hot water supply section 140. The hot water supply section 140 is a facility such as a faucet or a shower for supplying water. The water stop valve 160 is connected to an external water supply source such as a water supply. The water stop valve 160 is operated to supply water to the hot water storage unit 120.

(1-1) Heat Pump Unit

[0026] The heat pump unit 110 mainly includes a compressor 11, a water heat exchanger 12, an expansion valve 13, and an air heat exchanger 14. The compressor 11, the water heat exchanger 12, the expansion valve 13, and the air heat exchanger 14 are annularly connected by a refrigerant pipe and form a heat pump cycle. Furthermore, the heat pump unit 110 includes a first control apparatus 10.

[0027] The compressor 11 includes a compression mechanism that compresses a refrigerant by driving a motor. The refrigerant compressed by the compressor 11 is sent to the water heat exchanger 12. The capacity of the heat pump unit 110 is adjustable by controlling an operating frequency of the motor.

[0028] The water heat exchanger 12 performs heat exchange between the high-temperature refrigerant compressed by the compressor 11 and water supplied from the hot water storage unit 120 to heat the water. The water heat exchanger 12 is, for example, a double pipe heat exchanger formed of an outer pipe and an inner pipe inserted into the outer pipe.

[0029] The expansion valve 13 decompresses the refrigerant heat-exchanged by passing through the water heat exchanger 12. The expansion valve 13 is, for example, an electric expansion valve.

[0030] The air heat exchanger 14 performs heat exchange between the refrigerant decompressed by passing through the expansion valve 13 and outdoor air to heat the refrigerant. Outdoor air is supplied to the air heat exchanger 14 by, for example, an outdoor air fan. The refrigerant heat-exchanged by passing through the air heat exchanger 14 is sent to the compressor 11.

(1-2) Hot Water Storage Unit

[0031] The hot water storage unit 120 mainly includes a tank 21, a first water boiling pipe B1 (first pipe), a second water boiling pipe B2 (second pipe), a fourth water boiling pipe B4 (fourth pipe), a fifth water boiling pipe B5 (fifth pipe), an eighth water boiling pipe B8 (eighth pipe), a first hot water supply pipe S1 to a sixth hot water supply pipe S6, a water supply pipe L1, a water discharge pipe L2, a first water boiling valve 22 (second valve), a water boil-

ing pump 24, a first hot water supply valve 25, a second hot water supply valve 26, and a water discharge valve 28. Furthermore, the hot water storage unit 120 includes a second control apparatus 20.

[0032] The tank 21 stores water. Since the density of water changes according to the temperature, the water stored in the tank 21 forms layers including a high-temperature layer, a middle-temperature layer, and a low-temperature layer, sequentially from an upper side to a lower side.

[0033] The first water boiling pipe B1 extends from a side surface of the tank 21. A distal end of the first water boiling pipe B1 on a side opposite to the tank 21 is connected to the second water boiling pipe B2.

[0034] The second water boiling pipe B2 is connected to the first water boiling pipe B1 and extends upward. In the present embodiment, the second water boiling pipe B2 extends upward from the distal end of the first water boiling pipe B1. The second water boiling pipe B2 may extend upward from an intermediate portion of the first water boiling pipe B1. The second water boiling pipe B2 is connected to the first water boiling valve 22.

[0035] The fourth water boiling pipe B4 extends from an upper surface of the tank 21. A distal end of the fourth water boiling pipe B4 on a side opposite to the tank 21 is connected to the first water boiling valve 22.

[0036] One end of the fifth water boiling pipe B5 is connected to the first water boiling valve 22, and the other end of the fifth water boiling pipe B5 is connected to an outlet side of the water heat exchanger 12 of the heat pump unit 110.

[0037] The eighth water boiling pipe B8 extends from a lower surface of the tank 21. A distal end of the eighth water boiling pipe B8 on a side opposite to the tank 21 is connected to an inlet side of the water heat exchanger 12 of the heat pump unit 110. The eighth water boiling pipe B8 is provided with the water boiling pump 24.

[0038] The first water boiling valve 22 adjusts a flow path of water. The fourth water boiling pipe B4, the fifth water boiling pipe B5, and the second water boiling pipe B2 are connected to each other via the first water boiling valve 22. The first water boiling valve 22 is, for example, a three-way valve or a mixing valve. Opening and closing of the three-way valve is adjustable for each connected pipe. An opening degree of the mixing valve is adjustable for each connected pipe. In the present embodiment, the first water boiling valve 22 is a mixing valve.

[0039] The tank 21, the first water boiling pipe B1, the second water boiling pipe B2, the fourth water boiling pipe B4, the fifth water boiling pipe B5, the eighth water boiling pipe B8, the first water boiling valve 22, and the water heat exchanger 12 of the heat pump unit 110 form a water boiling circuit C1 for heating the water in the tank 21.

[0040] The first hot water supply pipe S1 extends from a side surface of the tank 21. A distal end of the first hot water supply pipe S1 on a side opposite to the tank 21 is connected to the second hot water supply pipe S2.

[0041] The second hot water supply pipe S2 is connected to the first hot water supply pipe S1 and extends upward. In the present embodiment, the second hot water supply pipe S2 extends upward from the distal end of the first hot water supply pipe S1. The second hot water supply pipe S2 may extend upward from an intermediate portion of the first hot water supply pipe S1. The second hot water supply pipe S2 is connected to the first hot water supply valve 25.

[0042] The third hot water supply pipe S3 extends downward from the distal end of the first hot water supply pipe S1. The third hot water supply pipe S3 is connected to the second hot water supply valve 26.

[0043] The fourth hot water supply pipe S4 extends from the upper surface of the tank 21. A distal end of the fourth hot water supply pipe S4 on a side opposite to the tank 21 is connected to the first hot water supply valve 25.

[0044] One end of the fifth hot water supply pipe S5 is connected to the first hot water supply valve 25, and the other end of the fifth hot water supply pipe S5 is connected to the hot water supply section 140.

[0045] The sixth hot water supply pipe S6 extends from the lower surface of the tank 21. A distal end of the sixth hot water supply pipe S6 on a side opposite to the tank 21 is connected to the second hot water supply valve 26. The second hot water supply valve 26 is an electric on-off valve.

[0046] One end of the water supply pipe L1 is connected to the second hot water supply valve 26, and the other end of the water supply pipe L1 is connected to the water stop valve 160 outside the hot water storage unit 120.

[0047] The water discharge pipe L2 extends from the lower surface of the tank 21. The water discharge pipe L2 is provided with the water discharge valve 28. The water discharge pipe L2 is connected to a pipe for discharging water outside the hot water storage unit 120.

[0048] The first hot water supply valve 25 adjusts a flow path of water. The fourth hot water supply pipe S4, the fifth hot water supply pipe S5, and the second hot water supply pipe S2 are connected to each other via the first hot water supply valve 25. In the present embodiment, the first hot water supply valve 25 is a three-way valve.

[0049] The second hot water supply valve 26 adjusts a flow path of water. The third hot water supply pipe S3, the sixth hot water supply pipe S6, and the water supply pipe L1 are connected to each other via the second hot water supply valve 26. In the present embodiment, the second hot water supply valve 26 is a three-way valve.

[0050] The tank 21, the first hot water supply pipe S1 to the second hot water supply pipe S2, the fourth hot water supply pipe S4 to the sixth hot water supply pipe S6, the water supply pipe L1, and the hot water supply section 140 form a hot water supply circuit C2 for supplying water in the tank 21.

[0051] The water discharge valve 28 is operated to discharge the water in the tank 21, in the water boiling circuit C1, and in the hot water supply circuit C2 to the outside.

(1-3) Control Unit

[0052] The control unit 190 mainly includes the first control apparatus 10 of the heat pump unit 110 and the second control apparatus 20 of the hot water storage unit 120. The first control apparatus 10 and the second control apparatus 20 typically include a microcomputer including a control arithmetic device and a storage device, and input and output circuits. The control arithmetic device is a processor such as a CPU or a GPU. The control arithmetic device reads a control program stored in the storage device and controls operations of the hot water supply system 100 in accordance with the control program. The control arithmetic device can write a calculation result in the storage device and read information stored in the storage device in accordance with the control program.

[0053] The control unit 190 controls the compressor 11, the expansion valve 13, the first water boiling valve 22, the water boiling pump 24, the first hot water supply valve 25, the second hot water supply valve 26, the water discharge valve 28, and the like, on the basis of a signal from a temperature sensor (not illustrated) or the like provided in the tank 21.

(2) Manner of Operations of Hot Water Supply System

[0054] The hot water supply system 100 mainly performs a water boiling operation and a hot water supply operation. The control unit 190 controls these operations performed by the hot water supply system 100.

(2-1) Water Boiling Operation

[0055] The water boiling operation is an operation of heating the water in the tank 21 by the heat pump unit 110. The control unit 190 drives the water boiling pump 24 to circulate the water in the tank 21 through the first water boiling pipe B1, the second water boiling pipe B2, the fourth water boiling pipe B4, the fifth water boiling pipe B5, and the eighth water boiling pipe B8 while heating the water in the water heat exchanger 12.

[0056] The control unit 190 controls the operation frequency of the motor of the compressor 11 and the opening degree of the expansion valve 13 to adjust the temperature or the like of the water heated in the water heat exchanger 12.

[0057] For example, the control unit 190 performs a first water boiling operation. In the first water boiling operation, the water in the tank 21 is heated by sequentially being made to pass through the eighth water boiling pipe B8, the water heat exchanger 12, the fifth water boiling pipe B5, and the fourth water boiling pipe B4. Specifically, the control unit 190 controls the first water boiling valve 22 so as to open a fourth water boiling pipe B4 side and a fifth water boiling pipe B5 side of the first water boiling valve 22 and close a second water boiling pipe B2 side of the first water boiling valve 22. When the control unit

190 drives the water boiling pump 24 after controlling the first water boiling valve 22 as described above, the water from the low-temperature layer in the tank 21 is heated by the water heat exchanger 12 and is returned to the high-temperature layer in the tank 21.

[0058] For example, the control unit 190 performs a second water boiling operation. In the second water boiling operation, the water in the tank 21 is heated by sequentially being made to pass through the eighth water boiling pipe B8, the water heat exchanger 12, the fifth water boiling pipe B5, the second water boiling pipe B2, and the first water boiling pipe B1. Specifically, the control unit 190 controls the first water boiling valve 22 so as to open the second water boiling pipe B2 side and the fifth water boiling pipe B5 side of the first water boiling valve 22 and close the fourth water boiling pipe B4 side of the first water boiling valve 22. When the control unit 190 drives the water boiling pump 24 after controlling the first water boiling valve 22 as described above, the water from the low-temperature layer in the tank 21 is heated by the water heat exchanger 12 and is returned to the middle-temperature layer in the tank 21.

[0059] The heating of the water by the heat pump unit 110 is insufficient for a while after the start of the water boiling operation. Therefore, there is concern that, if the first water boiling operation is performed from the start of the water boiling operation, the temperature in the tank 21 may decrease as the water from the low-temperature layer in the tank 21 is returned to the high-temperature layer in the tank 21. Therefore, the control unit 190 may perform the second water boiling operation at the start of the water boiling operation, thereafter, may gradually reduce the opening degree of the second water boiling pipe B2 side of the first water boiling valve 22 and gradually increase the opening degree of the fourth water boiling pipe B4 side of the first water boiling valve 22, and may finally perform the first water boiling operation. Since the control unit 190 controls the first water boiling valve 22 as described above, the water from the low-temperature layer in the tank 21 is returned to the middle-temperature layer in the tank 21 for a while after the start of the water boiling operation. As a result, the temperature in the tank 21 is less likely to decrease.

(2-2) Hot Water Supply Operation

[0060] The hot water supply operation is an operation of releasing water at a predetermined temperature from the hot water supply section 140 using the water in the tank 21. The predetermined temperature is, for example, set by a user, of the hot water supply system 100, using a remote controller (not illustrated).

[0061] For example, the control unit 190 controls the first hot water supply valve 25 so as to open a fourth hot water supply pipe S4 side and a fifth hot water supply pipe S5 side of the first hot water supply valve 25 and close a second hot water supply pipe S2 side of the first hot water supply valve 25 in order to release water at a

predetermined temperature from the hot water supply section 140. Furthermore, the control unit 190 controls the second hot water supply valve 26 so as to open a water supply pipe L1 side and a sixth hot water supply pipe S6 side of the second hot water supply valve 26 and close a third hot water supply pipe S3 side of the second hot water supply valve 26. When a user releases water from the hot water supply section 140 after the first hot water supply valve 25 and the second hot water supply valve 26 are controlled as described above (in a state in which the water stop valve 160 is opened), water from the water supply source is supplied into the tank 21 from the lower surface of the tank 21 through the water supply pipe L1 and the sixth hot water supply pipe S6 due to a water supply pressure. As a result, the water in the high-temperature layer in the tank 21 is pushed out through the fourth hot water supply pipe S4, passes through the fifth hot water supply pipe S5, and flows out from the hot water supply section 140.

[0062] For example, the control unit 190 controls the first hot water supply valve 25 so as to open in three ways including the fourth hot water supply pipe S4 side, the fifth hot water supply pipe S5 side, and the second hot water supply pipe S2 side in order to release water at a predetermined temperature from the hot water supply section 140. Furthermore, the control unit 190 controls the second hot water supply valve 26 so as to open the water supply pipe L1 side and the sixth hot water supply pipe S6 side of the second hot water supply valve 26 and close the third hot water supply pipe S3 side of the second hot water supply valve 26. When a user releases water from the hot water supply section 140 after the first hot water supply valve 25 and the second hot water supply valve 26 are controlled as described above (in a state in which the water stop valve 160 is opened), water from the water supply source is supplied into the tank 21 from the lower surface of the tank 21 through the water supply pipe L1 and the sixth hot water supply pipe S6 due to a water supply pressure. As a result, the water in the high-temperature layer in the tank 21 is pushed out through the fourth hot water supply pipe S4 and, furthermore, the water in the middle-temperature layer in the tank 21 is pushed out through the first hot water supply pipe S1 and the second hot water supply pipe S2. These waters are mixed at the first hot water supply valve 25, and the mixed water passes through the fifth hot water supply pipe S5 and flows out from the hot water supply section 140.

(3) Detailed Structure of First Water Boiling Pipe

[0063] Fig. 2 is a view illustrating an example of a pipe B1' of related art extending from a tank 21'. As illustrated in Fig. 2, the pipe B1' extends horizontally (in a left-right direction) from a side surface of the tank 21'. A distal end of the pipe B1' on a side opposite to the tank 21' is connected to a pipe B2'. The pipe B2' extends upward from the distal end of the pipe B1'. When a state in which water is not made to flow between the tank 21' and the pipe

B1' continues, particularly the pipe B2' located away from the tank 21' is cooled by the ambient temperature. When the pipe B2' is cooled by the ambient temperature, the temperature in the vicinity of the inner wall inside the pipe B2' becomes lower than the temperature in the vicinity of the center inside the pipe B2', which causes a temperature difference in the pipe. At this time, as illustrated in Fig. 2, the temperature of the water in the vicinity of the inner wall inside the pipe B2' becomes relatively low, and the water flows downward (solid line arrows) in the pipe. In addition, the temperature of the water in the vicinity of the center inside the pipe B2' becomes relatively high, and the water flows upward (dotted line arrows) in the pipe. In other words, convection occurs in the water in the pipe B2'. There is concern that, when the cooled low-temperature water in the pipe B2' flows into the tank 21' due to the convection, the temperature stratification of the water in the tank 21' may be disrupted.

[0064] Fig. 3 is an enlarged view of a vicinity of the first water boiling pipe B1 in the present embodiment. As illustrated in Fig. 3, the first water boiling pipe B1 includes a suppressing portion 40. The suppressing portion 40 suppresses water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during a first state. The first state is a state in which water is not made to flow between the tank 21 and the first water boiling pipe B1. The first state is, for example, a state in which the control unit 190 closes the water discharge valve 28, stops the compressor 11 and the water boiling pump 24, and opens, in three ways, the first water boiling valve 22, the first hot water supply valve 25, and the second hot water supply valve 26 and a user does not release water from the hot water supply section 140. In the present embodiment, the suppressing portion 40 is a gradient portion 40a. The gradient portion 40a rises toward the tank 21. As illustrated in Fig. 3, a position P1 of a lowermost portion of a flow path at an end portion of the gradient portion 40a on a tank 21 side is higher than a position P2 of an uppermost portion of the flow path at an end portion of the gradient portion 40a on a side opposite to the tank 21.

[0065] As a result, during the first state in which water is not made to flow between the tank 21 and the first water boiling pipe B1, the hot water supply system 100 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1, and can prevent the temperature stratification of the water in the tank 21 from being disrupted.

(4) Features

[0066] (4-1)

In related art, there is a technology of supplying water at a predetermined temperature by forming a temperature stratification of water in a tank using a heat source device and mixing water having different temperatures in the tank, for example.

[0067] When a state in which water is not made to flow between a tank and a pipe extending from the tank continues, the pipe is cooled by the ambient temperature, which causes a temperature difference in the pipe. At this time, there is a problem where there is concern that convection may occur in the water in the pipe, causing low-temperature water to flow into the tank and disrupting the temperature stratification of the water in the tank.

[0068] The hot water supply system 100 (water system) of the present embodiment includes the tank 21, the first water boiling pipe B1 (first pipe), the second water boiling pipe B2 (second pipe), the heat pump unit 110 (heat source device), and the control unit 190. The tank 21 stores water. The first water boiling pipe B1 extends from the tank 21. The second water boiling pipe B2 is connected to the first water boiling pipe B1. The heat pump unit 110 heats water. The first water boiling pipe B1 includes the suppressing portion 40. The suppressing portion 40 suppresses the water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state. The first state is a state in which water is not made to flow between the tank 21 and the first water boiling pipe B1. The first water boiling pipe B1, the second water boiling pipe B2, and the heat pump unit 110 form the water boiling circuit C1 for heating the water in the tank 21.

[0069] In the hot water supply system 100 of the present embodiment, the suppressing portion 40 suppresses the water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state. The first state is a state in which water is not made to flow between the tank 21 and the first water boiling pipe B1. As a result, during the first state in which water is not made to flow between the tank 21 and the first water boiling pipe B1, the hot water supply system 100 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1, and can prevent the temperature stratification of the water in the tank 21 from being disrupted.

[0070] (4-2)

In the hot water supply system 100 of the present embodiment, the suppressing portion 40 is the gradient portion 40a. The gradient portion 40a rises toward the tank 21.

[0071] As a result, during the first state, the hot water supply system 100 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1.

[0072] (4-3)

In the hot water supply system 100 of the present embodiment, the position P1 of the lowermost portion of the flow path at the end portion of the gradient portion 40a on the tank 21 side is higher than the position P2 of the uppermost portion of the flow path at the end portion of the gradient portion 40a on a side opposite to the tank 21.

[0073] As a result, the hot water supply system 100 can more effectively suppress the low-temperature water

in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state.

[0074] (4-4)

The hot water supply system 100 of the present embodiment further includes the first water boiling valve 22 (second valve), the fourth water boiling pipe B4 (fourth pipe), the fifth water boiling pipe B5 (fifth pipe), and the eighth water boiling pipe B8 (eighth pipe). The first water boiling valve 22 adjusts the flow path of the water. The fourth water boiling pipe B4 extends from the upper surface of the tank 21. The fifth water boiling pipe B5 is connected to the heat pump unit 110. The eighth water boiling pipe B8 extends from the lower surface of the tank 21. The eighth water boiling pipe B8 is connected to the heat pump unit 110. The first water boiling pipe B1 extends from the side surface of the tank 21. The fourth water boiling pipe B4, the fifth water boiling pipe B5, and the second water boiling pipe B2 are connected to each other via the first water boiling valve 22. The control unit 190 controls the second water boiling pipe B2 so as to open the second water boiling pipe B2 side of the first water boiling valve 22 during the first state.

[0075] (4-5)

In the hot water supply system 100 of the present embodiment, the control unit 190 performs the first water boiling operation. In the first water boiling operation, the water in the tank 21 is heated by sequentially being made to pass through the eighth water boiling pipe B8, the heat pump unit 110, the fifth water boiling pipe B5, and the fourth water boiling pipe B4.

[0076] (4-6)

In the hot water supply system 100 of the present embodiment, the control unit 190 performs the second water boiling operation. In the second water boiling operation, the water in the tank 21 is heated by sequentially being made to pass through the eighth water boiling pipe B8, the heat pump unit 110, the fifth water boiling pipe B5, the second water boiling pipe B2, and the first water boiling pipe B1.

(5) Modifications

(5-1) Modification 1A

[0077] Fig. 4 is an enlarged view of a vicinity of the first water boiling pipe B1 in the present modification. In the present embodiment, the suppressing portion 40 is the gradient portion 40a. However, as illustrated in Fig. 4, the suppressing portion 40 may be a gradient portion 40b, for example. As illustrated in Fig. 4, a position P3 of a lowermost portion of a flow path at a first end portion of the gradient portion 40b on the tank 21 side may be higher than a position P4 of a lowermost portion of the flow path at a second end portion of the gradient portion 40b on a side opposite to the tank 21. In addition, in a flow path section A1 at the second end portion, an area of a first portion A2 (hatched portion on the left side) high-

er than the position P3 of the lowermost portion of the flow path at the first end portion may be 9% or more of an area of the flow path section A1, for example.

[0078] As a result, in the hot water supply system 100, a sufficient amount of water does not remain in the first water boiling pipe B1 when the water in the tank 21, in the water boiling circuit C1, and in the hot water supply circuit C2 is discharged to the outside by, for example, opening the water discharge valve 28 in a state in which the water stop valve 160 is closed. Thus, it is possible to prevent the first water boiling pipe B1 from freezing and being damaged. Note that a hatched portion W1 on the right side indicates an amount of water that remains in the first water boiling pipe B1 and is insufficient for the first water boiling pipe B1 to freeze and be damaged. Furthermore, the hot water supply system 100 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state.

(5-2) Modification 1B

[0079] Fig. 5 is an enlarged view of a vicinity of the first water boiling pipe B1 in the present modification. In the present embodiment, the suppressing portion 40 is the gradient portion 40a. However, as illustrated in Fig. 5, the suppressing portion 40 may be a stepped portion 40c, for example. The stepped portion 40c rises toward the tank 21.

[0080] As a result, during the first state, the hot water supply system 100 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1.

[0081] Furthermore, a position P5 of a lowermost portion of a flow path at an end portion of the stepped portion 40c on the tank 21 side may be higher than a position P6 of an uppermost portion of the flow path at an end portion of the stepped portion 40c on a side opposite to the tank 21.

[0082] As a result, the hot water supply system 100 can more effectively suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state.

(5-3) Modification 1C

[0083] Fig. 6 is an enlarged view of a vicinity of the first water boiling pipe B1 in the present modification. In the present embodiment, the gradient portion 40a is the entirety of the first water boiling pipe B1. However, as illustrated in Fig. 6, the gradient portion 40a may be a part of the first water boiling pipe B1, for example. The position P1 of the lowermost portion of the flow path at the end portion of the gradient portion 40a on the tank 21 side is higher than the position P2 of the uppermost portion of the flow path at the end portion of the gradient portion 40a on a side opposite to the tank 21.

(5-4) Modification 1D

[0084] In the present embodiment, the suppressing portion 40 is the gradient portion 40a. However, the suppressing portion 40 may be a first valve provided in the first water boiling pipe B1, for example. The first valve is, for example, an on-off valve or a check valve.

[0085] In a case where the first valve is an on-off valve, the control unit 190 closes the first valve during the first state and opens the first valve during a second state. The second state is a state in which water is made to flow between the tank 21 and the first water boiling pipe B1. In a case where the first valve is a check valve, the first valve is provided so that the water in the tank 21 does not flow out through the first water boiling pipe B1.

[0086] As a result, during the first state, the hot water supply system 100 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1.

(5-5) Modification 1E

[0087] In the present embodiment, the first water boiling pipe B1 (first pipe) extending from the side surface of the tank 21 includes the suppressing portion 40. However, the fourth water boiling pipe B4 extending from the upper surface of the tank 21 may include the suppressing portion 40, as the fourth water boiling pipe B4 (first pipe) and the second water boiling pipe B2 (second pipe) (or the fifth water boiling pipe B5 (second pipe)).

[0088] Fig. 7 is an enlarged view of a vicinity of the fourth water boiling pipe B4 in the present modification. In Fig. 7, the suppressing portion 40 is a gradient portion 40d. For example, the suppressing portion 40 may be a first valve provided in the fourth water boiling pipe B4. During the first state, the first water boiling valve 22 opens in three ways. A position P7 of a lowermost portion of a flow path at an end portion of the gradient portion 40d on the tank 21 side is higher than a position P8 of an uppermost portion of the flow path at an end portion of the gradient portion 40d on a side opposite to the tank 21.

[0089] As a result, during the first state in which water is not made to flow between the tank 21 and the fourth water boiling pipe B4, the hot water supply system 100 can suppress the low-temperature water in the second water boiling pipe B2 or in the fifth water boiling pipe B5 from flowing into the tank 21 through the fourth water boiling pipe B4 (as illustrated in Fig. 7, relatively high-temperature water flows (dotted line arrows) into the tank 21, but when compared to the temperature of the water in the tank 21, it is still the case where the low-temperature water flows into the tank 21), and can prevent the temperature stratification of the water in the tank 21 from being disrupted. Furthermore, in the hot water supply system 100, a sufficient amount of water does not remain in the fourth water boiling pipe B4 when the water in the tank 21, in the water boiling circuit C1, and in the hot water supply circuit C2 is discharged to the outside. Thus,

it is possible to prevent the fourth water boiling pipe B4 from freezing and being damaged.

[0090] (5-6)

The embodiment of the present disclosure has been described heretofore, and it will be understood that a variety of modifications in mode and detail may be made without departing from the gist and scope of the present disclosure as set forth in claims.

10 <Second Embodiment>

[0091] Hereinafter, portions different from those in the first embodiment will be mainly described. The present embodiment is basically the same as the first embodiment except for the contents described in the present embodiment.

(1) Configuration of Hot Water Supply System

20 **[0092]** Fig. 8 is a configuration diagram of a hot water supply system 200 (water system) in the present embodiment. A hot water storage unit 220 includes a third water boiling pipe B3 (third pipe). Furthermore, the eighth water boiling pipe B8 includes a sixth water boiling pipe B6 (sixth pipe) and a seventh water boiling pipe B7 (seventh pipe).

25 **[0093]** The third water boiling pipe B3 is connected to the first water boiling pipe B1 and extends downward. In the present modification, the third water boiling pipe B3 extends downward from the distal end of the first water boiling pipe B1. The first water boiling pipe B1, the second water boiling pipe B2, and the third water boiling pipe B3 are connected to each other. Furthermore, the third water boiling pipe B3 is connected to the sixth water boiling pipe B6 and the seventh water boiling pipe B7. The third water boiling pipe B3, the sixth water boiling pipe B6, and the seventh water boiling pipe B7 are connected to each other.

30 **[0094]** The sixth water boiling pipe B6 extends from the lower surface of the tank 21. A distal end of the sixth water boiling pipe B6 on a side opposite to the tank 21 is connected to the third water boiling pipe B3 and the seventh water boiling pipe B7.

35 **[0095]** One end of the seventh water boiling pipe B7 is connected to the third water boiling pipe B3 and the sixth water boiling pipe B6, and the other end of the seventh water boiling pipe B7 is connected to the inlet side of the water heat exchanger 12 of the heat pump unit 110. The seventh water boiling pipe B7 is provided with the water boiling pump 24.

40 **[0096]** The tank 21, the first water boiling pipe B1 to the seventh water boiling pipe B7, the first water boiling valve 22, and the water heat exchanger 12 of the heat pump unit 110 form a water boiling circuit C3 for heating the water in the tank 21.

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(2) Manner of Operation of Water Boiling Operation of Hot Water Supply System

[0097] The control unit 190 drives the water boiling pump 24 to circulate the water in the tank 21 through the first water boiling pipe B1 to the seventh water boiling pipe B7 while heating the water in the water heat exchanger 12.

[0098] For example, the control unit 190 controls the first water boiling valve 22 so as to open the fourth water boiling pipe B4 side and the fifth water boiling pipe B5 side of the first water boiling valve 22 and close the second water boiling pipe B2 side of the first water boiling valve 22. When the control unit 190 drives the water boiling pump 24 after controlling the first water boiling valve 22 as described above, the water from the low-temperature layer and the middle-temperature layer in the tank 21 is heated by the water heat exchanger 12 and is returned to the high-temperature layer in the tank 21.

(3) Detailed Structure of First Water Boiling Pipe

[0099] Fig. 9 is a view illustrating an example of a pipe B1' of related art extending from the tank 21'. As illustrated in Fig. 9, the pipe B1' extends horizontally (in the left-right direction) from the side surface of the tank 21'. The distal end of the pipe B1' on a side opposite to the tank 21' is branched into the pipe B2' and a pipe B3'. The pipe B2' extends upward from the distal end of the pipe B1', and the pipe B3' extends downward from the distal end of the pipe B1'. When a state in which water is not made to flow between the tank 21' and the pipe B1' continues, particularly the pipe B2' and the pipe B3', which are located away from the tank 21', are cooled by the ambient temperature. When the pipe B2' and the pipe B3' are cooled by the ambient temperature, the temperature in the vicinity of the inner walls inside the pipe B2' and inside the pipe B3' becomes lower than the temperature of the vicinity of the center inside the pipe B2' and inside the pipe B3', which causes a temperature difference in the pipes. At this time, as illustrated in Fig. 2, the temperature of the water in the vicinity of the inner walls inside the pipe B2' and inside the pipe B3' becomes relatively low, and the water flows downward (solid line arrows) in the pipes. In addition, the temperature of the water in the vicinity of the center inside the pipe B2' and inside the pipe B3' becomes relatively high, and the water flows upward (dotted line arrows) in the pipes. In other words, convection occurs in the water in the pipe B2' and in the pipe B3'. There is concern that, when the cooled low-temperature water in the pipe B2' or in the pipe B3' flows into the tank 21' due to the convection, the temperature stratification of the water in the tank 21' may be disrupted.

[0100] In view of the above, assume that a U-shaped pipe, for example, is used as the pipe B1' so that the low-temperature water does not flow into the tank 21'. In this case, there is concern that the water may remain at a

bottom of the U-shaped pipe when the water in the tank 21', in the water boiling circuit, and in the hot water supply circuit is discharged to the outside during maintenance or the like and that the pipe B1' may freeze and be damaged.

[0101] Fig. 10 is an enlarged view of a vicinity of the first water boiling pipe B1 in the present embodiment. As illustrated in Fig. 10, the first water boiling pipe B1 includes the gradient portion 40a rising toward the tank 21. The gradient portion 40a suppresses the water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state. As illustrated in Fig. 10, the position P1 of the lowermost portion of the flow path at the end portion of the gradient portion 40a on the tank 21 side is higher than the position P2 of the uppermost portion of the flow path at the end portion of the gradient portion 40a on a side opposite to the tank 21.

[0102] As a result, during the first state, the hot water supply system 200 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1, and can prevent the temperature stratification of the water in the tank 21 from being disrupted. Furthermore, the first water boiling pipe B1 includes the gradient portion 40a. Therefore, in the hot water supply system 200, a sufficient amount of water does not remain in the first water boiling pipe B1 when the water in the tank 21, in the water boiling circuit C3, and in the hot water supply circuit C2 is discharged to the outside by, for example, opening the water discharge valve 28 in a state in which the water stop valve 160 is closed. Thus, it is possible to prevent the first water boiling pipe B1 from freezing and being damaged.

(4) Features

[0103] The hot water supply system 200 of the present embodiment further includes the third water boiling pipe B3 (third pipe). The third water boiling pipe B3 is connected to the first water boiling pipe B1. The eighth water boiling pipe B8 includes the sixth water boiling pipe B6 (sixth pipe) and the seventh water boiling pipe B7 (seventh pipe). The sixth water boiling pipe B6 extends from the lower surface of the tank 21. The seventh water boiling pipe B7 is connected to the heat pump unit 110. The third water boiling pipe B3, the sixth water boiling pipe B6, and the seventh water boiling pipe B7 are connected to each other.

[0104] In the hot water supply system 200 of the present embodiment, the gradient portion 40a suppresses the water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state. As a result, during the first state, the hot water supply system 200 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1, and can prevent the temperature stratification

of the water in the tank 21 from being disrupted. Furthermore, in the hot water supply system 200, a sufficient amount of water does not remain in the first water boiling pipe B1 when the water in the tank 21, in the water boiling circuit C3, and in the hot water supply circuit C2 is discharged to the outside. Thus, it is possible to prevent the first water boiling pipe B1 from freezing and being damaged.

(5) Modification

(5-1) Modification 2A

[0105] In the present embodiment, the suppressing portion 40 is the gradient portion 40a. However, the suppressing portion 40 may be the gradient portion 40b or the stepped portion 40c, or as illustrated in Fig. 6, the gradient portion 40a may be a part of the first water boiling pipe B1, for example. Alternatively, for example, the fourth water boiling pipe B4 extending from the upper surface of the tank 21 may include the gradient portion 40d, as the fourth water boiling pipe B4 (first pipe), the second water boiling pipe B2 (second pipe), and the fifth water boiling pipe B5 (third pipe).

[0106] (5-2)

The embodiment of the present disclosure has been described heretofore, and it will be understood that a variety of modifications in mode and detail may be made without departing from the gist and scope of the present disclosure as set forth in claims.

<Third Embodiment>

[0107] Hereinafter, portions different from those in the first embodiment will be mainly described. The present embodiment is basically the same as the first embodiment except for the contents described in the present embodiment.

(1) Configuration of Hot Water Supply System

[0108] Fig. 11 is a configuration diagram of a hot water supply system 300 (water system) in the present embodiment. A hot water storage unit 320 includes the third water boiling pipe B3 (third pipe), the sixth water boiling pipe B6 (sixth pipe), and the seventh water boiling pipe B7 (seventh pipe).

[0109] The third water boiling pipe B3 is connected to the first water boiling pipe B1 and extends downward. In the present modification, the third water boiling pipe B3 extends downward from the distal end of the first water boiling pipe B1. Furthermore, the third water boiling pipe B3 is connected to the sixth water boiling pipe B6 and the seventh water boiling pipe B7. The third water boiling pipe B3, the sixth water boiling pipe B6, and the seventh water boiling pipe B7 are connected to each other.

[0110] The sixth water boiling pipe B6 extends from the lower surface of the tank 21. The distal end of the

sixth water boiling pipe B6 on a side opposite to the tank 21 is connected to the third water boiling pipe B3 and the seventh water boiling pipe B7.

[0111] One end of the seventh water boiling pipe B7 is connected to the third water boiling pipe B3 and the sixth water boiling pipe B6, and the other end of the seventh water boiling pipe B7 is connected to the inlet side of the water heat exchanger 12 of the heat pump unit 110. The seventh water boiling pipe B7 is provided with the water boiling pump 24.

[0112] In the present embodiment, the suppressing portion 40 is a third water boiling valve 40e (third valve). The third water boiling valve 40e is connected to an end portion of the first water boiling pipe B1 on a side opposite to the tank 21. The third water boiling valve 40e adjusts a flow path of water. The first water boiling pipe B1, the second water boiling pipe B2, and the third water boiling pipe B3 are connected to each other via the third water boiling valve 40e. The third water boiling valve 40e is a mixing valve.

[0113] The first water boiling pipe B1 extends horizontally (in the left-right direction) from the side surface of the tank 21.

[0114] The tank 21, the first water boiling pipe B1 to the seventh water boiling pipe B7, the first water boiling valve 22, the third water boiling valve 40e, and the water heat exchanger 12 of the heat pump unit 110 form a water boiling circuit C4 for heating the water in the tank 21.

[0115] The control unit 190 controls the compressor 11, the expansion valve 13, the first water boiling valve 22, the third water boiling valve 40e, the water boiling pump 24, the first hot water supply valve 25, the second hot water supply valve 26, the water discharge valve 28, and the like, on the basis of a signal from a temperature sensor (not illustrated) or the like provided in the tank 21.

(2) Manner of Operation of Water Boiling Operation of Hot Water Supply System

[0116] The control unit 190 drives the water boiling pump 24 to circulate the water in the tank 21 through the first water boiling pipe B1 to the seventh water boiling pipe B7 while heating the water in the water heat exchanger 12.

[0117] For example, the control unit 190 performs a third water boiling operation. In the third water boiling operation, the water in the tank 21 is heated by sequentially being made to pass through the first water boiling pipe B1, the third water boiling pipe B3, the seventh water boiling pipe B7, the water heat exchanger 12, the fifth water boiling pipe B5, and the fourth water boiling pipe B4. Specifically, the control unit 190 controls the first water boiling valve 22 so as to open the fourth water boiling pipe B4 side and the fifth water boiling pipe B5 side of the first water boiling valve 22 and close the second water boiling pipe B2 side of the first water boiling valve 22. Furthermore, the control unit 190 controls the third water boiling valve 40e so as to open a first water boiling pipe

B1 side and a third water boiling pipe B3 side of the third water boiling valve 40e and close a second water boiling pipe B2 side of the third water boiling valve 40e. When the control unit 190 drives the water boiling pump 24 after controlling the first water boiling valve 22 and the third water boiling valve 40e as described above, the water from the low-temperature layer and the middle-temperature layer in the tank 21 is heated by the water heat exchanger 12 and is returned to the high-temperature layer in the tank 21.

[0118] The heating of the water by the heat pump unit 110 is insufficient for a while after the start of the water boiling operation. Therefore, there is concern that, if the water from the low-temperature layer in the tank 21 is returned to the high-temperature layer in the tank 21 from the start of the water boiling operation, the temperature in the tank 21 may decrease. Therefore, the control unit 190 may perform the third water boiling operation at the start of the water boiling operation, thereafter, may control the third water boiling valve 40e so as to gradually reduce the opening degree of the third water boiling pipe B3 side of the third water boiling valve 40e and gradually increase the opening degree of the second water boiling pipe B2 side of the third water boiling valve 40e, and may finally control the third water boiling valve 40e so as to open the first water boiling pipe B1 side and the second water boiling pipe B2 side of the third water boiling valve 40e and close the third water boiling pipe B3 side of the third water boiling valve 40e. Since the control unit 190 controls the third water boiling valve 40e as described above, the water from the low-temperature layer and the middle-temperature layer in the tank 21 is returned to the high-temperature layer in the tank 21 for a while after the start of the water boiling operation. As a result, the temperature in the tank 21 is less likely to decrease.

(3) Detailed Structure of First Water Boiling Pipe

[0119] Fig. 12 is an enlarged view of a vicinity of the first water boiling pipe B1 in the present embodiment. As illustrated in Fig. 12, the suppressing portion 40 suppresses the water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state. In the present embodiment, the suppressing portion 40 is the third water boiling valve 40e. The third water boiling valve 40e is connected to the end portion of the first water boiling pipe B1 on a side opposite to the tank 21. The first water boiling pipe B1, the second water boiling pipe B2, and the third water boiling pipe B3 are connected to each other via the third water boiling valve 40e. The control unit 190 controls the third water boiling valve 40e so as to open the second water boiling pipe B2 side and the third water boiling pipe B3 side of the third water boiling valve 40e and close the first water boiling pipe B1 side of the third water boiling valve 40e during the first state.

[0120] As a result, during the first state, the hot water supply system 200 can suppress the low-temperature

water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1, and can prevent the temperature stratification of the water in the tank 21 from being disrupted.

(4) Features

[0121] (4-1)

The hot water supply system 200 of the present embodiment further includes the first water boiling valve 22, the third water boiling pipe B3 (third pipe), the fourth water boiling pipe B4, the fifth water boiling pipe B5, the sixth water boiling pipe B6 (sixth pipe), and the seventh water boiling pipe B7 (seventh pipe). The first water boiling valve 22 adjusts the flow path of the water. The third water boiling pipe B3 is connected to the first water boiling pipe B1. The fourth water boiling pipe B4 extends from the upper surface of the tank 21. The fifth water boiling pipe B5 is connected to the heat pump unit 110. The sixth water boiling pipe B6 extends from the lower surface of the tank 21. The seventh water boiling pipe B7 is connected to the heat pump unit 110. The first water boiling pipe B1 extends from the side surface of the tank 21. The fourth water boiling pipe B4, the fifth water boiling pipe B5, and the second water boiling pipe B2 are connected to each other via the first water boiling valve 22. The third water boiling pipe B3, the sixth water boiling pipe B6, and the seventh water boiling pipe B7 are connected to each other. The suppressing portion 40 is the third water boiling valve 40e (third valve). The third water boiling valve 40e is connected to the end portion of the first water boiling pipe B1 on a side opposite to the tank 21. The first water boiling pipe B1 adjusts the flow path of water. The control unit 190 controls the third water boiling valve 40e so as to open the second water boiling pipe B2 side and the third water boiling pipe B3 side of the third water boiling valve 40e and close the first water boiling pipe B1 side of the third water boiling valve 40e during the first state. The first water boiling pipe B1, the second water boiling pipe B2, and the third water boiling pipe B3 are connected to each other via the third water boiling valve 40e.

[0122] In the hot water supply system 200 of the present embodiment, the control unit 190 controls the third water boiling valve 40e so as to open the second water boiling pipe B2 side and the third water boiling pipe B3 side of the third water boiling valve 40e and close the first water boiling pipe B1 side of the third water boiling valve 40e during the first state. As a result, during the first state, the hot water supply system 200 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1, and can prevent the temperature stratification of the water in the tank 21 from being disrupted.

[0123] (4-2)

In the hot water supply system 200 of the present embodiment, the third water boiling valve 40e is a mixing

valve. An opening degree of the mixing valve is adjustable for each connected pipe.

[0124] As a result, for example, the hot water supply system 200 can return the water from the low-temperature layer and the middle-temperature layer in the tank 21 to the high-temperature layer in the tank 21 for a while after the start of the water boiling operation, and thereafter, can gradually reduce the amount of water to be returned from the middle-temperature layer to the high-temperature layer. In this manner, the hot water supply system 200 can flexibly perform the water boiling operation.

[0125] (4-3)

In the hot water supply system 200 of the present embodiment, the control unit 190 performs the third water boiling operation. In the third water boiling operation, the water in the tank 21 is heated by sequentially being made to pass through the first water boiling pipe B1, the third water boiling pipe B3, the seventh water boiling pipe B7, the heat pump unit 110, the fifth water boiling pipe B5, and the fourth water boiling pipe B4.

(5) Modification

[0126] The embodiment of the present disclosure has been described heretofore, and it will be understood that a variety of modifications in mode and detail may be made without departing from the gist and scope of the present disclosure as set forth in claims.

<Fourth Embodiment>

[0127] Hereinafter, portions different from those in the second embodiment will be mainly described. The present embodiment is basically the same as the second embodiment except for the contents described in the present embodiment.

(1) Configuration of Hot Water Supply System

[0128] Fig. 13 is a configuration diagram of a hot water supply system 400 (water system) in the present embodiment. A hot water storage unit 420 includes a second water boiling valve 23 (fourth valve).

[0129] The second water boiling valve 23 adjusts a flow path of water. The third water boiling pipe B3, the sixth water boiling pipe B6, and the seventh water boiling pipe B7 are connected to each other via the second water boiling valve 23. In the present embodiment, the second water boiling valve 23 is a mixing valve.

[0130] The tank 21, the first water boiling pipe B1 to the seventh water boiling pipe B7, the first water boiling valve 22, the second water boiling valve 23, and the water heat exchanger 12 of the heat pump unit 110 form a water boiling circuit C5 for heating the water in the tank 21.

[0131] The control unit 190 controls the compressor 11, the expansion valve 13, the first water boiling valve 22, the second water boiling valve 23, the water boiling

pump 24, the first hot water supply valve 25, the second hot water supply valve 26, the water discharge valve 28, and the like, on the basis of a signal from a temperature sensor (not illustrated) or the like provided in the tank 21.

(2) Manner of Operation of Water Boiling Operation of Hot Water Supply System

[0132] For example, the control unit 190 performs the third water boiling operation. In the third water boiling operation, the water in the tank 21 is heated by sequentially being made to pass through the first water boiling pipe B1, the third water boiling pipe B3, the seventh water boiling pipe B7, the water heat exchanger 12, the fifth water boiling pipe B5, and the fourth water boiling pipe B4. Specifically, the control unit 190 controls the first water boiling valve 22 so as to open the fourth water boiling pipe B4 side and the fifth water boiling pipe B5 side of the first water boiling valve 22 and close the second water boiling pipe B2 side of the first water boiling valve 22. Furthermore, the control unit 190 controls the second water boiling valve 23 so as to open the third water boiling pipe B3 side and a seventh water boiling pipe B7 side of the second water boiling valve 23 and close a sixth water boiling pipe B6 side of the second water boiling valve 23. The control unit 190 drives the water boiling pump 24 after controlling the first water boiling valve 22 and the second water boiling valve 23 as described above, the water from the middle-temperature layer in the tank 21 is heated by the water heat exchanger 12 and is returned to the high-temperature layer in the tank 21.

(3) Detailed Structure of First Water Boiling Pipe

[0133] As illustrated in Fig. 10, the first water boiling pipe B1 includes the gradient portion 40a rising toward the tank 21. The gradient portion 40a suppresses the water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1 during the first state. The first state is, for example, a state in which the control unit 190 closes the water discharge valve 28, stops the compressor 11 and the water boiling pump 24, and opens, in three ways, the first water boiling valve 22, the second water boiling valve 23, the first hot water supply valve 25, and the second hot water supply valve 26, and a user does not release water from the hot water supply section 140.

[0134] As a result, during the first state, the hot water supply system 200 can suppress the low-temperature water in the second water boiling pipe B2 from flowing into the tank 21 through the first water boiling pipe B1, and can prevent the temperature stratification of the water in the tank 21 from being disrupted. Furthermore, the first water boiling pipe B1 includes the gradient portion 40a. Therefore, in the hot water supply system 200, a sufficient amount of water does not remain in the first water boiling pipe B1 when the water in the tank 21, in the water boiling circuit C5, and in the hot water supply

circuit C2 is discharged to the outside by, for example, opening the water discharge valve 28 in a state in which the water stop valve 160 is closed. Thus, it is possible to prevent the first water boiling pipe B1 from freezing and being damaged.

(4) Features

[0135] (4-1)

The hot water supply system 200 of the present embodiment further includes the second water boiling valve 23 (fourth valve). The second water boiling valve 23 adjusts the flow path of the water. The third water boiling pipe B3, the sixth water boiling pipe B6, and the seventh water boiling pipe B7 are connected to each other via the second water boiling valve 23.

[0136] (4-2)

In the hot water supply system 200 of the present embodiment, the control unit 190 performs the third water boiling operation. In the third water boiling operation, the water in the tank 21 is heated by sequentially being made to pass through the first water boiling pipe B1, the third water boiling pipe B3, the seventh water boiling pipe B7, the heat pump unit 110, the fifth water boiling pipe B5, and the fourth water boiling pipe B4.

(5) Modification

[0137] The embodiment of the present disclosure has been described heretofore, and it will be understood that a variety of modifications in mode and detail may be made without departing from the gist and scope of the present disclosure as set forth in claims.

Reference Signs List

[0138]

21	TANK	
22	FIRST WATER BOILING VALVE (SECOND VALVE)	40
23	SECOND WATER BOILING VALVE (FOURTH VALVE)	
40	SUPPRESSING PORTION	
40a, 40b, 40d	GRADIENT PORTION	45
40c	STEPPED PORTION	
40e	THIRD WATER BOILING VALVE (THIRD VALVE)	
100	HOT WATER SUPPLY SYSTEM (WATER SYSTEM)	50
110	HEAT PUMP UNIT (HEAT SOURCE DEVICE)	
190	CONTROL UNIT	
B1	FIRST WATER BOILING PIPE (FIRST PIPE)	55
B2	SECOND WATER BOILING PIPE (SECOND PIPE)	
B3	THIRD WATER BOILING PIPE	

	(THIRD PIPE)	
B4	FOURTH WATER BOILING PIPE (FOURTH PIPE, FIRST PIPE)	
B5	FIFTH WATER BOILING PIPE (FIFTH PIPE, SECOND PIPE)	
B6	SIXTH WATER BOILING PIPE (SIXTH PIPE)	
B7	SEVENTH WATER BOILING PIPE (SEVENTH PIPE)	
B8	EIGHTH WATER BOILING PIPE (EIGHTH PIPE)	
C1, C3 to C5	WATER BOILING CIRCUIT	
P1, P2, P5 to P8	POSITION	

15 Citation List

Patent Literature

20 [0139] PTL 1: Japanese Unexamined Patent Application Publication No. 2012-042090

Claims

- 25 1. A water system (100) comprising:
- a tank (21) that stores water;
 - a first pipe (B1, B4) extending from the tank;
 - a second pipe (B2, B5) connected to the first pipe;
 - a heat source device (110) that heats water; and
 - a control unit (190), wherein
- 30 the first pipe includes a suppressing portion (40), the suppressing portion suppresses water in the second pipe from flowing into the tank through the first pipe during a first state in which water is not made to flow between the tank and the first pipe, and
- 35 the first pipe, the second pipe, and the heat source device form a water boiling circuit (C1, C3 to C5) for heating the water in the tank.
2. The water system (100) according to claim 1, wherein
- 45 the suppressing portion is a gradient portion (40a, 40b, 40d) or a stepped portion (40c) rising toward the tank.
3. The water system (100) according to claim 2, wherein
- 50 a position (P1, P5, P7) of a lowermost portion of a flow path at an end portion of the gradient portion or the stepped portion on a tank side is higher than a position (P2, P6, P8) of an uppermost portion of the flow path at an end portion of the gradient portion or the stepped portion on a side opposite to the tank.
- 55 4. The water system (100) according to claim 1, where-

- in
the suppressing portion is a first valve provided in
the first pipe.
5. The water system (100) according to any one of
claims 1 to 4, further comprising:
- a second valve (22) that adjusts a flow path of
water;
- a fourth pipe (B4) extending from an upper sur-
face of the tank;
- a fifth pipe (B5) connected to the heat source
device; and
- an eighth pipe (B8) extending from a lower sur-
face of the tank and connected to the heat
source device, wherein
- the first pipe extends from a side surface of the
tank,
- the fourth pipe, the fifth pipe, and the second
pipe are connected to each other via the second
valve, and
- the control unit controls the second valve so as
to open a second pipe side of the second valve
during the first state.
6. The water system (100) according to claim 5, where-
in
the control unit performs a first water boiling opera-
tion in which the water in the tank is heated by se-
quentially being made to pass through the eighth
pipe, the heat source device, the fifth pipe, and the
fourth pipe.
7. The water system (100) according to claim 5 or 6,
wherein
the control unit performs a second water boiling op-
eration in which the water in the tank is heated by
sequentially being made to pass through the eighth
pipe, the heat source device, the fifth pipe, the sec-
ond pipe, and the first pipe.
8. The water system (100) according to any one of
claims 5 to 7, further comprising
- a third pipe (B3) connected to the first pipe,
wherein
- the eighth pipe includes a sixth pipe (B6) extend-
ing from the lower surface of the tank and a sev-
enth pipe (B7) connected to the heat source de-
vice, and
- the third pipe, the sixth pipe, and the seventh
pipe are connected to each other.
9. The water system (100) according to claim 1, further
comprising:
- a second valve (22) that adjusts a flow path of
water;
- a third pipe (B3) connected to the first pipe;
- a fourth pipe (B4) extending from an upper sur-
face of the tank;
- a fifth pipe (B5) connected to the heat source
device;
- a sixth pipe (B6) extending from a lower surface
of the tank; and
- a seventh pipe (B7) connected to the heat
source device, wherein
- the first pipe extends from a side surface of the
tank,
- the fourth pipe, the fifth pipe, and the second
pipe are connected to each other via the second
valve,
- the third pipe, the sixth pipe, and the seventh
pipe are connected to each other,
- the suppressing portion is a third valve (40e) that
is connected to an end portion of the first pipe
on a side opposite to the tank and adjusts a flow
path of water,
- the control unit controls the third valve so as to
open a second pipe side and a third pipe side
of the third valve and close a first pipe side of
the third valve during the first state, and
- the first pipe, the second pipe, and the third pipe
are connected to each other via the third valve.
10. The water system (100) according to claim 9, where-
in
the third valve is a mixing valve, an opening degree
of which is adjustable for each connected pipe.
11. The water system (100) according to claim 9, where-
in
the control unit performs a third water boiling op-
eration in which the water in the tank is heated by se-
quentially being made to pass through the first pipe,
the third pipe, the seventh pipe, the heat source de-
vice, the fifth pipe, and the fourth pipe.
12. The water system (100) according to claim 8, further
comprising
- a fourth valve (23) that adjusts a flow path of
water, wherein
- the third pipe, the sixth pipe, and the seventh
pipe are connected to each other via the fourth
valve.
13. The water system (100) according to claim 12,
wherein
the control unit performs a third water boiling op-
eration in which the water in the tank is heated by se-
quentially being made to pass through the first pipe,
the third pipe, the seventh pipe, the heat source de-
vice, the fifth pipe, and the fourth pipe.

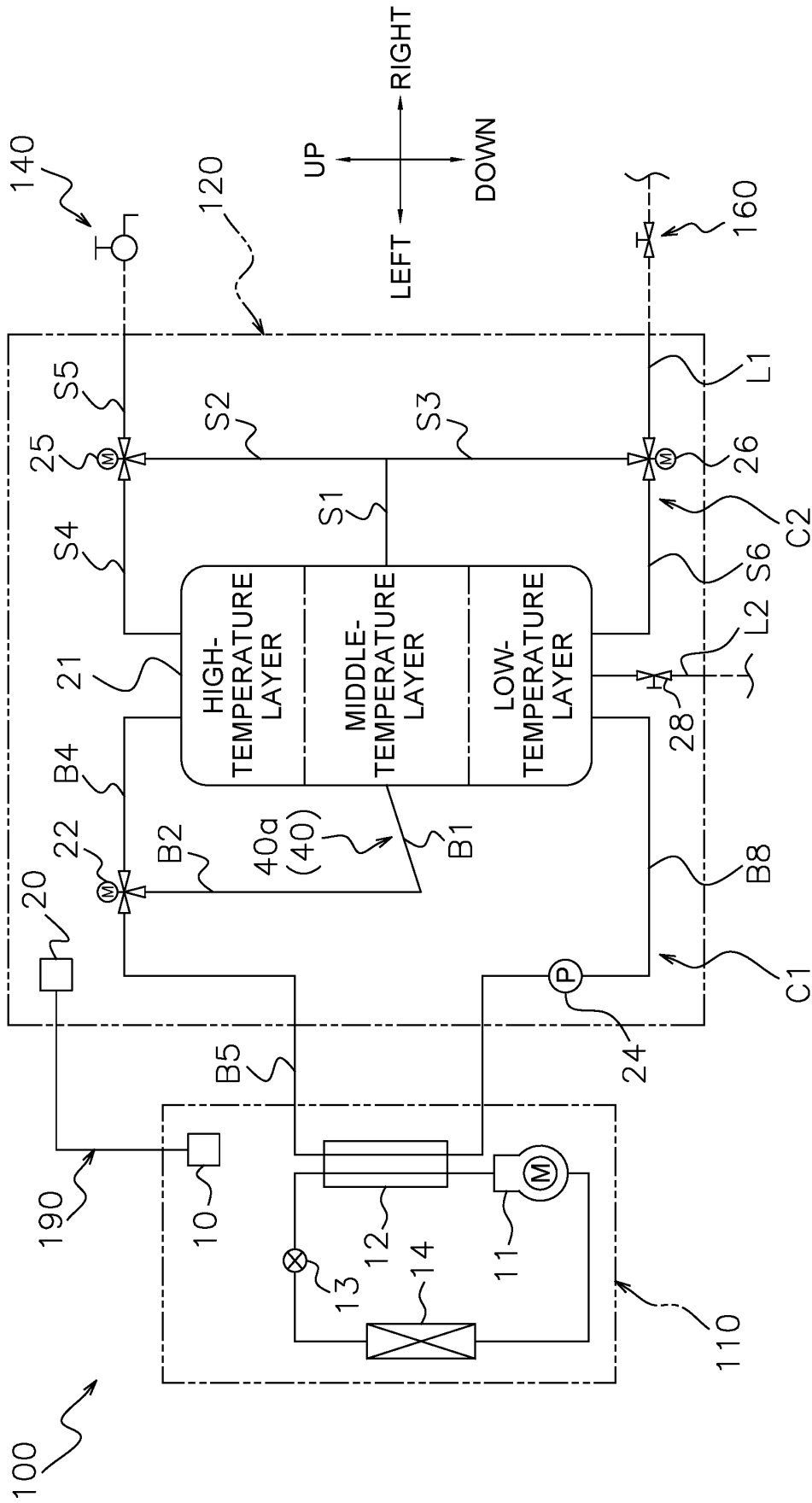


FIG. 1

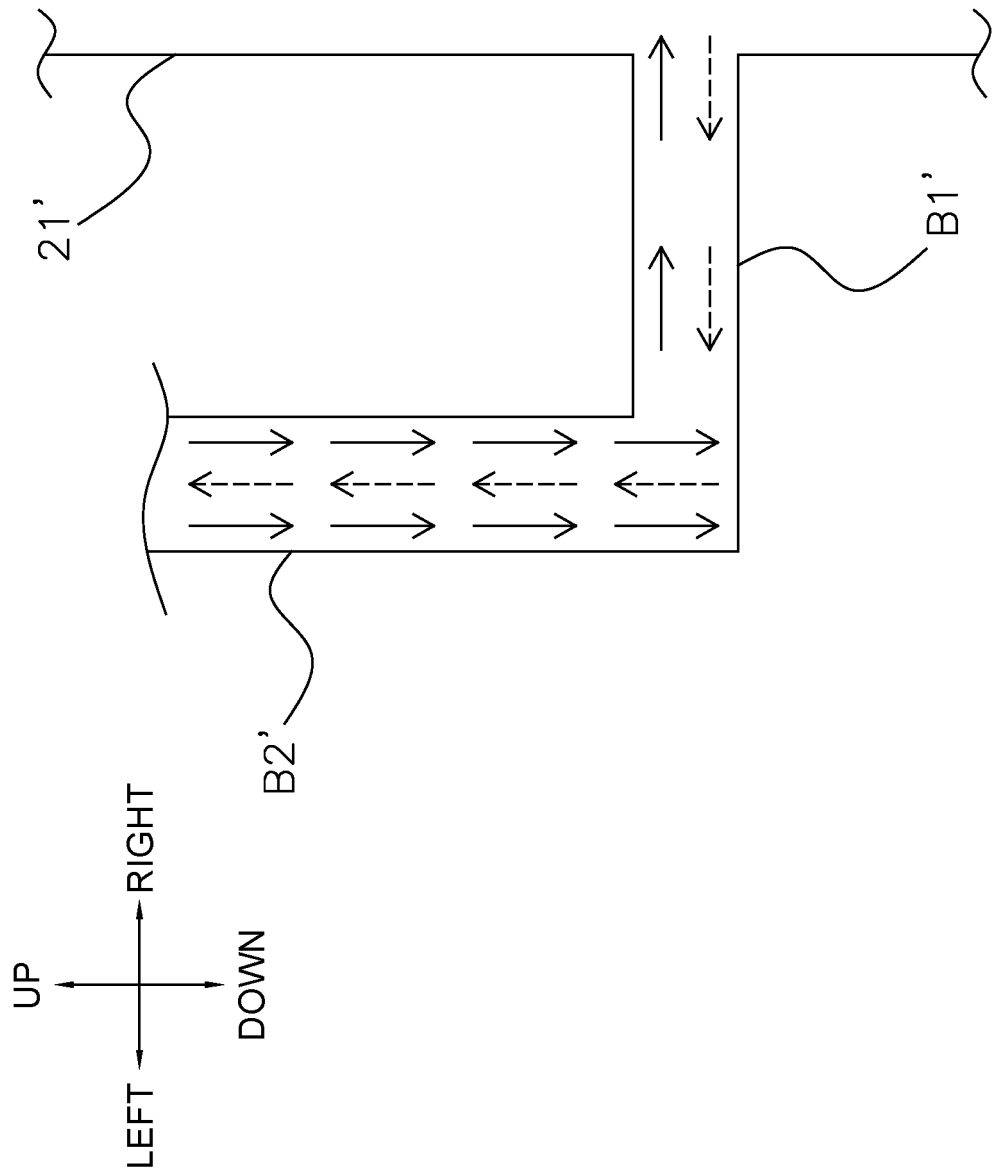


FIG. 2

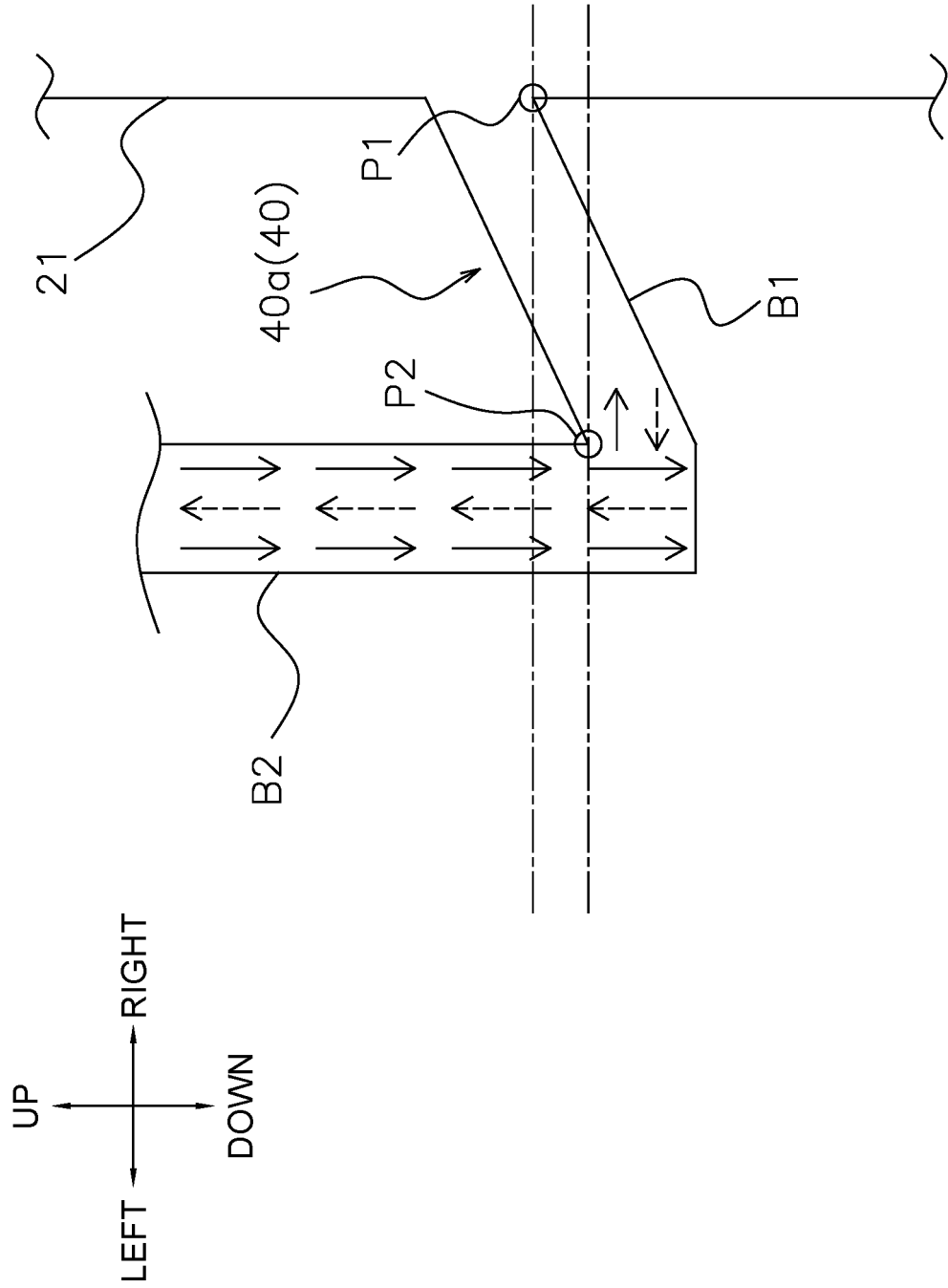


FIG. 3

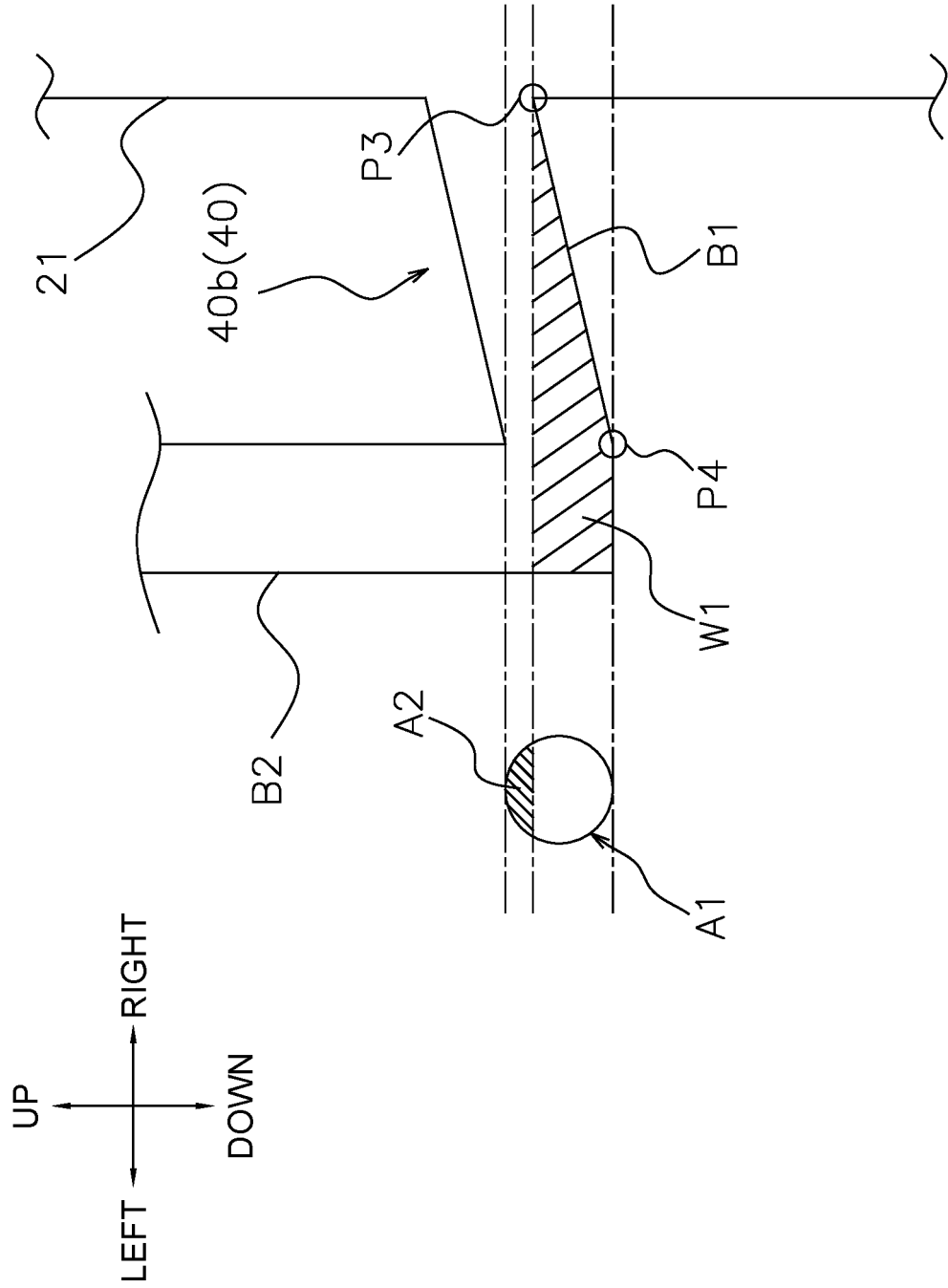


FIG. 4

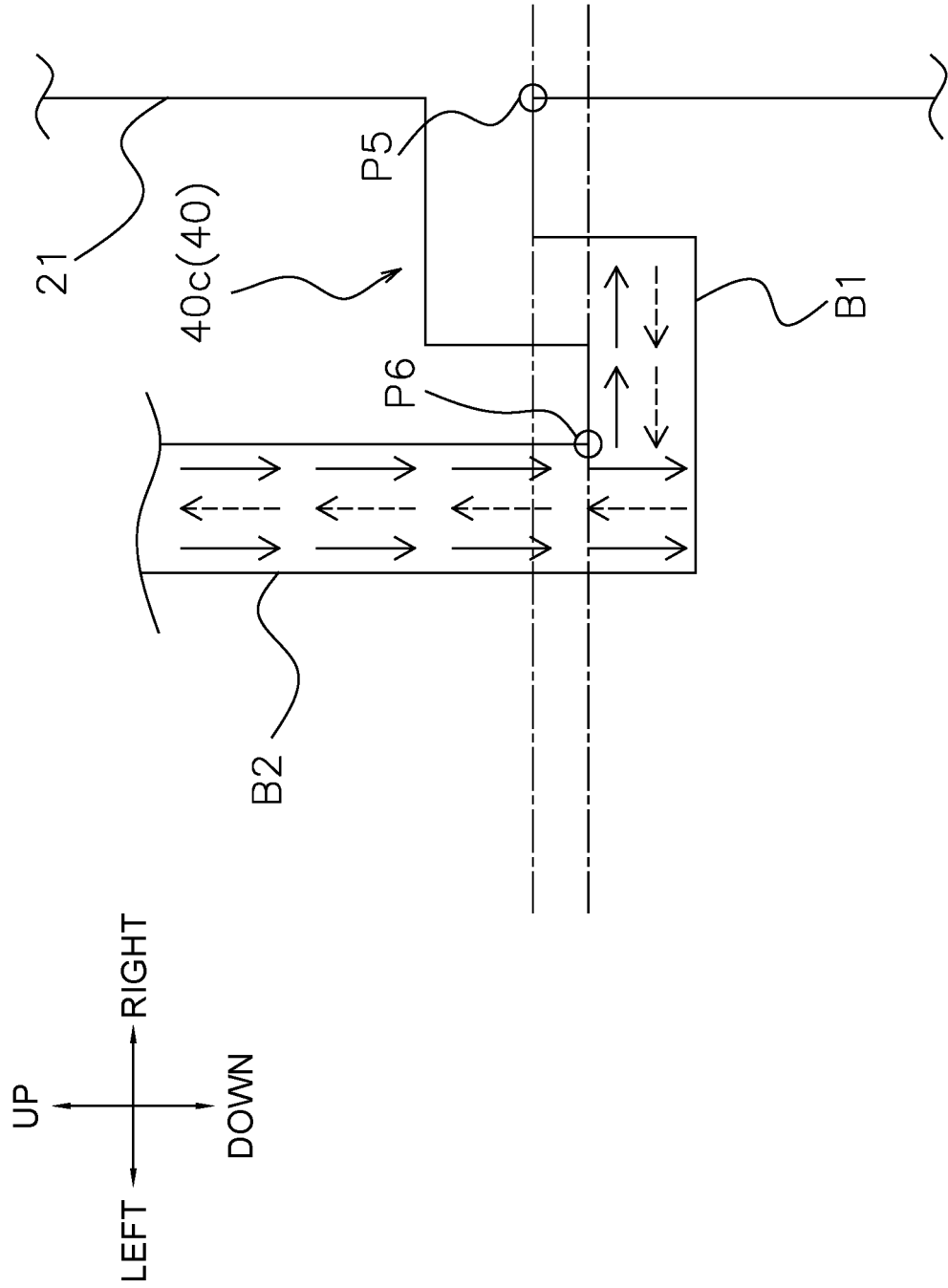


FIG. 5

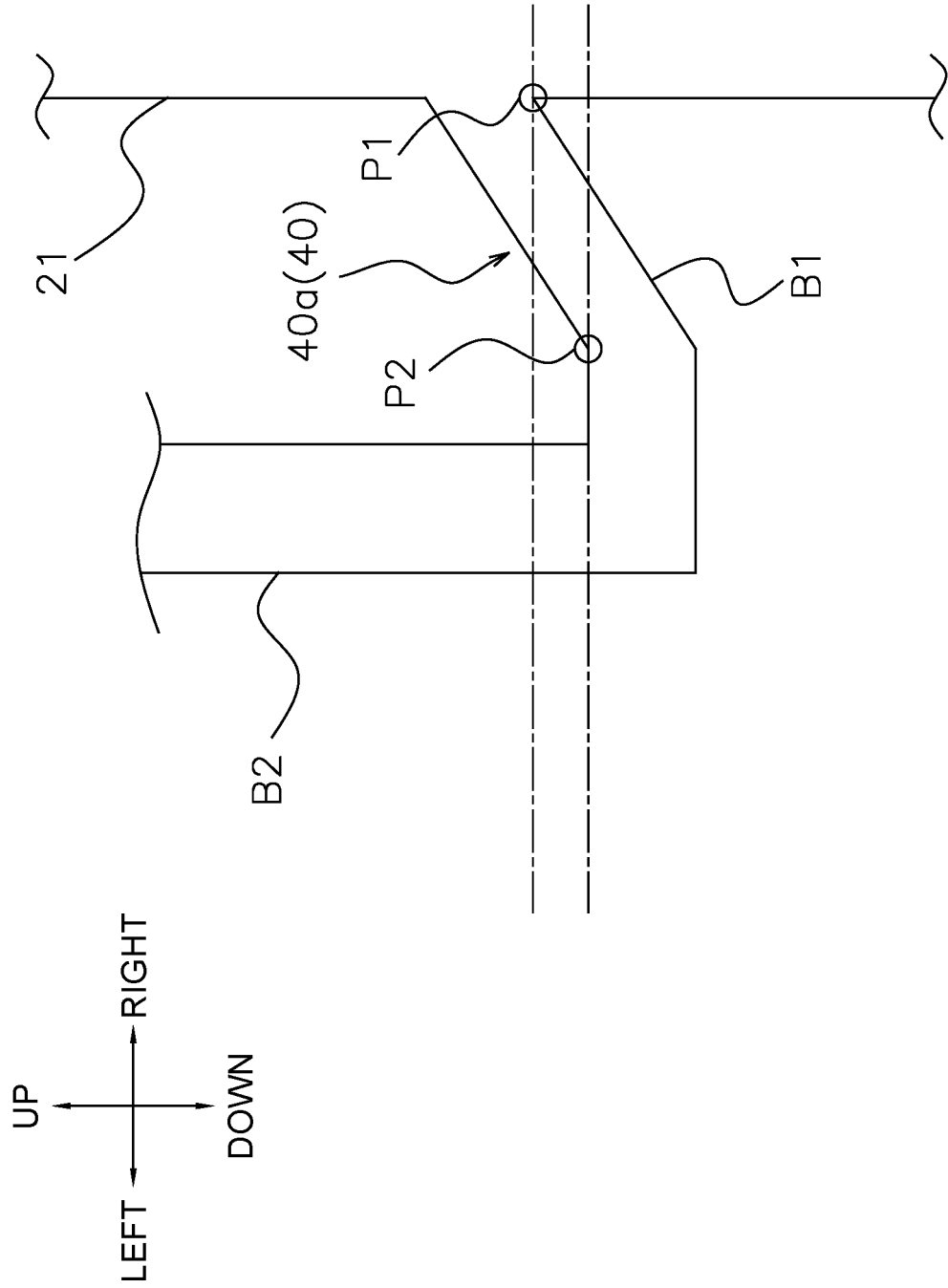


FIG. 6

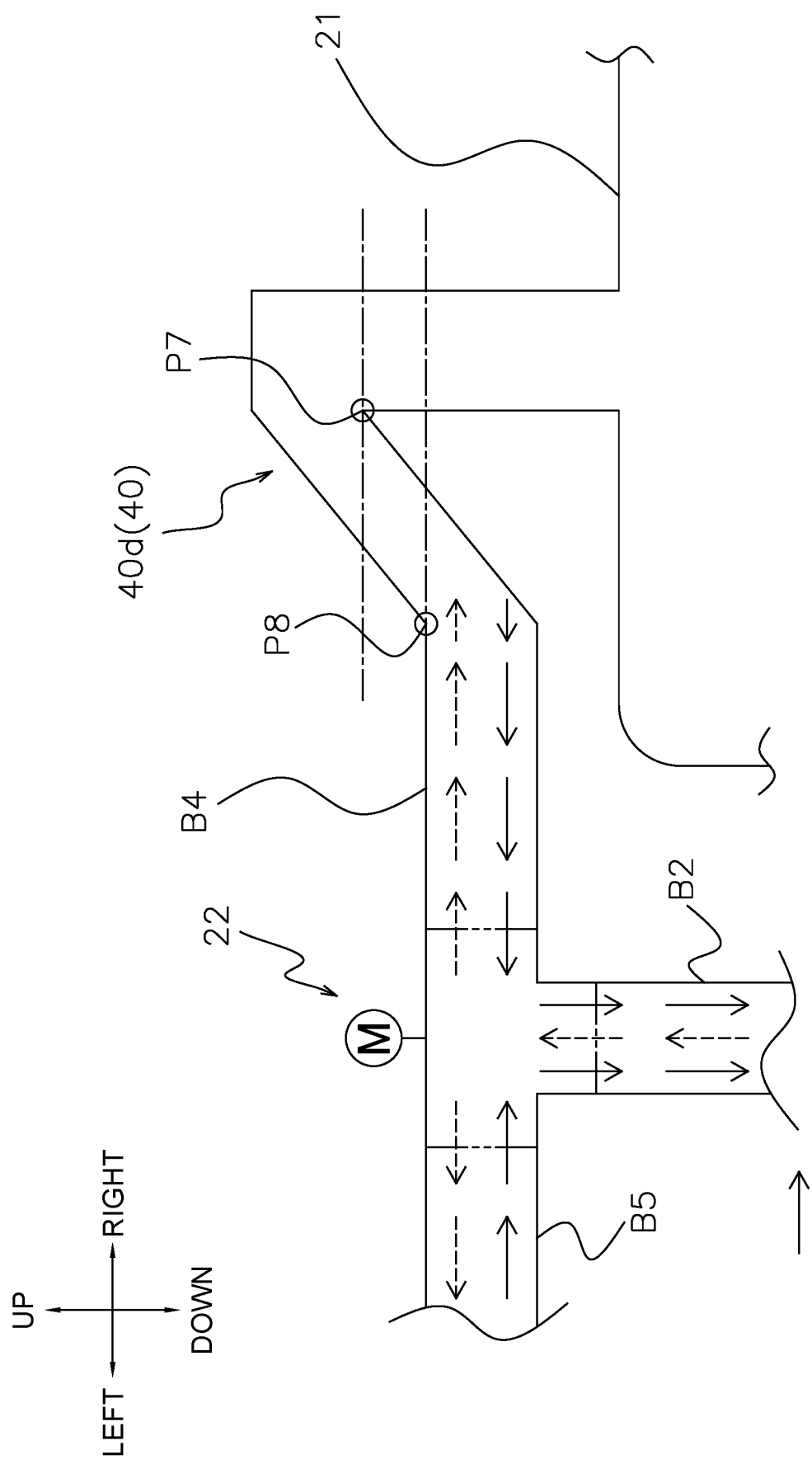


FIG. 7

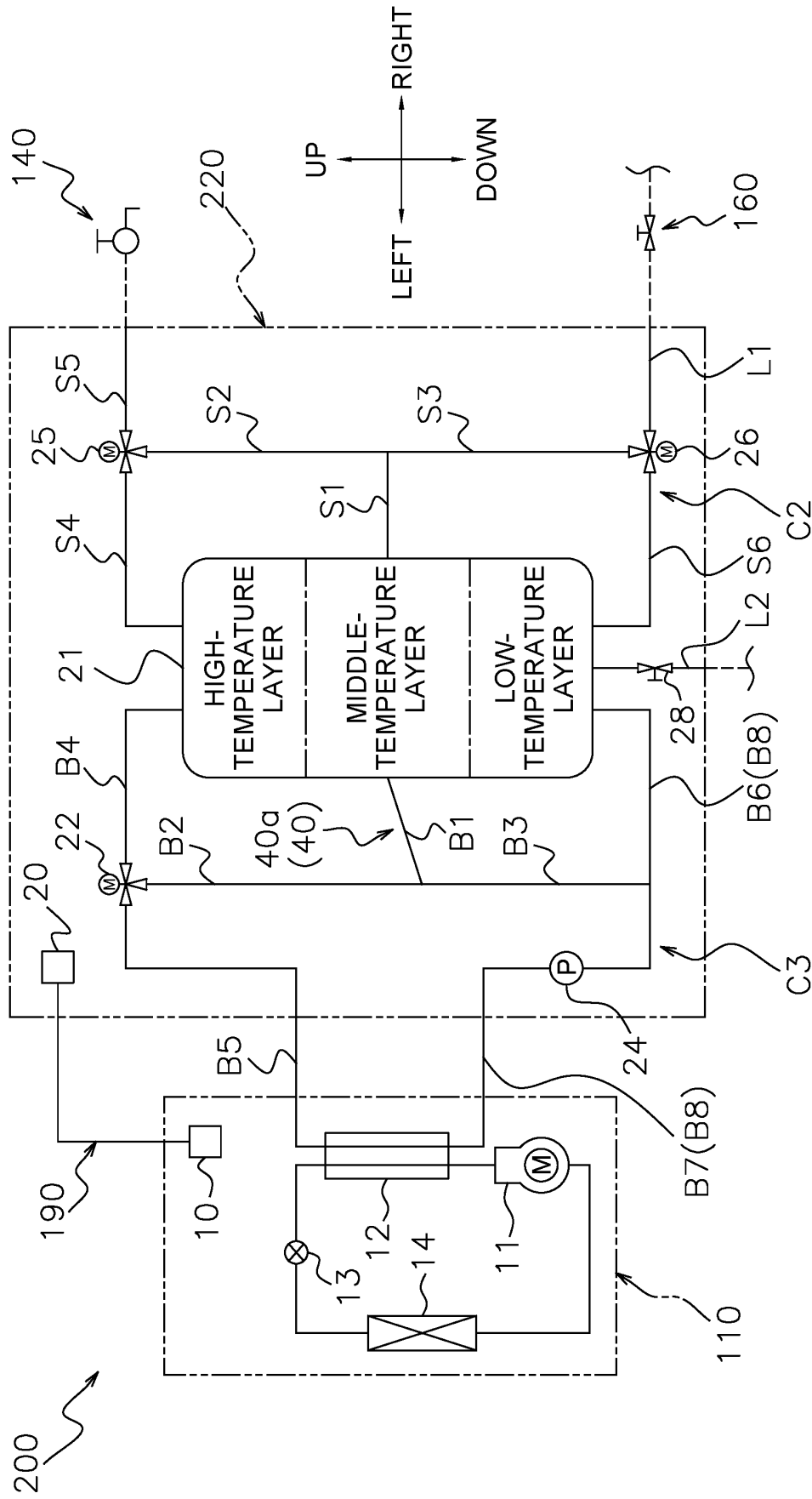


FIG. 8

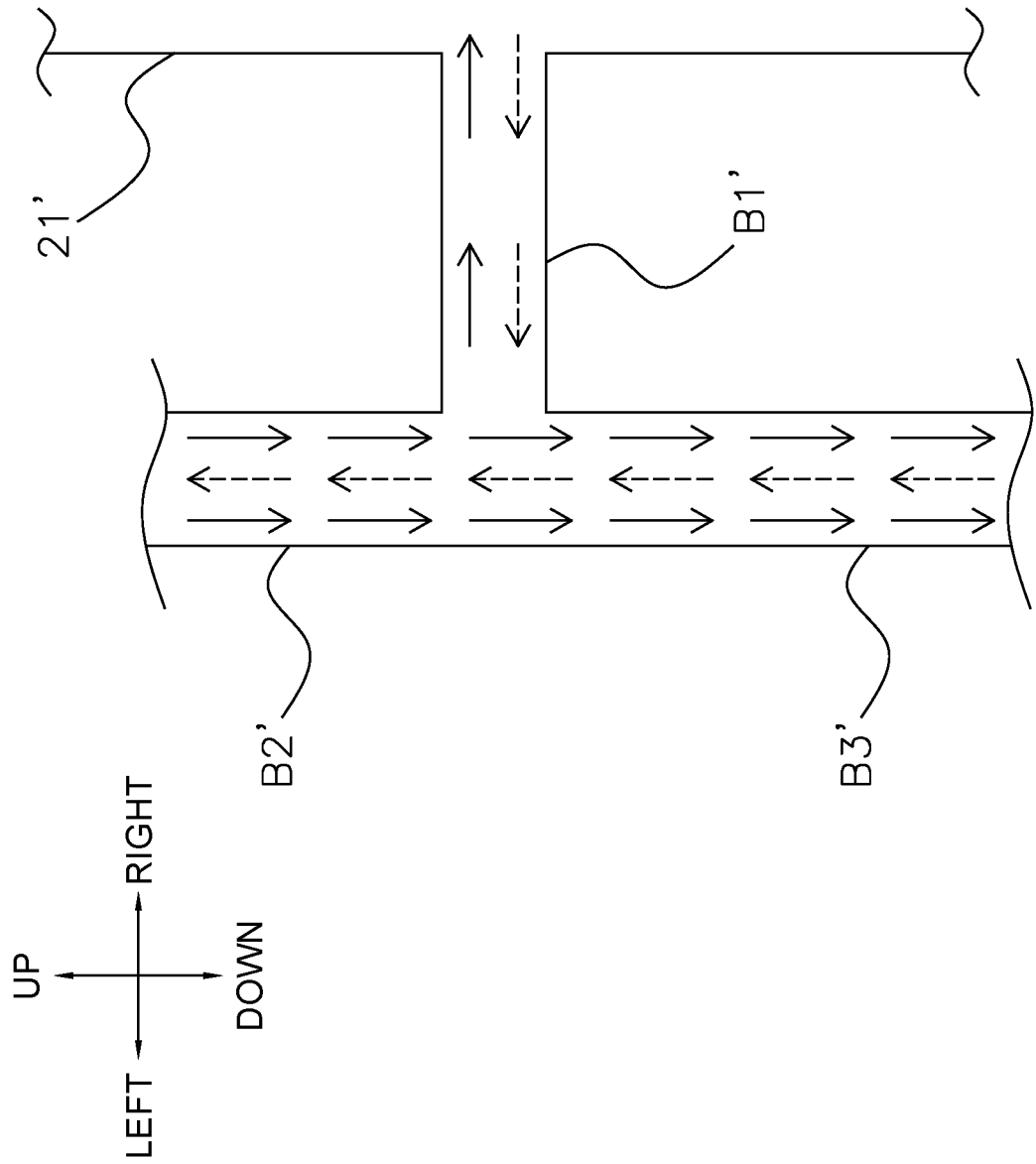


FIG. 9

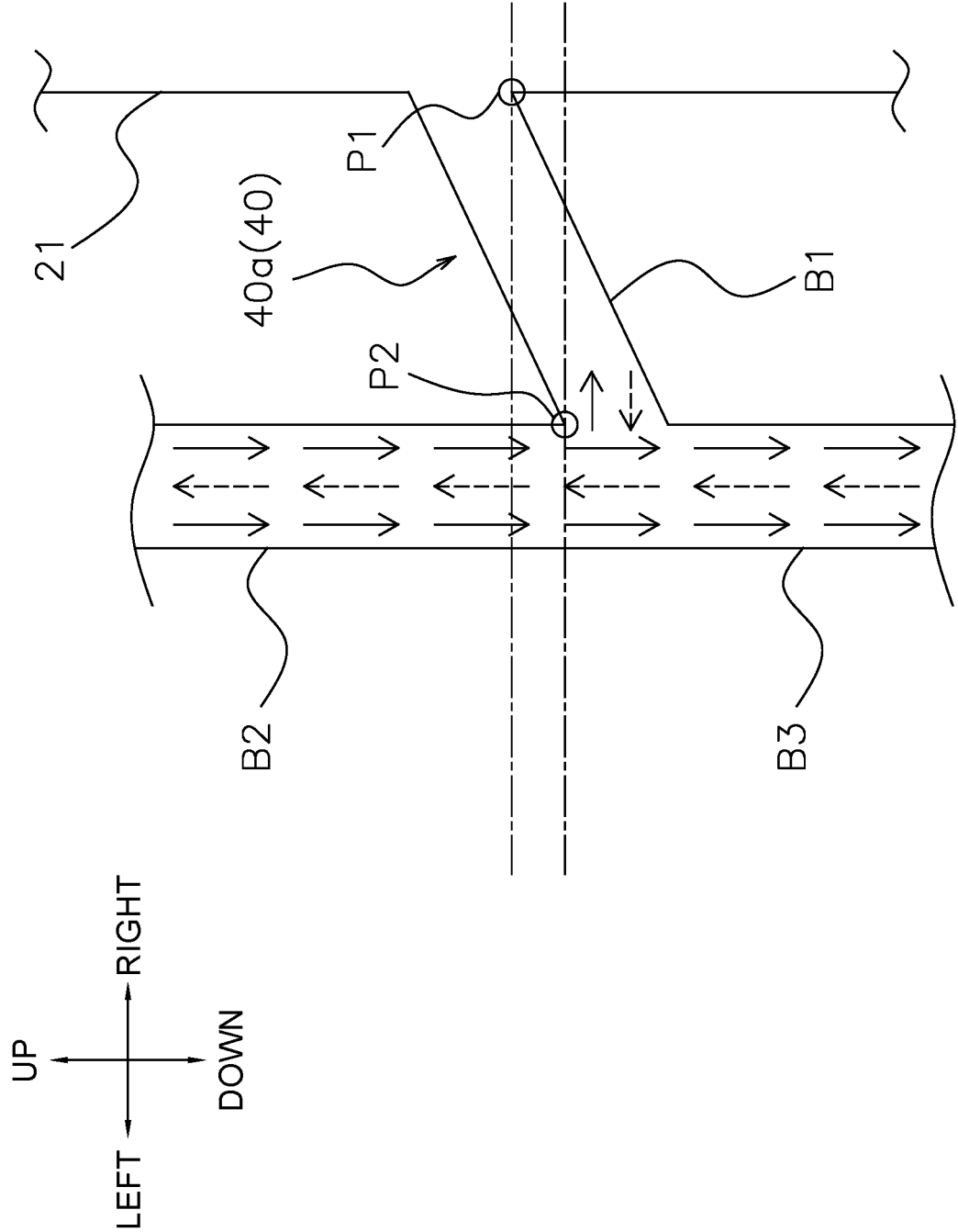


FIG. 10

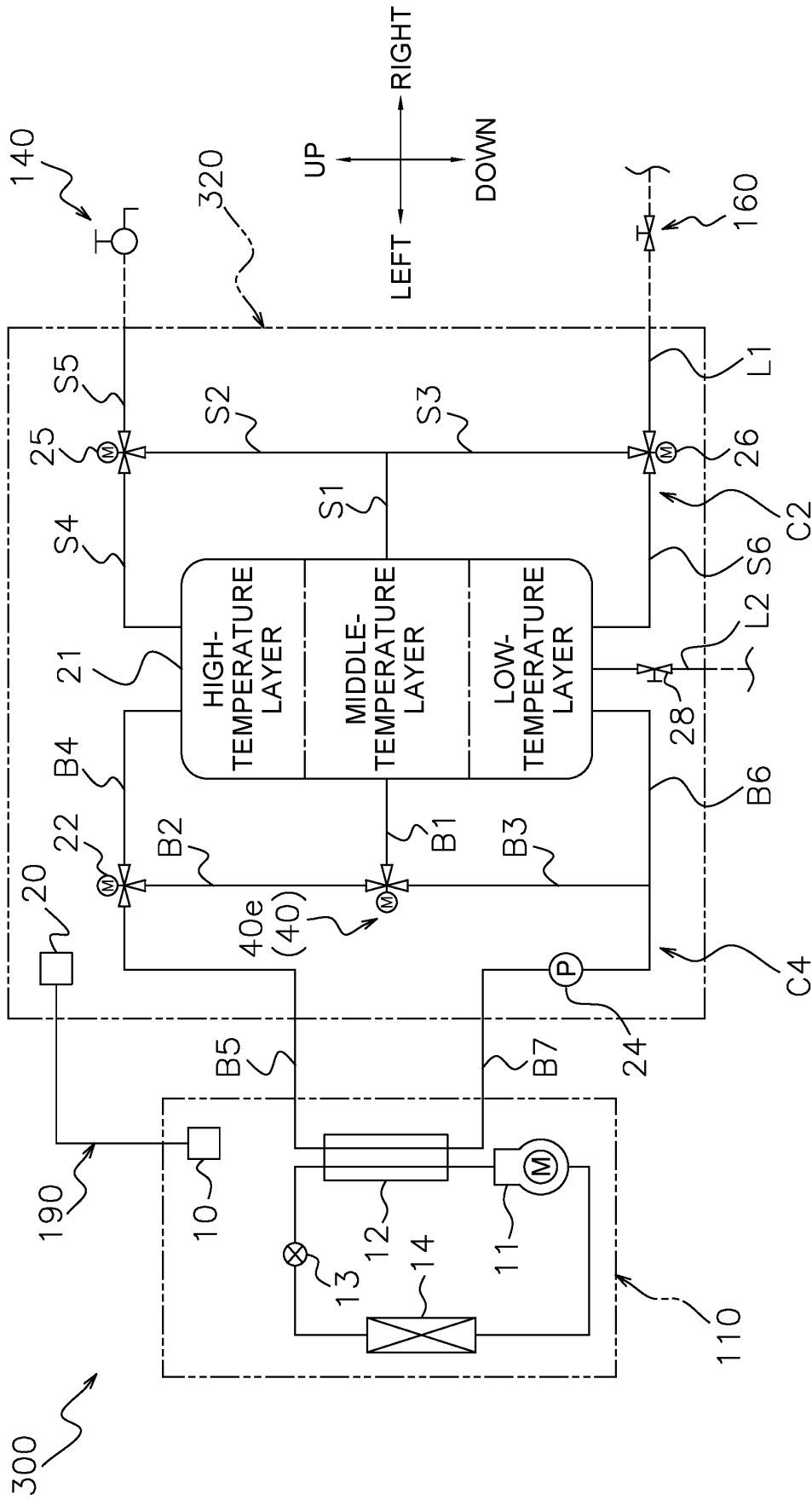


FIG. 11

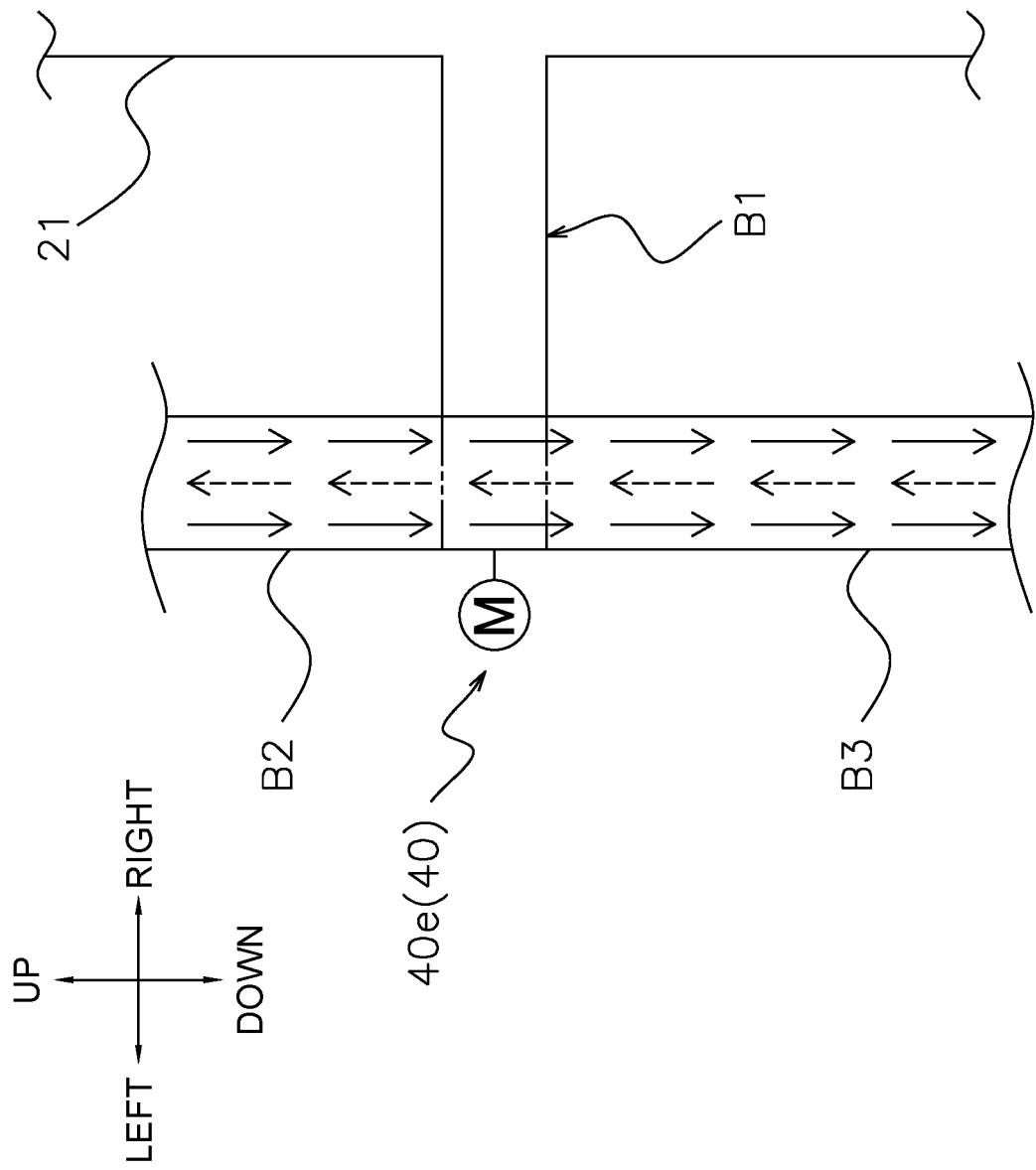


FIG. 12

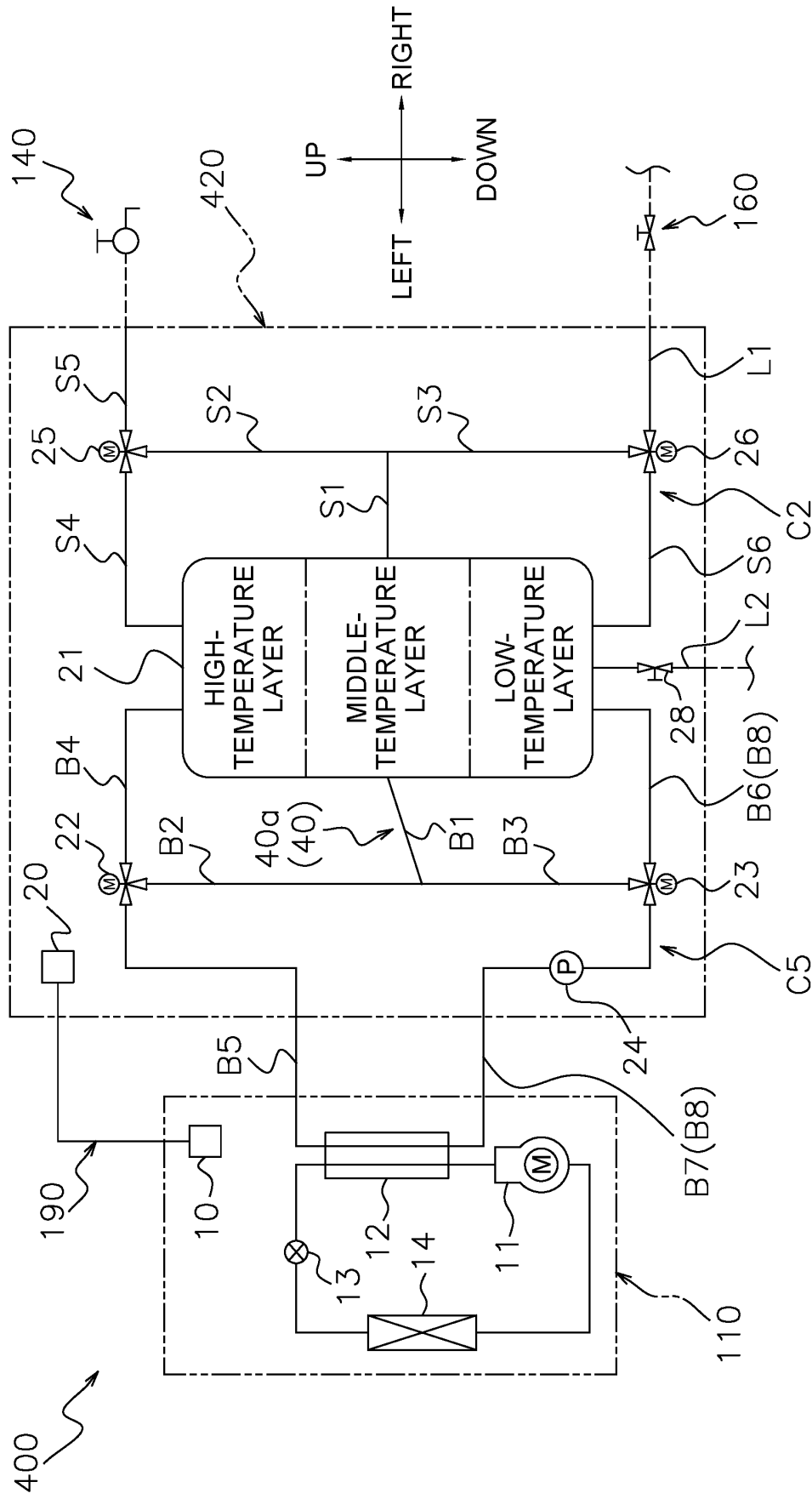


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/012910

5	A. CLASSIFICATION OF SUBJECT MATTER F24H 1/18 (2022.01)i; F24H 4/02 (2022.01)i; F24H 9/00 (2022.01)i FI: F24H1/18 H; F24H4/02 G; F24H9/00 E According to International Patent Classification (IPC) or to both national classification and IPC		
10	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F24H1/00-15/493 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2024 Registered utility model specifications of Japan 1996-2024 Published registered utility model applications of Japan 1994-2024 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
15			
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT		
	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	X	JP 2000-55468 A (OSAKA GAS CO., LTD.) 25 February 2000 (2000-02-25) in particular, paragraphs [0008]-[0010], fig. 1	1,4
25	A		2-3, 5-13
	X	JP 2021-8966 A (CORONA CORP.) 28 January 2021 (2021-01-28) in particular, paragraphs [0012]-[0043], fig. 1	1,4
	A		2-3, 5-13
30	X	CN 215372947 U (GUANGDONG PHNIX ECO-ENERGY SOLUTION LTD.) 31 December 2021 (2021-12-31) in particular, paragraphs [0027]-[0037], fig. 1-5	1,4
	A		2-3, 5-13
	A	JP 2012-42090 A (PANASONIC CORPORATION) 01 March 2012 (2012-03-01) in particular, paragraphs [0019]-[0046], fig. 1, 8	1-13
35			
	☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
40	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
45			
	Date of the actual completion of the international search		Date of mailing of the international search report
	20 May 2024		28 May 2024
50	Name and mailing address of the ISA/JP		Authorized officer
	Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan		
			Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/012910

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2006-10188 A (CORONA CORP.) 12 January 2006 (2006-01-12) in particular, paragraphs [0014]-[0036], fig. 1-3	1-13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2024/012910

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP	2000-55468	A	25 February 2000	(Family: none)	
JP	2021-8966	A	28 January 2021	(Family: none)	
CN	215372947	U	31 December 2021	(Family: none)	
JP	2012-42090	A	01 March 2012	(Family: none)	
JP	2014-105949	A	09 June 2014	(Family: none)	
JP	2006-10188	A	12 January 2006	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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