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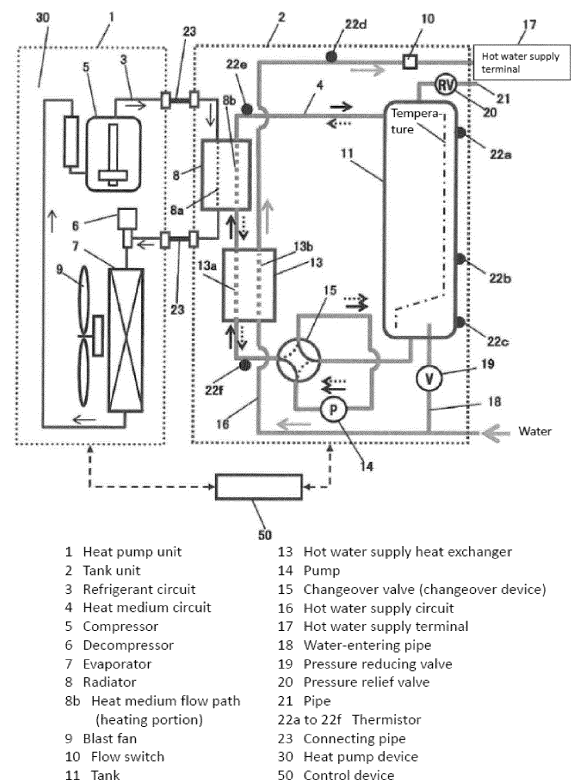
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(54) **HOT-WATER SUPPLY DEVICE**

(57) A water heater includes: a heat medium circuit 4 in which a lower portion and an upper portion of a tank 11 storing heat medium therein are annularly connected to each other through a heat medium pipe; a heating device 30; a pump (14, 31); and a hot water supply circuit 16. The water heater includes a hot water supply heat exchanger 13 which exchanges heat between the heat medium flowing through the heat medium circuit 4 and the water flowing through the hot water supply circuit 16. Since the heat medium circuit 4 is a closed circuit, it is possible to use water including much hard component. It is possible to heat the heat medium and to heat water supplied to the hot water supply terminal by the single heat medium circuit 4. Therefore, it is possible to reduce the water heater in size and cost.

[Fig. 1]



Description

[TECHNICAL FIELD]

[0001] The present invention relates to a water heater.

[BACKGROUND TECHNIQUE]

[0002] As a conventional water heater, there is one having a tank in which heat exchanger is stored (see patent document 1 for example).

[0003] As shown in Fig. 14, this water heater includes a heat accumulation tank in which heat medium is stored, a heat pump unit for heating the heat medium, a general hot water supply circuit for supplying hot water to the general hot water supply terminal, a bathtub hot water supply circuit for supplying hot water to a bathtub, a hot water supply heating circuit through which high temperature heat medium stored in the heat accumulation tank flows, and a hot water supply heat exchanger for exchanges heat between the high temperature heat medium flowing through the hot water supply heating circuit and water supplied from a water pipe.

[0004] This water heater stores heat medium heated by the heat pump unit in the heat accumulation tank, heat is exchanged between the heat medium stored in the heat accumulation tank and water supplied from the water pipe, thereby producing hot water.

[0005] According to this configuration, the heat medium only circulates through the water circuit formed by annularly connecting the heat pump unit and the heat accumulation tank with each other, and through the hot water supply heating circuit formed by annularly connecting the hot water supply heat exchanger and the heat accumulation tank with each other, and the heat medium is not supplied to the general hot water supply terminal or the bathtub. That is, the heat medium circulates through a closed circuit. According to this, water including much hard components does not always flow into the heat pump unit, precipitation of scale (formed by solidifying calcium component in water) is suppressed, and it is possible to obtain water having much hard components.

[PRIOR ART DOCUMENT]

[PATENT DOCUMENT]

[0006] [PATENT DOCUMENT 1] Japanese Patent Application Laid-open No.2012-7802

[SUMMARY OF THE INVENTION]

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0007] According to this conventional configuration, however, the water circuit formed by annularly connecting the heat pump unit and the heat accumulation tank

with each other, and the hot water supply heating circuit formed by annularly connecting the hot water supply heat exchanger and the heat accumulation tank with each other are separately provided. Further, pumps through which fluid circulates are mounted in each of the circuits. According to this, there are problems that the water heater is increased in size and costs there is increased.

[0008] The present invention is accomplished to solve the conventional problem, and it is an object of the invention to provide a small inexpensive water heater capable of using water including much hard components.

[MEANS FOR SOLVING THE PROBLEM]

[0009] To solve the conventional problem, the present invention provides a water heater comprising: a heat medium circuit in which a lower portion and an upper portion of a tank storing heat medium therein are annularly connected to each other through a heat medium pipe and the heat medium circulating through the heat medium circuit; a heating device for heating the heat medium; a pump placed on the heat medium circuit and circulating the heat medium therethrough; and a hot water supply circuit in which water supplied from a water pipe flows to a hot water supply terminal, wherein the water heater includes a heat exchanger which exchanges heat between the heat medium flowing through the heat medium circuit and the water flowing through the hot water supply circuit.

[0010] According to this, the heat medium circuit becomes a closed circuit. Further, the heat exchanger is configured such that heat is exchanged between the heat medium which flows through the heat medium circuit and water which flows through the hot water supply circuit. Therefore, it is possible to heat the heat medium and water supplied to the hot water supply terminal by one heat medium circuit.

[EFFECT OF THE INVENTION]

[0011] According to the present invention, it is possible to provide a small inexpensive water heater capable of using water including much hard components.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0012]

Fig. 1 is a schematic block diagram of a water heater in a first embodiment of the present invention;

Fig. 2 is a graph showing solubility curve of calcium carbonate (CaCO_3);

Fig. 3 is a schematic block diagram of a water heater in a second embodiment of the invention;

Fig. 4 is a schematic block diagram of a water heater in a third embodiment of the invention;

Fig. 5 is a schematic block diagram of a water heater in a fourth embodiment of the invention;

Fig. 6 is a schematic block diagram of a water heater in a fifth embodiment of the invention;

Fig. 7 is a schematic block diagram of a water heater in a sixth embodiment of the invention;

Fig. 8 is a schematic block diagram of a water heater in a seventh embodiment of the invention;

Fig. 9 is a schematic block diagram of a water heater in an eighth embodiment of the invention;

Fig. 10(a) is a schematic perspective view a three-way heat exchanger in a water heater in a ninth embodiment of the invention, and Fig. 10(b) is a schematic sectional view of the three-way heat exchanger;

Fig. 11 is a schematic block diagram of a water heater in a tenth embodiment of the invention;

Fig. 12 is a schematic block diagram of a water heater in an eleventh embodiment of the invention;

Fig. 13 is a schematic block diagram of a water heater in a twelfth embodiment of the invention; and

Fig. 14 is a schematic block diagram of a conventional water heater.

[MODE FOR CARRYING OUT THE INVENTION]

[0013] First aspect of the present invention provides a water heater comprising: a heat medium circuit in which a lower portion and an upper portion of a tank storing heat medium therein are annularly connected to each other through a heat medium pipe and the heat medium circulating through the heat medium circuit; a heating device for heating the heat medium; a pump placed on the heat medium circuit and circulating the heat medium therethrough; and a hot water supply circuit in which water supplied from a water pipe flows to a hot water supply terminal, wherein the water heater includes a heat exchanger which exchanges heat between the heat medium flowing through the heat medium circuit and the water flowing through the hot water supply circuit.

[0014] According to this, the heat medium circuit becomes a closed circuit. Heat medium flowing through the heat medium circuit heats three-way. Therefore, precipitation of scale (formed by solidifying calcium component in water) in the vicinity of a high temperature portion in the water heater, especially in the vicinity of a heating device is suppressed. Hence, it is possible to provide a water heater capable of using water including much hard components.

[0015] Water supplied from the water pipe and which flows into the hot water supply circuit flows toward a hot water supply terminal by pressure (water pressure) of water flowing through the water pipe. According to this, it is possible to secure a flow rate of hot water supplied from the hot water supply terminal. Hence, usability of a user can be enhanced.

[0016] It is possible to heat the heat medium and water to be supplied to the hot water supply terminal by the one heat medium circuit, and it is possible to reduce the number of pumps. Hence, it is possible to reduce the hot

water in both size and cost.

[0017] According to a second aspect, especially in the first aspect, the heat medium circuit is provided with a heating portion in which the heat medium is heated by the heating device, and the heat exchanger is a hot water supply heat exchanger including a heat medium flow path through which the heat medium flows and a water flow path through which the water flows.

[0018] In the hot water supply heat exchanger, heat is exchanged between water supplied from the water pipe and heat medium. Temperature of hot water supplied to a shower, a faucet or a bathtub as a general hot water supply terminal is about 50° at the highest. Scale is prone to be precipitated when temperature of water is higher. Hence, in the hot water supply heat exchanger having lower temperature as compared with a heating portion, scale is less prone to be precipitated.

[0019] According to a third aspect, especially in the second aspect, the heating device is a heat pump device having a refrigerant circuit formed by annularly connecting a compressor, a radiator, a decompressor and an evaporator to one another, refrigerant circulates through the refrigerant circuit, and the radiator exchanges heat between the refrigerant flowing through the refrigerant circuit and the heat medium flowing through the heat medium circuit.

[0020] According to this, it is possible to realize an energy saving water heater.

[0021] According to a fourth aspect, especially in the third aspect, the water heater further includes control device, the control device executes a heating operation in which the refrigerant and heat medium flow in opposed directions in the radiator, and a hot water supplying operation in which the heat medium and the water flow in opposed directions in the hot water supply heat exchanger.

[0022] According to this, refrigerant and heat medium are made to flow in the opposed directions, and heat exchanging efficiency of a heating operation for heating the heat medium can be enhanced. Further, heat medium and water are made to flow in the opposed directions, and heat exchanging efficiency of a hot water supply operation for heating water can be enhanced. That is, the one heat medium circuit is used for both a heating operation and a hot water supply operation, and it is possible to enhance the energy saving performance of the water heater.

[0023] According to a fifth aspect, especially in the fourth aspect, the control device executes a hot water supply auxiliary operation in which the refrigerant and the heat medium exchange heat with each other in the radiator and the heat medium and the water exchange heat with each other in the hot water supply heat exchanger.

[0024] If the hot water supply operation is carried out in a state where high temperature heat medium in the tank is reduced, water is not sufficiently heated only by heat exchange between water and heat medium in the

hot water supply heat exchanger in some cases. In such a case, the control device operates the heat pump device, heat medium is heated in the radiator, and simultaneously, water is heated in the hot water supply heat exchanger. According to this, it is possible to supply hot water to the hot water supply terminal.

[0025] That is, when the high temperature heat medium in the tank is reduced, hot water can be produced by simultaneously heating the heat medium by refrigerant and heating water by heat medium. Therefore, it is possible to realize a water heater in which user's comfort is enhanced.

[0026] According to a sixth aspect, especially in the first aspect, the heating device is a heat pump device having a refrigerant circuit through which refrigerant circulates, and heating the heat medium, and the heat exchanger is a three-way heat exchanger including a refrigerant flow path configuring the refrigerant circuit, a heat medium flow path configuring the heat medium circuit, and a hot water supply flow path configuring the hot water supply circuit.

[0027] According to this, the heat medium circuit becomes a closed circuit. Heat medium flowing through the heat medium circuit heats three-way. Therefore, precipitation of scale (formed by solidifying calcium component in water) in the vicinity of a high temperature portion in the water heater, especially in the vicinity of a heating device is suppressed. Hence, it is possible to provide a water heater capable of using water including much hard components.

[0028] Water supplied from the water pipe and flowing into the hot water supply circuit flows toward the hot water supply terminal by pressure (water pressure) of water flowing through the water pipe. According to this, it is possible to secure a flow rate of hot water supplied from the hot water supply terminal. Hence, it is possible to enhance user's usability.

[0029] It is possible to heat the heat medium and heat water supplied to the hot water supply terminal by one heat medium circuit and one three-way heat exchanger, and it is possible to reduce the number of pumps. Hence, it is possible to reduce the hot water in both size and cost.

[0030] The three-way heat exchanger heats water supplied from the water pipe. Temperature of hot water supplied to a shower, a faucet or a bathtub as a general hot water supply terminal is about 50° at the highest. Scale is prone to be precipitated when temperature of water is higher. Hence, in the hot water supply flow path, scale is less prone to be precipitated.

[0031] According to a seventh aspect, especially in the sixth aspect, the three-way heat exchanger has such a configuration that the refrigerant flow path, the heat medium flow path and the hot water supply flow path come into contact with each other.

[0032] According to this, the three-way heat exchanger in which the refrigerant flow path, the heat medium flow path and the hot water supply flow path are integrally formed together is configured. Hence, it is possible to

reduce the three-way heat exchanger and the water heater in size.

[0033] According to an eighth aspect, especially in the seventh aspect, the water heater further includes a control device, the control device executes a heating operation in which the refrigerant and heat medium flow in opposed directions in the three-way heat exchanger, and a hot water supplying operation in which the heat medium and the water flow in opposed directions in the three-way heat exchanger.

[0034] According to this, refrigerant and heat medium are made to flow in the opposed directions, and heat exchanging efficiency of a heating operation for heating the heat medium can be enhanced. Further, heat medium and water are made to flow in the opposed directions, and heat exchanging efficiency of a hot water supply operation for heating water can be enhanced. That is, one heat medium circuit can be used for both the heating operation and the hot water supply operation, and it is possible to enhance the energy saving performance of the water heater.

[0035] According to a ninth aspect, especially in the eighth aspect, the control device executes a hot water supply auxiliary operation in which the refrigerant, the heat medium and the water flow into the three-way heat exchanger, and the water is heated.

[0036] If the hot water supply operation is carried out in a state where high temperature heat medium in the tank is reduced, water is not sufficiently heated only by heat exchange between water and heat medium in the three-way heat exchanger in some cases. In such a case, the control device operates the heat pump device, makes refrigerant, heat medium and water flow into the three-way heat exchanger, and heats water. According to this, it is possible to supply hot water to the hot water supply terminal.

[0037] That is, when the high temperature heat medium in the tank is reduced, hot water can be produced by simultaneously heating the heat medium by refrigerant and heating water by heat medium. Therefore, it is possible to realize a water heater in the user's comfort is enhanced.

[0038] According to a tenth aspect, especially in the eighth or ninth aspect, the water heater further includes a thermistor for detecting temperature of the heat medium stored in the tank, when hot water is supplied to the hot water supply terminal in a state where temperature of the hot water supplied to the hot water supply terminal is higher than the temperature of the heat medium in the tank, the control device executes an emergency hot water supplying operation in which the refrigerant and the water flow in opposed directions in the three-way heat exchanger.

[0039] According to this, when temperature of heat medium in the tank is lower than that of hot water supplied to the hot water supply terminal, heat is exchanged between refrigerant and water, and hot water can be produced. Hence, even when high temperature heat medi-

um is not stored in the tank, since hot water can be supplied to a user, it is possible to enhance the usability.

[0040] According to an eleventh aspect, especially in any of the first to tenth aspects, the heat medium circuit includes a changeover valve for changing over circulating directions of the heat medium.

[0041] According to this, it is possible to change over a circulating direction of heat medium by the changeover valve. That is, refrigerant in the three-way heat exchanger and heat medium can be made to flow in the opposed directions and water and heat medium in the three-way heat exchanger can be made to flow in the opposed directions only by placing one pump in the heat medium circuit. Hence, operation efficiency of the water heater can be enhanced.

[0042] According to a twelfth aspect, especially in any of the first to tenth aspects, the pump is a reversible pump capable of reversing a circulating direction of the heat medium.

[0043] According to this, it is possible to change over the circulating direction of heat medium by the reversible pump. That is, refrigerant in the three-way heat exchanger and heat medium can be made to flow in the opposed directions and water and heat medium in the heat exchanger can be made to flow in the opposed directions only by placing one pump in the heat medium circuit. Hence, operation efficiency of the water heater can be enhanced.

[0044] According to a thirteenth aspect, especially in any one of the first to twelfth aspects, the water heater further includes a supply pipe which includes a closing valve for closing a flow path, and which is connected to a position above the tank.

[0045] According to this, it is possible to open the closing valve and replenish the heat medium circuit with heat medium. If antifreeze liquid is used as heat medium for example, heat medium in the heat medium circuit does not freeze. Hence, if only the pump is driven and heat medium is circulated in the heat medium circuit, a freezing-preventing operation for preventing the freezing phenomenon is unnecessary and a heater for preventing the freezing phenomenon is unnecessary.

[0046] According to a fourteenth aspect, especially in any one of the first to twelfth aspects, the water heater further includes a water-entering pipe which includes a pressure reducing valve or a closing valve for closing a flow path, which branches off from the hot water supply circuit at a location upstream of the three-way heat exchanger, and which is connected to the lower portion of the tank.

[0047] According to this, even if an amount of heat medium in the heat medium circuit is reduced, heat medium flows through a water-entering pipe and the heat medium is supplied to the tank. Hence, Heat medium of a constant amount or more can always be stored in the heat medium circuit. Further, it becomes easy to replenish the heat medium.

[0048] Embodiments of the present invention will be

described below with reference to the drawings. The invention is not limited to the embodiments.

(First Embodiment)

[0049] Fig. 1 is a schematic block diagram of a water heater according to a first embodiment of the present invention.

[0050] As shown in Fig. 1, the water heater of this embodiment uses a heat pump device 30 as a heating device. The heat pump device 30 includes a refrigerant circuit 3.

[0051] As shown in Fig. 1, the water heater of the embodiment includes a heat pump unit 1, a tank unit 2 and a control device 50 for controlling the water heater. The heat pump unit 1 and the tank unit 2 are connected to each other through a connecting pipe 23. In this embodiment, water supplied from a water pipe is used as heat medium.

[0052] A portion of the refrigerant circuit 3 configuring the heat pump device 30 is accommodated in the heat pump unit 1. Refrigerant circulates through the refrigerant circuit 3. A portion of the refrigerant circuit 3 and a heat medium circuit 4 through which heat medium circulates are accommodated in the tank unit 2.

[0053] The refrigerant circuit 3 is configured by annularly connecting, to one another through refrigerant pipes, a compressor 5 for compressing refrigerant, a radiator 8 for heat-exchanging between refrigerant and heat medium, a decompressor 6 for decompressing refrigerant, and an evaporator 7 for exchanging heat between refrigerant and air in this order. The radiator 8 is placed in the tank unit 2. The compressor 5, the decompressor 6 and the evaporator 7 are placed in the heat pump unit 1. An electric expansion valve is used as the decompressor 6 for example. A blast fan 9 for sending air into the evaporator 7 is placed in the heat pump unit 1.

[0054] The heat medium circuit 4 through which heat medium circulates is formed by annularly connecting to one another through heat medium pipes, a lower portion of a tank 11 in which heat medium is stored, a hot water supply heat exchanger 13 for exchanging heat between water and heat medium, the radiator 8, and an upper portion (although upper side portion is illustrated in Fig. 1, this upper portion may be a top) of the tank 11 in this order.

[0055] The radiator 8 includes a refrigerant flow path 8a through which refrigerant flows, and a heat medium flow path (heating portion) 8b through which heat medium flows. The hot water supply heat exchanger 13 includes a heat medium flow path 13a and a flow path 13b. A plate-type heat exchanger or a double-pipe heat exchanger are used as the radiator 8 and the hot water supply heat exchanger 13.

[0056] A thermistor 22e for detecting temperature of heat medium is placed on the heat medium circuit 4 between the radiator 8 and an upper portion of the tank 11. A thermistor 22f for detecting temperature of heat medi-

um is placed on the heat medium circuit 4 between the hot water supply heat exchanger 13 and a lower portion of the tank 11.

[0057] A pump 14 through which heat medium circulates is placed on the heat medium circuit 4 between the tank 11 and the hot water supply heat exchanger 13. Further, a changeover valve 15 is placed on the heat medium circuit 4 between the tank 11 and the hot water supply heat exchanger 13. The changeover valve 15 changes over a circulating direction of heat medium by changing over a flow path of the heat medium circuit 4 as a changeover device. That is, the changeover valve 15 changes over between a circulating direction in which heat medium flows out from the upper portion of the tank 11 and flows into from a lower portion of the tank 11 and a circulating direction in which heat medium flows out from the lower portion of the tank 11 and flows into from the upper portion of the tank 11.

[0058] The changeover valve 15 is provided with inlets or outlets in four directions so that the circulating direction of heat medium can be changed over. As shown in Fig. 1, the changeover valve 15 can change over a flow path shown by a solid line and a flow path shown by a broken line.

[0059] The hot water supply circuit 16 is a circuit through which water from a water pipe flows toward the hot water supply terminal 17 such as a faucet a bathtub and a shower head. In the hot water supply heat exchanger 13, water and heat medium exchange heat, and hot water is produced. The produced hot water flows through the hot water supply circuit 16 and is supplied from the hot water supply terminal 17 to a user. A thermistor 22d for detecting temperature of water and a flow switch 10 for detecting a flow of water are placed on the hot water supply circuit 16 between the hot water supply heat exchanger 13 and the hot water supply terminal 17.

[0060] A water-entering pipe 18 branches off from the hot water supply circuit 16 located upstream of the hot water supply heat exchanger 13 in the flowing direction of water of the hot water supply circuit 16, and the water-entering pipe 18 is connected to the lower portion of the tank 11. The water-entering pipe 18 includes a pressure reducing valve 19 which reduces pressure of water flowing through the water-entering pipe 18. Pressure in the heat medium circuit 4 is reduced by a given value or more, a portion of water flowing into the hot water supply circuit 16 flows toward the water-entering pipe 18, and the water flows into the lower portion of the tank 11 through the pressure reducing valve 19. That is, water heater of this embodiment uses, as heat medium, water flowing into the heat medium circuit 4 from the water-entering pipe 18. Instead of the pressure reducing valve 19 it is also possible to use a closing valve which can close or open the flow path of the water-entering pipe 18.

[0061] A pipe 21 having a pressure relief valve (relief valve) 20 is connected to the upper portion of the tank 11, thereby configuring a pressure removing device for reducing pressure in the heat medium circuit 4.

[0062] The tank 11 is provided with thermistors 22a, 22b and 22c for measuring temperature of heat medium in the tank 11.

[0063] The heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23. In this embodiment, the radiator 8 which exchanges heat between refrigerant and heat medium is placed in the tank unit 2. That is, the connecting pipe 23 is a refrigerant pipe configuring a portion of the refrigerant circuit 3.

[0064] The heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23 when the water heater is installed. A remote control (not shown) and the heat pump unit 1 are connected to each other by a lead wire, and the heat pump unit 1 and the tank unit 2 are connected to each other by a power supply wire when the water heater is installed.

[0065] After the water heater is installed, if the pressure relief valve 20 is opened in a state where the hot water supply terminal 17 is closed, water flows into the hot water supply circuit 16, flows through the water-entering pipe 18, passes through the pressure reducing valve 19 and flows into the tank 11. Thereafter, water also flows into the heat medium circuit 4, and the tank 11 and the heat medium circuit 4 are filled with water. It is possible to determine whether the heat medium circuit 4 and the tank 11 are filled with water by determining whether water flows out from the pipe 21. That is, if water flows out, this means that the heat medium circuit 4 and the tank 11 are filled with water. The water heater in this embodiment use, as heat medium, water which flows through the water-entering pipe 18 and flows into the tank 11 and the heat medium circuit 4.

[0066] If heat medium in the heat medium circuit 4 is reduced after the tank 11 and the heat medium circuit 4 are filled with heat medium (water), pressure in the tank 11 and the heat medium circuit 4 is reduced. If pressure in the tank 11 and the heat medium circuit 4 is reduced by a given value or more, water which flows into the hot water supply circuit 16 flows through the water-entering pipe 18, and automatically flows into the tank 11. Hence, it is unnecessary for a user of the water heater to replenish heat medium by himself or herself.

[0067] Water which flows into the hot water supply circuit 16 from a water pipe flows toward the hot water supply terminal 17 by pressure of water which flows through the water pipe. Generally, pressure (water pressure) of water which flows through a water pipe is higher than that of water which is sent by the pump 14 under pressure. Hence, a given amount or more hot water flowing out from the hot water supply terminal 17 can be secured, and user's comfort is enhanced.

[0068] Next, an operation of the water heater in this embodiment will be described.

[0069] In a heating operation for heating heat medium stored in the tank 11, the control device 50 operates the heat pump device 30 such that high temperature and high pressure refrigerant flows into the radiator 8, and controls the changeover valve 15 and the pump 14 such

that heat medium circulates in the direction of the solid line arrows shown in Fig. 1. According to this, refrigerant and heat medium exchange heat in the radiator 8.

[0070] At this time, heat medium flows through the flow paths of the changeover valve 15 shown by the solid arrow as shown in Fig. 1. According to this, heat medium flows through the lower portion of the tank 11, the changeover valve 15, the pump 14, the changeover valve 15, the hot water supply heat exchanger 13 and the radiator 8 in this order, and flows into the tank 11 from its upper portion.

[0071] Further, the control device 50 actuates the compressor 5 of the heat pump device 30, and compresses refrigerant to high pressure. The compressed high temperature and high pressure refrigerant passes through the connecting pipe 23, and flows into the radiator 8 placed in the tank unit 2.

[0072] In the radiator 8, the high temperature and high pressure gas phase refrigerant and heat medium which is sent by the pump 14 under pressure and which flows through the heat medium circuit 4 exchange heat. According to this, the heat medium is heated, and high temperature heat medium is produced. The high temperature heat medium flows out from the radiator 8, flows through the heat medium circuit 4 and flows into the tank 11 from the upper portion of the tank 11.

[0073] The refrigerant exchanges heat with the heat medium in the radiator 8, and is condensed, and becomes low temperature and low pressure gas-liquid two-phase state or liquid state. Thereafter, the refrigerant is decompressed by the decompressor 6 and is expanded, and flows into the evaporator 7. The refrigerant exchanges heat with air sent by the blast fan 9 in the evaporator 7, evaporates and becomes the gas phase state. The gas phase refrigerant again flows into a compressor 4.

[0074] The refrigerant circulates through the refrigerant circuit 3 in this manner, heat medium circulates through the heat medium circuit 4, and the refrigerant and the heat medium exchange heat in the radiator 8. According to this, heat medium stored in the tank 11 is heated. The control device 50 may controls the number of rotations of the heat pump device 30 and the number of rotations of the pump 14 such that temperature of heat medium detected by the thermistor 22e becomes equal to a predetermined value.

[0075] The heat medium which is heated by the radiator 8 to high temperature flows into the tank 11 from its upper portion. According to this, high temperature heat medium is stored in the tank 11. Hence, temperature of heat medium stored in the tank 11 is higher in the upper portion of the tank 11 and is lower in the lower portion of the tank 11.

[0076] That is, temperature stratification of heat medium is formed in the tank 11. A dot-and-dash line in the tank 11 in Fig. 1 shows this temperature stratification, and temperature thereof becomes higher rightward. As shown in Fig. 1, the heat medium in the tank 11 is divided into a high temperature region having substantially con-

stant temperature, a transition region where temperature is reduced abruptly, and a low temperature region.

[0077] Heat medium which flows out from the lower portion of the tank 11 during the heating operation is in the low temperature region. Until the entire heat medium in the tank 11 becomes high temperature, temperature rise of the heat medium which flows into the radiator 8 is suppressed. Operation efficiency of the heat pump device 30 is high when the heat medium which flows into the radiator 8 is low. Hence, the operation of the heat pump device 30 is enhanced.

[0078] As described above, in the heating operation, refrigerant and heat medium exchange heat in the radiator 8, and high temperature heat medium is produced.

[0079] In the heating operation, the control device 50 controls the changeover valve 15 such that a flowing direction through the refrigerant flow path 8a and a flowing direction through the heat medium flow path 8b are opposed to each other. That is, temperature variation of refrigerant flowing through the refrigerant flow path 8a and temperature variation of heat medium flowing through the heat medium flow path 8b are opposed to each other. The refrigerant flows into the refrigerant flow path 8a in its high temperature state, exchanges heat with heat medium, the temperature of refrigerant becomes lower than that when the refrigerant flows into, and the refrigerant flows out from the refrigerant flow path 8a. Heat medium flows into the heat medium flow path 8b in its low temperature state, exchanges heat with refrigerant, temperature of the heat medium becomes higher than that when the heat medium flows into, and the heat medium flows out from the heat medium flow path 8b. According to this, refrigerant and heat medium exchange heat in a state where a temperature difference therebetween is secured at a given level or more. Hence, heat exchanging efficiency in the radiator 8 is enhanced. Therefore, the operation efficiency of the heat pump device 30 is enhanced.

[0080] Next, a hot water supplying operation for supplying hot water to the hot water supply terminal 17 will be described. The hot water supplying operation is for heating water by high temperature heat medium stored in the tank 11, thereby producing hot water which is to be supplied to the hot water supply terminal 17.

[0081] If a user opens the hot water supply terminal 17, water in the hot water supply circuit 16 flows out from the hot water supply terminal 17. If the flow switch 10 detects a flow of water through the hot water supply circuit 16, the hot water supplying operation is started. The hot water supplying operation may be started when a user instructs through a remote control (not shown).

[0082] In the hot water supplying operation in which water flowing through the hot water supply circuit 16 is heated to produce hot water, and the hot water is supplied from the hot water supply terminal 17, the control device 50 controls the changeover valve 15 and the pump 14 such that heat medium circulates in the direction of the broke line arrows shown in Fig. 1. According to this, heat

medium and water exchange heat in the hot water supply heat exchanger 13. The control device 50 may control the number of rotations of the pump 14 such that temperature detected by the thermistor 22d becomes equal to a predetermined value.

[0083] In the hot water supplying operation, the control device 50 controls the pump 14 and the changeover valve 15 such that heat medium flows in the direction shown by the broke line arrows shown in Fig. 1. According to this, high temperature heat medium stored in the upper portion in the tank 11 flows out from the upper portion of the tank 11, flows through the heat medium circuit 4, and flows into the hot water supply heat exchanger 13. The heat medium which flows into the hot water supply heat exchanger 13 flows through the hot water supply circuit 16, and exchanges heat with water which flows into the hot water supply heat exchanger 13. According to this, hot water is produced. The produced hot water flows through the hot water supply circuit 16 and flows out from the hot water supply terminal 17.

[0084] Here, in the hot water supplying operation, the hot water supply heat exchanger 13 is configured such that a flowing direction through the heat medium flow path 13a and a flowing direction through the hot water supply flow path 13b are opposed. That is, the hot water supply heat exchanger 13 is configured such that temperature variation of heat medium flowing through the heat medium flow path 13a and temperature variation of water flowing through the hot water supply flow path 13b are opposed to each other. The heat medium flows into the heat medium flow path 13a in its high temperature state, exchanges heat with water, and flows out from the heat medium flow path 13a in a state where temperature of the heat medium becomes lower than that when the heat medium flows into the heat medium flow path 13a. On the other hand, water flows into the hot water supply flow path 13b in its low temperature state, exchanges heat with heat medium, and flows out from the hot water supply flow path 13b in a state where temperature of the water becomes higher than that when the water flows into the hot water supply flow path 13b. According to this, heat medium and water exchange heat in a state where a temperature difference therebetween is maintained at a given value or higher. According to this, heat exchanging efficiency in the hot water supply heat exchanger 13 is enhanced.

[0085] The hot water supply heat exchanger 13 exchanges heat with water, heat medium having lowered temperature flows through the changeover valve 15, the pump 14 and the changeover valve 15, and flows into the tank 11 from its lower portion. Hence, if the hot water supplying operation is carried out, an amount of heat medium in a low temperature region is increased in the tank 11. In this manner, heat medium exchanges heat with water in the hot water supply heat exchanger 13 and temperature of the heat medium is lowered, and this heat medium flows into the low temperature region from the lower portion of the tank 11. Therefore, it is possible to

heat water while maintaining the temperature stratification in the tank 11.

[0086] By changing over the circulating direction of heat medium by the changeover device, the hot water supplying operation and the heating operation are executed while maintaining the temperature stratification of the heat medium in the tank 11. Hence, the operation efficiency of the heat pump device 30 can be enhanced. Further, it is possible to adjust temperature of hot water to be supplied to the hot water supply terminal 17.

[0087] When a user sets temperature of hot water which flows out from the hot water supply terminal 17 by a remote control for example, the control device 50 can control the number of rotations of the pump 14 such that temperature of hot water detected by the thermistor 22d becomes equal to a set temperature. According to this, hot water having temperature which is set by a user is supplied from the hot water supply terminal 17. When the hot water supply terminal 17 has a temperature control function, it is unnecessary to control the number of rotations of the pump 14 and to adjust temperature of produced hot water. It is only necessary to supply hot water having predetermined temperature to the hot water supply terminal 17.

[0088] It is possible to changeover the circulating direction of heat medium by the changeover valve 15 in this manner. That is, in the heating operation, heat medium flows through the lower portion of the tank 11, the changeover valve 15, the pump 14, the changeover valve 15, the hot water supply heat exchanger 13, the radiator 8 and the upper portion of the tank 11 in this order. In the hot water supplying operation on the other hand, heat medium flows through the upper portion of the tank 11, the radiator 8, the hot water supply heat exchanger 13, the changeover valve 15, the pump 14, the changeover valve 15 and the lower portion of the tank 11 in this order.

[0089] Hence, the control device 50 executes the heating operation, since refrigerant and heat medium flow in the opposed directions in the radiator 8, the heat exchanging efficiency is enhanced. Further, when the control device 50 executes the hot water supplying operation, heat medium and water flow in the opposed directions in the hot water supply heat exchanger 13, the heat exchanging efficiency is enhanced. According to this, it is possible to save energy of the water heater.

[0090] By the one heat medium circuit 4 and the one pump 14, it is possible to make heat medium flow in different circulating directions. Hence, it is possible to reduce the water heater in size and cost while enhancing the operation efficiency of the water heater. It is possible to reduce the number of pumps 14, and to reduce noise and vibration caused when the pump 14 operates.

[0091] According to the water heater of this embodiment, the pump 14 is placed in the tank unit 2. Hence, resonance of vibration generated when the compressor 5 operates and vibration generated when the pump 14 operates can be prevented. Hence, it is possible to reduce noise, to reduce a using amount of soundproof ma-

terial, and to reduce cost of the water heater.

[0092] The changeover valve 15 is more inexpensive than the pump 14, and a control circuit which operates the changeover valve 15 is more inexpensive than a control circuit which operates the pump 14. Hence, a case where two pumps 14 are used to circulate heat medium and a case where the pump 14 and the changeover valve 15 are used to circulate heat medium are compared with each other, the latter case, i.e., the case where the pump 14 and the changeover valve 15 are used to circulate heat medium is more inexpensive.

[0093] Next, a hot water supply auxiliary operation in which the heat pump device 30 is operated to heat the heat medium, heat medium is circulated, and hot water is supplied to the hot water supply terminal 17 will be described.

[0094] If the hot water supplying operation is carried out in a state where an amount of heat medium in the high temperature region in the tank 11 is small, water flows through the hot water supply circuit 16 cannot be sufficiently heated in some cases even if heat exchange between heat medium and water is carried out by the hot water supply heat exchanger 13.

[0095] Based on detection values of thermistors 22a to 22c mounted in the tank 11, the control device 50 can detect that an amount of heat medium in the high temperature region in the tank 11 is smaller than the predetermined value. In a state where heat medium in the high temperature region is smaller than the predetermined value, if it is necessary to supply hot water to the hot water supply terminal 17, the hot water supply auxiliary operation in which the heating operation of heat medium carried out by the heat pump device 30 and the heating operation of water carried out by heat medium are carried out in parallel is executed. This predetermined value in this case is set from a design value of the water heater such as heat capacity which can be accumulated in the tank 11 and a lifting height of the pump 14.

[0096] The hot water supply auxiliary operation may be executed by user's instructions through a remote control.

[0097] In the hot water supply auxiliary operation, the control device 50 controls the heat pump device 30, the pump 14 and the changeover valve 15. In the hot water supply auxiliary operation, refrigerant circulates in the refrigerant circuit 3 in directions of the solid line arrows shown in Fig. 1. Heat medium circulates in the heat medium circuit 4 in the directions of the broke line arrows shown in Fig. 1. That is, heat medium flows through the upper portion of the tank 11, the radiator 8, the hot water supply heat exchanger 13, the changeover valve 15, the pump 14, the changeover valve 15 and the lower portion of the tank 11 in this order.

[0098] In the hot water supply auxiliary operation and the hot water supplying operation, circulating directions of heat medium are the same. Water which flows into the hot water supply circuit 16 from the water pipe exchanges heat with heat medium in the hot water supply heat ex-

changer 13 and becomes hot water of predetermined temperature, and flows toward the hot water supply terminal 17.

[0099] In this manner, heat medium before it flows into the hot water supply heat exchanger 13 can be heated by the radiator 8.

[0100] Even when the amount of heat medium in the high temperature region is small, it is possible to rise the temperature of heat medium which flows into the hot water supply heat exchanger 13 and flows the heated heat medium into the hot water supply heat exchanger 13.

[0101] Hence, it is possible to heat water and to produce hot water in the hot water supply heat exchanger 13, and it is possible to realize a water heater having high usability.

[0102] When the hot water supply auxiliary operation is executed, it is preferable that the radiator 8 and the hot water supply heat exchanger 13 are placed in the same casing. According to this, it is possible to reduce quantity of heat (heat loss) radiated from the hot water supply circuit 16 between the radiator 8 and the hot water supply heat exchanger 13.

[0103] If an amount of hot water flowing out from the hot water supply terminal 17 is large, quantity of heat radiated from heat medium in the hot water supply heat exchanger 13 becomes larger than quantity of heat sucked by heat medium in the heat pump device 30 in some cases. Hence, when the hot water supply auxiliary operation is executed, it is preferable that the heating ability of the heat pump device 30 is made greater (e.g., 20 kW) than that when the hot water supply auxiliary operation is not carried out.

[0104] When the hot water supply auxiliary operation is executed in a state where the control device 50 detects that an amount of heat medium in the high temperature region in the tank 11 is smaller than a predetermined value, it is preferable that the control device 50 controls such that the heating ability of the heat pump device 30 becomes the maximum.

[0105] In the hot water supply auxiliary operation, since a flowing direction of refrigerant flowing through the refrigerant flow path 8a and a flowing direction of heat medium flowing through the heat medium flow path 8b are the same, the operation efficiency of the heat pump device 30 is deteriorated. Hence, it is preferable that the remote control includes selecting means for selecting whether the hot water supply auxiliary operation should automatically be executed. That is, it is preferable that the water heater includes means for prohibiting that the water heater automatically executes the hot water supply auxiliary operation. According to this, a user can select whether the hot water supply auxiliary operation having lower operation efficiency than that of the hot water supplying operation should be executed. Hence, it is possible to enhance the usability of the water heater.

[0106] The water heater in this embodiment can use water including much hard component. A reason will be described below.

[0107] In Japan where a ground form is generally precipitous and lengths of rivers are short, an amount of hard component dissolved in water flowing through the river is small, and there are many places where water supplied from water pipes is soft water. Depending upon areas, places where an amount of hard component in water is high exist. Ground water includes much hard component in some cases.

[0108] On the other hand, in Europe and China where ground forms are gentle and lengths of rivers are long, an amount of hard component dissolved in water flowing through the river is large, and water supplied from water pipe is harder than that of Japan in many cases.

[0109] Many hard components such as calcium carbonate are dissolved in this hard water. The hard component has such characteristics that as the temperature of water becomes higher, solubility becomes lower, and the hard component is precipitated as scale. According to this, scale is precipitated on the high temperature portion of the water heater and the flow path is closed in some cases. Even if the flow path is not closed, if scale adheres to the flow path, a pressure loss increases, and operation efficiency of the water heater is deteriorated.

[0110] For example, calcium carbonate (CaCO_3) which is one of the hard components has such a tendency that if temperature of water rises, solubility of the calcium carbonate is lowered as shown in Fig. 2. That is, the higher the temperature of water becomes, the more the hard component is precipitated as scale, and the hard component is prone to adhere to a flow path.

[0111] Further, in a state where supply of water including much hard component is continued, since precipitation of scale and adhesion of scale are continuously generated, scale is prone to become deposited. The precipitation of scale is prone to be generated in the heat medium flow path 8b in the vicinity of the radiator 8 (heating device) whose temperature becomes the highest in the water heater. Scale is prone to be deposited when supply of water having much hard component to the heat medium flow path 8b is continued.

[0112] In the other hand, in the water heater of this embodiment, the heat medium circuit 4 is the closed circuit. Therefore, when pressure in the heat medium circuit 4 rises and a small amount of heat medium is discharged from the pipe 21, water is newly recruited to the heat medium circuit 4.

[0113] Hence, heat medium circulating through the heat medium circuit 4 is used for a long term without being exchanged, and new hard component is not supplied. Therefore, it is possible to suppress the precipitation and deposition of scale in the heat medium flow path 8b.

[0114] Fresh water is always supplied to the hot water supply flow path 13b of the hot water supply heat exchanger 13. Temperature of hot water to be supplied to the hot water supply terminal 17 such as a faucet, a bathtub and a shower head is about 50° at the highest. Hence, in the hot water supply heat exchanger 13 having lower

temperature than that of the radiator 8, precipitation of scale is less prone to be generated.

[0115] The water-entering pipe 18 branches off from the hot water supply circuit 16 located upstream of the hot water supply heat exchanger 13, and is connected to the lower portion of the tank 11, and the pressure reducing valve 19 is placed in the water-entering pipe 18. If the water heater is operated and the heat medium expands and pressure in the heat medium circuit 4 rises, a portion of the expanded heat medium is discharged from the pipe 21 having the pressure relief valve 20. If the amount of heat medium in the heat medium circuit 4 is reduced and pressure in the heat medium circuit 4 is reduced by a given value or more, water flows into the water-entering pipe 18 from the hot water supply circuit 16, and water (heat medium) is recruited to the heat medium circuit 4. According to this, pressure in the heat medium circuit 4 is automatically adjusted. Hence, it is unnecessary for a user to recruit the heat medium. When the closing valve is used instead of the pressure reducing valve 19, by opening the closing valve, it is possible to supply water (heat medium) to the heat medium circuit 4 whose pressure is lowered by a given value or more.

[0116] In the heat pump unit 1 of this embodiment, the compressor 5, the decompressor 6, the evaporator 7 and the blast fan 9 are placed. The heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23 through which refrigerant flows. Hence, the heat pump unit 1 has the same configuration as that of an outdoor unit of an air conditioner. According to this, the outdoor unit of the air conditioner and the heat pump unit 1 can commonly be used. If refrigerant is R410A refrigerant which is usually used in an air conditioner, a connecting operation of the connecting pipe 23 at the time of an installation operation becomes easy.

[0117] Since the heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23 through which refrigerant flows, refrigerant in the connecting pipe 23 does not freeze, and it is unnecessary to carry out a freezing-preventing operation.

(Second Embodiment)

[0118] Fig. 3 is a schematic block diagram of a water heater in a second embodiment of the present invention. In the second embodiment, the same symbols as those of the members in the first embodiment are used, and explanation thereof will be omitted.

[0119] The water heater in the second embodiment includes the heat medium circuit 4 formed by annularly connecting, to one another, the lower portion of the tank 11, the radiator 8, the hot water supply heat exchanger 13 and an upper portion of the tank 11. The pump 14 and the changeover valve 15 are placed on the heat medium circuit 4 between the lower portion of the tank 11 and the radiator 8.

[0120] If the heating operation is executed, heat medium circulates through the heat medium circuit 4 in the

order of the lower portion of the tank 11, the changeover valve 15, the pump 14, the radiator 8, the hot water supply heat exchanger 13 and the upper portion of the tank 11. If the hot water supplying operation is executed, heat medium circulates through the heat medium circuit 4 in the order of the upper portion of the tank 11, the hot water supply heat exchanger 13, the radiator 8, the changeover valve 15, the pump 14, the changeover valve 15 and the lower portion of the tank 11 in this order.

[0121] According to this configuration, when the hot water supplying operation is executed, high temperature heat medium which flows out from the upper portion of the tank 11 first flows into the hot water supply heat exchanger 13 and heats water flowing through the hot water supply circuit 16. Hence, it is possible to reduce quantity of heat (heat loss) radiated from the heat medium circuit 4 between the upper portion of the tank 11 and the hot water supply heat exchanger 13.

(Third Embodiment)

[0122] Fig. 4 is a schematic block diagram of a water heater in a third embodiment of the present invention. In the third embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0123] The water heater in the third embodiment includes the heat pump unit 1 in which the heat pump device 30 is placed. The refrigerant circuit 3 and the blast fan 9 are placed in the heat pump unit 1. The refrigerant circuit 3 is annularly connected to the compressor 5 which compresses refrigerant, the radiator 8 which exchanges heat between the refrigerant and heat medium, the decompressor 6 which decompresses refrigerant, and the evaporator 7 which exchanges heat with refrigerant and air. Carbon dioxide is used as refrigerant. The heat pump unit 1 and the tank unit 2 are connected to each other through a connecting pipe 24. Heat medium circulates through the connecting pipe 24. That is, the connecting pipe 24 configures a portion of the heat medium circuit 4.

[0124] Carbon dioxide having zero (0) global warming potential can be used as refrigerant which circulates through the refrigerant circuit 3. Carbon dioxide has a lower critical point temperature than that of conventionally used HFC refrigerant such as R410A and R32. Hence, if carbon dioxide is used as refrigerant, a supercritical cycle in which pressure on the high pressure side of the refrigerant circuit 3 exceeds the critical point is configured.

[0125] According to this, heat medium can be heated to high temperature (e.g., 85°) as compared with HFC refrigerant such as R410A and R32. Since the heat medium can be heated to high temperature, heat quantity accumulated in the tank 11 can be increased, and the tank 11 can be reduced in size.

[0126] If carbon dioxide is used as refrigerant, pressure on the high pressure side of the refrigerant circuit 3 becomes high (e.g., 8 MPa) as compared with a case where

HFC refrigerant is used. Hence, it is necessary to enhance pressure resistance of the refrigerant pipe.

[0127] According to the water heater of the third embodiment, the radiator 8 is placed in the heat pump unit 1, and the heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 24. Heat medium circulates through the connecting pipe 24. Hence, refrigerant does not flow through the connecting pipe 24. Hence, it is unnecessary to excessively increase the pressure resistance of the connecting pipe 23. Therefore, an installing operation when the water heater is installed can be made easy.

(Fourth Embodiment)

[0128] Fig. 5 is a schematic block diagram of a water heater in a fourth embodiment of the present invention. In the fourth embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0129] The water heater in the fourth embodiment includes an integral unit 25 in which the heat pump device 30, the heat medium circuit 4, the hot water supply circuit 16, the water-entering pipe 18 and the pipe 21 are placed.

[0130] According to this, installation time when the water heater is installed can be shortened. Further, since there is no connecting pipe, it is possible to prevent heat radiation from the connecting pipe. Further, the radiator 8 and the hot water supply heat exchanger 13 can closely be placed, and heat radiation loss from the heat medium circuit 4 can be reduced.

(Fifth Embodiment)

[0131] Fig. 6 is a schematic block diagram of a water heater in a fifth embodiment of the present invention. In the fifth embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0132] As shown in Fig. 6, the water heater in the fifth embodiment includes a supply pipe 27 connected to the upper portion of the tank 11 and having a closing valve 26. The closing valve 26 can close and open a flow path.

[0133] The tank 11 includes a liquid level sensor 28 which detects an amount of heat medium stored in the tank 11. The control device 50 can detect reduction in an amount of heat medium by means of the liquid level sensor 28, display a result thereof on the remote control, and inform a user of this result.

[0134] Further, the heat medium circuit 4 is a closed circuit formed by annularly connecting the tank 11, the changeover valve 15, the pump 14, the hot water supply heat exchanger 13 and the radiator 8 to one another. According to this, water having much hard component does not flow into the radiator 8. It is possible to suppress the precipitation and deposition of scale. An expansion tank 29 is placed on the heat medium circuit 4 between the radiator 8 and the upper portion of the tank 11. When

heat medium expands, the expansion tank 29 adjusts pressure in the heat medium circuit 4.

[0135] When an amount of heat medium is reduced, the closing valve 26 is opened and it is possible to recruit heat medium into the tank 11 from the supply pipe 27.

[0136] As heat medium, antifreeze liquid circulates through the heat medium circuit 4. Water may be main component as the heat medium, or the heat medium having higher specific heat or thermal conductivity than those of water may be used. For example, it is possible to use, as the heat medium, galinstan which is eutectic alloy of gallium, indium and tin. According to this, it is possible to prevent heat medium flowing through the heat medium circuit 4 from freezing.

(Sixth Embodiment)

[0137] Fig. 7 is a schematic block diagram of a water heater in a sixth embodiment of the present invention. In the sixth embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0138] The water heater in the sixth embodiment includes a reversible pump 31 as a pump for sending heat medium under pressure.

[0139] The reversible pump 31 has a function to reverse a circulating direction of heat medium flowing through the heat medium circuit 4. That is, the reversible pump 31 functions as a changeover device which reverse the circulating direction of heat medium. Hence, it is possible to change the circulating direction of heat medium without using the changeover valve.

[0140] In the heating operation, the control device 50 controls the reversible pump 31 such that heat medium circulates in directions of solid line arrows shown in Fig. 7. Heat medium in the heat medium circuit 4 flows through the lower portion of the tank 11, the reversible pump 31, the hot water supply heat exchanger 13, the radiator 8 and the upper portion of the tank 11 in this order.

[0141] At this time, the control device 50 controls the heat pump device 30 such that high temperature and high pressure refrigerant flows into the radiator 8. According to this, heat medium and refrigerant which flows into the radiator 8 exchange heat with each other, and high temperature heat medium is produced. The produced heat medium flows through the heat medium circuit 4, and flows into the tank 11 from its upper portion. Hence, high temperature heat medium is stored in the tank 11. The control device 50 may control the reversible pump 31 and the heat pump device 30 so that a detection value of the thermistor 22e becomes equal to a predetermined value.

[0142] In the hot water supplying operation, the control device 50 controls the reversible pump 31 such that heat medium circulates in directions of broken line arrows shown in Fig. 7. Heat medium in the heat medium circuit 4 flows through the upper portion of the tank 11, the radiator 8, the hot water supply heat exchanger 13, the

reversible pump 31 and the lower portion of the tank 11 in this order.

[0143] Heat medium flows through the heat medium circuit 4 exchanges heat with water which flows through the hot water supply circuit 16 in the hot water supply heat exchanger 13. According to this, hot water is produced.

[0144] When a user sets temperature of hot water flowing out from the hot water supply terminal 17 by means of the remote control, the control device 50 can detect temperature of hot water flowing into the hot water supply heat exchanger 13 by the thermistor 22e, and based on the detection value, the control device 50 can control the number of rotations of the reversible pump 31 such that temperature of hot water detected by the thermistor 22d becomes equal to the set temperature.

[0145] when it is possible to adjust the temperature by the hot water supply terminal 17, it is unnecessary for the control device 50 to appropriately control the number of rotations of the reversible pump 31 for adjusting the temperature of hot water supplied to the hot water supply terminal 17, and it is only necessary to supply hot water having predetermined temperature or higher to the hot water supply terminal 17.

[0146] By changing over the circulating direction of heat medium by the reversible pump 31 in this manner, it is possible to execute both the heating operation and the hot water supplying operation by the one heat medium circuit 4 and the one reversible pump 31.

(Seventh Embodiment)

[0147] Fig. 8 is a schematic block diagram of a water heater in a seventh embodiment of the present invention. In the seventh embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0148] As shown in Fig. 8, the heat medium circuit 4 of the water heater of the seventh embodiment includes a main flow path 4a provided with the radiator 8 and an auxiliary flow path 4b provided with the hot water supply heat exchanger 13.

[0149] The auxiliary flow path 4b connects a branching point P and a branching point Q to each other. The branching point P is provided on the heat medium circuit 4 between the radiator 8 and the changeover valve 15. The branching point Q is provided on the heat medium circuit 4 between the radiator 8 and the upper portion of the tank 11. That is, the auxiliary flow path 4b functions as a bypass passage which bypasses the radiator 8.

[0150] It is preferable that the thermistor 22f is provided on the heat medium circuit 4 between the branching point P and the changeover valve 15, and the thermistor 22e is provided on the heat medium circuit 4 between the branching point Q and the upper portion of the tank 11. When the pump 14 is the reversible pump 31 and the changeover valve 15 is not provided, the branching point P is provided on the heat medium circuit 4 between the

radiator 8 and the reversible pump 31. At this time, it is preferable that the thermistor 22f is provided between the branching point P and the reversible pump 31.

[0151] The heat medium circuit 4 is provided with a flow path-changeover device (not shown) for selectively making the heat medium flow through the main flow path 4a and the auxiliary flow path 4b. According to this, the heat medium circuit 4 has a plurality of circulation passages for a case where heat medium flows through the main flow path 4a and a case where heat medium flows through the auxiliary flow path 4b.

[0152] The flow path-changeover device can be realized by a plurality of methods. For example, the flow path-changeover device can be realized by providing the main flow path 4a and the auxiliary flow path 4b with closing valves capable of closing the flow paths. That is, when heat medium is made to flow through the main flow path 4a, the pump 14 is operated in a state where a first closing valve provided in the main flow path 4a is opened and a second closing valve provided in the auxiliary flow path 4b is closed. When heat medium is made to flow through the auxiliary flow path 4b on the other hand, the pump 14 is operated in a state where the first closing valve is closed and the second closing valve provided on the auxiliary flow path 4b is opened. Further, it is possible to realize the flow path-changeover device by providing the branching point P or the branching point Q with a three-way valve. That is, when heat medium is made to flow through the main flow path 4a, the pump 14 is operated in a state where the three-way valve is switched toward the main flow path 4a, and when heat medium is made to flow through the auxiliary flow path 4b on the other hand, the pump 14 is operated in a state where the three-way valve is switched toward the auxiliary flow path 4b. If the flow path-changeover device is configured such that it is possible to selectively flow the heat medium through the main flow path 4a and the auxiliary flow path 4b, it is not limited to these embodiments, and other ways may be used.

[0153] In the heating operation, the control device 50 controls the pump 14, the changeover valve 15 and the flow path-changeover device so that heat medium circulates in directions of solid line arrows shown in Fig. 8. According to this, heat medium flows through the heat medium circuit 4 toward the main flow path 4a through the lower portion of the tank 11, the changeover valve 15, the pump 14 and the changeover valve 15, the heat medium is heated by the heat pump device 30 in the heat medium flow path 8b, and the heat medium flows into the upper portion of the tank 11.

[0154] In the hot water supplying operation, the control device 50 controls the pump 14, the changeover valve 15 and the flow path-changeover device so that heat medium circulates in directions of dotted line arrows shown in Fig. 8. According to this, heat medium flows through the heat medium circuit 4 from the upper portion of the tank 11 toward the auxiliary flow path 4b, the heat medium heats, by the hot water supply heat exchanger 13,

water which flows through the hot water supply circuit 16 and then, the heat medium flows into the lower portion of the tank 11 through the changeover valve 15, the pump 14 and the changeover valve 15.

[0155] The heat medium circuit 4 is provided with the main flow path 4a where the radiator 8 is placed and with the auxiliary flow path 4b where the hot water supply heat exchanger 13 is placed in this manner. By properly and separately using the main flow path 4a and the auxiliary flow path 4b, heat radiation loss from the heat medium circuit 4 can be reduced. That is, in the heating operation, since the control device 50 controls such that heat medium flows only through the main flow path 4a, heat radiation loss of heat medium in the hot water supply heat exchanger 13 can be reduced. In the hot water supplying operation, the control device 50 controls such that heat medium flows only through the auxiliary flow path 4b, heat radiation loss of heat medium in the radiator 8 can be reduced. It is possible to heat the heat medium and to heat water to be supplied to the hot water supply terminal 17 by one pump. As a result, the water heater can be reduced in size and cost.

(Eighth Embodiment)

[0156] Fig. 9 is a schematic block diagram of a water heater in an eighth embodiment of the present invention.

[0157] As shown in Fig. 9, the water heater of the eighth embodiment uses the heat pump device 30 as a heating device. The heat pump device 30 includes the refrigerant circuit 3.

[0158] As shown in Fig. 9, the water heater of the eighth embodiment includes the heat pump unit 1, the tank unit 2 and the control device 50 controlling the water heater. The heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23. In the eighth embodiment, water supplied from a water pipe is used as heat medium.

[0159] A portion of the refrigerant circuit 3 through which refrigerant circulates is accommodated in the heat pump unit 1. A portion of the refrigerant circuit 3 and the heat medium circuit 4 through which heat medium circulates are accommodated in the tank unit 2.

[0160] The refrigerant circuit 3 is configured by annularly connecting, to one another through refrigerant pipes, the compressor 5 for compressing refrigerant, a refrigerant flow path 60a placed in a three-way heat exchanger 60, the decompressor 6 for decompressing refrigerant, and the evaporator 7 which exchanges heat between refrigerant and air in this order. The three-way heat exchanger 60 is placed in the tank unit 2. The compressor 5, the decompressor 6 and the evaporator 7 are placed in the heat pump unit 1. An electric expansion valve is used as the decompressor 6 for example. The blast fan 9 for sending air to the evaporator 7 is placed in the heat pump unit 1.

[0161] The heat medium circuit 4 through which heat medium circulates is formed by annularly connecting to

one another through heat medium pipes, the lower portion of the tank 11 in which heat medium is stored, a heat medium flow path 60b placed in the three-way heat exchanger 60, and the upper portion (although upper side portion is illustrated in Fig. 9, this upper portion may be a top) of the tank 11 in this order.

[0162] The three-way heat exchanger 60 includes the refrigerant flow path 60a, the heat medium flow path 60b and a hot water supply flow path 60c. The hot water supply flow path 60c configures a portion of the hot water supply circuit 16 through which water supplied from a water pipe flows. The three-way heat exchanger 60 is for exchanging heat between refrigerant which flows through the refrigerant flow path 60a, heat medium which flows through the heat medium flow path 60b, and water which flows through the hot water supply flow path 60c. That is, the three-way heat exchanger 60 is equal to a configuration in which a radiator which exchanges heat between refrigerant and heat medium, and a hot water supply heat exchanger which exchanges heat between heat medium and water are integrally formed together. The refrigerant flow path 60a, the heat medium flow path 60b and the hot water supply flow path 60c are placed in parallel in this order.

[0163] The thermistor 22e for detecting temperature of heat medium is placed on the heat medium circuit 4 between the three-way heat exchanger 60 and the upper portion of the tank 11. The thermistor 22f for detecting temperature of heat medium is placed on the heat medium circuit 4 between the three-way heat exchanger 60 and the lower portion of the tank 11.

[0164] The pump 14 through which heat medium circulates is placed on the heat medium circuit 4 between the tank 11 and the three-way heat exchanger 60. Further, the changeover valve 15 is placed on the heat medium circuit 4 between the tank 11 and the hot water supply heat exchanger 13. The changeover valve 15 changes over a circulating direction of heat medium by changing over a flow path of the heat medium circuit 4 as a changeover device. That is, the changeover valve 15 can change over between a circulating direction in which heat medium flows out from the upper portion of the tank 11 and flows into from the lower portion of the tank 11 and a circulating direction in which heat medium flows out from the lower portion of the tank 11 and flows into the upper portion of the tank 11.

[0165] The changeover valve 15 is provided with inlets or outlets in four directions so that the circulating directions of heat medium can be changed over. As shown in Fig. 9, the changeover valve 15 can change over a flow path shown by a solid line and a flow path shown by a broken line.

[0166] The hot water supply circuit 16 is a circuit through which water from a water pipe flows toward the hot water supply terminal 17 such as a faucet a bathtub and a shower head. In the three-way heat exchanger 60, hot water is produced. The produced hot water flows through the hot water supply circuit 16 and is supplied

from the hot water supply terminal 17 to a user. The thermistor 22d for detecting temperature of water and the flow switch 10 which detects a flow of water are placed on the hot water supply circuit 16 between the three-way heat exchanger 60 and the hot water supply terminal 17.

[0167] The water-entering pipe 18 branches off from the hot water supply circuit 16 located upstream of the hot water supply heat exchanger 13 in the flowing direction of water through the hot water supply circuit 16, and the water-entering pipe 18 is connected to the lower portion of the tank 11. The water-entering pipe 18 includes the pressure reducing valve 19 which reduces pressure of water flowing through the water-entering pipe 18. If pressure in the heat medium circuit 4 is reduced by a given pressure or more, a portion of water flowing into the hot water supply circuit 16 flows toward the water-entering pipe 18, and the water flows into the lower portion of the tank 11 through the pressure reducing valve 19. That is, the water heater of eighth embodiment uses, as heat medium, water flowing into the heat medium circuit 4 from the water-entering pipe 18. Instead of the pressure reducing valve 19, it is possible to use a closing valve which can closer or open a flow path of the water-entering pipe 18.

[0168] The pipe 21 having the pressure relief valve (relief valve) 20 is connected to the upper portion of the tank 11, thereby configuring a pressure removing device for reducing pressure in the heat medium circuit 4.

[0169] The tank 11 is provided with the thermistors 22a, 22b and 22c for measuring temperature of heat medium in the tank 11.

[0170] The heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23. In eighth embodiment, the radiator 8 which exchange heat between refrigerant and heat medium is placed in the tank unit 2. That is, the connecting pipe 23 is a refrigerant pipe configuring a portion of the refrigerant circuit 3.

[0171] The heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23 when the water heater is installed. A remote control (not shown) and the heat pump unit 1 are connected to each other by a lead wire and the heat pump unit 1 and the tank unit 2 are connected to each other by a power supply wire when the water heater is installed.

[0172] After the water heater is installed, if the pressure relief valve 20 is opened in a state where the hot water supply terminal 17 is closed, water flowing through the water pipe flows into the hot water supply circuit 16, flows through the water-entering pipe 18, passes through the pressure reducing valve 19 and flows into the tank 11. Thereafter, water also flows through the heat medium circuit 4, and the tank 11 and the heat medium circuit 4 are filled with water. It is possible to determine whether the heat medium circuit 4 and the tank 11 are filled with water by determining whether water flows out from the pipe 21. That is, if water flows out, this means that the heat medium circuit 4 and the tank 11 are filled with water.

The water heater in eighth embodiment use, as heat medium, water which flows through the water-entering pipe 18 and flows into the tank 11 and the heat medium circuit 4.

[0173] If heat medium in the heat medium circuit 4 is reduced after the tank 11 and the heat medium circuit 4 are filled with heat medium (water), pressure in the tank 11 and the heat medium circuit 4 is reduced. If pressure in the tank 11 and the heat medium circuit 4 is lowered by a given value or more, water which flows into the hot water supply circuit 16 flows through the water-entering pipe 18, and automatically flows into the tank 11. Hence, it is unnecessary for a user of the hot water heater to replenish heat medium by himself or herself.

[0174] Water which flows into the hot water supply circuit 16 from a water pipe flows toward the hot water supply terminal 17 by pressure of water which flows through the water pipe. Generally, pressure (water pressure) of water which flows through a water pipe is higher than pressure of water which is sent by a pump 14 under pressure. Hence, a given amount or more hot water flowing out from the hot water supply terminal 17 can be secured, and comfort of a user is enhanced.

[0175] Next, operation of the water heater in the eighth embodiment will be described.

[0176] In the heating operation for heating heat medium stored in the tank 11, the control device 50 operates the heat pump device 30 such that high temperature and high pressure refrigerant flows into the three-way heat exchanger 60, and controls the changeover valve 15 and the pump 14 such that heat medium circulates in the direction of the solid line arrows shown in Fig. 9. According to this, refrigerant and heat medium exchange heat in the three-way heat exchanger 60.

[0177] At this time, heat medium flows through the flow paths of the changeover valve 15 shown by a solid line as shown in Fig. 9. According to this, heat medium flows through the lower portion of the tank 11, the changeover valve 15, the pump 14, the changeover valve 15 and the three-way heat exchanger 60 in this order, and flows into the the tank 11 from its upper portion.

[0178] Further, the control device 50 actuates the compressor 5 of the heat pump device 30, and compresses refrigerant up to high pressure. The compressed high temperature and high pressure refrigerant passes through the connecting pipe 23, and flows into the three-way heat exchanger 60 placed in the tank unit 2.

[0179] In the three-way heat exchanger 60, the high temperature and high pressure gas phase refrigerant and heat medium which is sent by the pump 14 under pressure and which flows through the heat medium circuit 4 exchange heat. According to this, the heat medium is heated and high temperature heat medium is produced. The high temperature heat medium flows out from the radiator 8, flows through the heat medium circuit 4 and flows into the tank 11 from its upper portion of the tank 11.

[0180] The refrigerant exchanges heat with heat medium in the three-way heat exchanger 60 and is con-

densed, and becomes low temperature and low pressure gas-liquid two phase state or liquid state. Thereafter, the refrigerant is decompressed by the decompressor 6 and is expanded, and flows into the evaporator 7. The refrigerant exchanges heat with air sent by the blast fan 9 in the evaporator 7, evaporates and becomes gas phase state. The gas phase refrigerant again flows into the compressor 4.

[0181] The refrigerant circulates through the refrigerant circuit 3 in this manner, heat medium circulates through the heat medium circuit 4, and the refrigerant and the heat medium exchange heat in the three-way heat exchanger 60. According to this, heat medium stored in the tank 11 is heated. The control device 50 may control the number of rotations of the heat pump device 30 and the number of rotations of the pump 14 such that temperature of heat medium detected by the thermistor 22e becomes equal to a predetermined value.

[0182] The heat medium which is heated by the three-way heat exchanger 60 to high temperature flows into the tank 11 from its upper portion. According to this, high temperature heat medium is stored in the tank 11. Hence, temperature of heat medium stored in the tank 11 is higher in the upper portion of the tank 11 and lower in the lower portion of the tank 11.

[0183] That is, temperature stratification of heat medium is formed in the tank 11. A dot-and-dash line in the tank 11 shown in Fig. 9 shows this temperature stratification, and its temperature becomes higher rightward. As shown in Fig. 9, the heat medium in the tank 11 is divided into a high temperature region having substantially constant temperature, a transition region where temperature is reduced abruptly, and a low temperature region.

[0184] Heat medium which flows out from the lower portion of the tank 11 during the heating operation is in the low temperature region. Until the entire heat medium in the tank 11 becomes high temperature, temperature rise of the heat medium which flows into the radiator 8 is suppressed. Operation efficiency of the heat pump device 30 is high when the heat medium which flows into the radiator 8 is low. Hence, the operation of the heat pump device 30 is enhanced.

[0185] As described above, in the heating operation, refrigerant and heat medium exchange heat in the radiator 8, and high temperature heat medium is produced.

[0186] In the heating operation, the control device 50 controls the changeover valve 15 such that a flowing direction through the refrigerant flow path 60a and a flowing direction through the heat medium flow path 60b are opposed to each other. That is, temperature variation of refrigerant flowing through the refrigerant flow path 60a and temperature variation of heat medium flowing through the heat medium flow path 60b are opposed to each other. The refrigerant flows into the refrigerant flow path 60a in its high temperature state, exchanges heat with heat medium, the temperature of refrigerant becomes lower than that when the refrigerant flows into,

and the refrigerant flows out from the refrigerant flow path 60a. Heat medium flows into the heat medium flow path 60b in its low temperature state, exchanges heat with refrigerant, temperature of the heat medium becomes higher than that when the heat medium flows into, and the heat medium flows out from the heat medium flow path 60b. According to this, refrigerant and heat medium exchange heat in a state where a temperature difference therebetween is secured at a given level or more. Hence, heat exchanging efficiency in the three-way heat exchanger 60 is enhanced. Therefore, the operation efficiency of the heat pump device 30 is enhanced.

[0187] Next, a hot water supplying operation for supplying hot water to the hot water supply terminal 17 will be described. The hot water supplying operation is for heating water by high temperature heat medium stored in the tank 11, thereby producing hot water which is to be supplied to the hot water supply terminal 17.

[0188] If a user opens the hot water supply terminal 17, water in the hot water supply circuit 16 flows out from the hot water supply terminal 17. If the flow switch 10 detects a flow of water through the hot water supply circuit 16, the hot water supplying operation is started. The hot water supplying operation may be started when a user instructs through a remote control (not shown).

[0189] In the hot water supplying operation in which water flowing through the hot water supply circuit 16 is heated to produce hot water, and the hot water is supplied from the hot water supply terminal 17, the control device 50 controls the changeover valve 15 and the pump 14 such that heat medium circulates in the direction of the broke line arrows shown in Fig. 9. According to this, heat medium and water exchange heat in the three-way heat exchanger 60. The control device 50 may control the number of rotations of the pump 14 such that temperature detected by the thermistor 22d becomes equal to a predetermined value.

[0190] In the hot water supplying operation, the control device 50 controls the pump 14 and the changeover valve 15 such that heat medium flows in the direction shown by the broke line arrows shown in Fig. 9. According to this, high temperature heat medium stored in the upper portion in the tank 11 flows out from the upper portion of the tank 11, flows through the heat medium circuit 4, and flows into the three-way heat exchanger 60. The heat medium which flows into the three-way heat exchanger 60 flows through the hot water supply circuit 16, and exchanges heat with water which flows into the three-way heat exchanger 60. According to this, hot water is produced. The produced hot water flows through the hot water supply circuit 16 and flows out from the hot water supply terminal 17.

[0191] Here, in the hot water supplying operation, the control device 50 controls the changeover valve 15 such that a flowing direction of the heat medium flow path 60b and a flowing direction of the hot water supply flow path 60c are opposed to each other. That is, it is configured such that temperature variation of heat medium flowing

through the heat medium flow path 60b and temperature variation of water flowing through the hot water supply flow path 60c are opposed to each other. The heat medium flows into the heat medium flow path 60b in its high temperature state, exchanges heat with water, and the heat medium flows out from the heat medium flow path 60b in a state where temperature of the heat medium becomes lower than that when the heat medium flows into the heat medium flow path 60b.. On the other hand, water flows into the hot water supply flow path 60c in its low temperature state, exchanges heat with heat medium, and flows out from the hot water supply flow path 60c in a state where temperature of the water becomes higher than that when the water flows into the hot water supply flow path 60c. According to this, heat medium and water exchange heat in a state where a temperature difference therebetween is maintained at a given value or higher. According to this, heat exchanging efficiency in the three-way heat exchanger 60 is enhanced.

[0192] The three-way heat exchanger 60 exchanges heat with water, heat medium having lowered temperature flows through the changeover valve 15, the pump 14 and the changeover valve 15, and flows into the tank 11 from its lower portion. Hence, if the hot water supplying operation is carried out, an amount of heat medium in a low temperature region is increased in the tank 11. In this manner, heat medium exchanges heat with water in the three-way heat exchanger 60 and temperature of the heat medium is lowered, and this heat medium flows into the low temperature region from the lower portion of the tank 11. Therefore, it is possible to heat water while maintaining the temperature stratification in the tank 11.

[0193] By changing over the circulating direction of heat medium by the changeover device, the hot water supplying operation and the heating operation are executed while maintaining the temperature stratification of the heat medium in the tank 11. Hence, the operation efficiency of the heat pump device 30 can be enhanced. Further, it is possible to adjust temperature of hot water to be supplied to the hot water supply terminal 17.

[0194] When a user sets temperature of hot water which flows out from the hot water supply terminal 17 by a remote control for example, the control device 50 can control the number of rotations of the pump 14 such that temperature of hot water detected by the thermistor 22d becomes equal to a set temperature. According to this, hot water having temperature which is set by a user is supplied from the hot water supply terminal 17. When the hot water supply terminal 17 has a temperature control function, it is unnecessary to control the number of rotations of the pump 14 and to adjust temperature of produced hot water. It is only necessary to supply hot water having predetermined temperature to the hot water supply terminal 17.

[0195] It is possible to changeover the circulating direction of heat medium by the changeover valve 15 in this manner. That is, in the heating operation, heat medium flows through the lower portion of the tank 11, the

changeover valve 15, the pump 14, the changeover valve 15, the three-way heat exchanger 60 and the upper portion of the tank 11 in this order. In the hot water supplying operation on the other hand, heat medium flows through the upper portion of the tank 11, the three-way heat exchanger 60, the changeover valve 15, the pump 14, the changeover valve 15 and the lower portion of the tank 11 in this order.

[0196] Hence, the control device 50 executes the heating operation, since refrigerant and heat medium flow in the opposed directions in the three-way heat exchanger 60, the heat exchanging efficiency is enhanced. Further, when the control device 50 executes the hot water supplying operation, heat medium and water flow in the opposed directions in the three-way heat exchanger 60, the heat exchanging efficiency is enhanced. According to this, it is possible to save energy of the water heater.

[0197] By the one heat medium circuit 4 and the one pump 14, it is possible to make heat medium flow in different circulating directions. Hence, it is possible to reduce the water heater in size and cost while enhancing the operation efficiency of the water heater. It is possible to reduce the number of pumps 14, and to reduce noise and vibration caused when the pump 14 operates.

[0198] According to the water heater of this embodiment, the pump 14 is placed in the tank unit 2. Hence, resonance of vibration generated when the compressor 5 operates and vibration generated when the pump 14 operates can be prevented. Hence, it is possible to reduce noise, to reduce a using amount of soundproof material, and to reduce cost of the water heater.

[0199] The changeover valve 15 is more inexpensive than the pump 14, and a control circuit which operates the changeover valve 15 is more inexpensive than a control circuit which operates the pump 14. Hence, a case where two pumps 14 are used to circulate heat medium and a case where the pump 14 and the changeover valve 15 are used to circulate heat medium are compared with each other, the latter case, i.e., the case where the pump 14 and the changeover valve 15 are used to circulate heat medium is more inexpensive.

[0200] Next, a hot water supply auxiliary operation in which the heat pump device 30 is operated to heat the heat medium, heat medium is circulated, and hot water is supplied to the hot water supply terminal 17 will be described.

[0201] If the hot water supplying operation is carried out in a state where an amount of heat medium in the high temperature region in the tank 11 is small, water flows through the hot water supply circuit 16 cannot be sufficiently heated in some cases even if heat exchange between heat medium and water is carried out by the hot water supply heat exchanger 13.

[0202] Based on detection values of thermistors 22a to 22c mounted in the tank 11, the control device 50 can detect that an amount of heat medium in the high temperature region in the tank 11 is smaller than the predetermined value. If it is necessary to supply hot water to

the hot water supply terminal 17 in such a state, the hot water supply auxiliary operation in which the heating operation of heat medium carried out by the heat pump device 30 and the heating operation of water carried out by heat medium are carried out in parallel is executed. This predetermined value in this case is set from a design value of the water heater such as heat capacity which can be accumulated in the tank 11 and a lifting height of the pump 14.

[0203] The hot water supply auxiliary operation may be executed by user's instructions through a remote control.

[0204] In the hot water supply auxiliary operation, the control device 50 controls the heat pump device 30, the pump 14 and the changeover valve 15. In the hot water supply auxiliary operation, refrigerant circulates in the refrigerant circuit 3 in directions of the solid line arrows shown in Fig. 9. Heat medium circulates in the heat medium circuit 4 in the directions of the broke line arrows shown in Fig. 9. That is, heat medium flows through the upper portion of the tank 11, the three-way heat exchanger 60, the changeover valve 15, the pump 14, the changeover valve 15 and the lower portion of the tank 11 in this order.

[0205] In the hot water supply auxiliary operation and the hot water supplying operation, circulating directions of heat medium are the same. Water which flows into the hot water supply circuit 16 from the water pipe exchanges heat with heat medium and refrigerant in the three-way heat exchanger 60 and becomes hot water of predetermined temperature, and flows toward the hot water supply terminal 17.

[0206] As described above, it is possible to heat water while heating heat medium which flows into the three-way heat exchanger 60 by refrigerant. Even when an amount of heat medium in the high temperature region is small, it is possible to rise the temperature of heat medium which flows into the three-way heat exchanger 60. According to this, it is possible to heat water and to produce hot water in the three-way heat exchanger 60, and it is possible to realize a water heater having excellent usability.

[0207] If an amount of hot water flowing out from the hot water supply terminal 17 is large, quantity of heat discharged from heat medium in the hot water supply heat exchanger 13 becomes larger than quantity of heat sucked by heat medium in the heat pump device 30 in some cases. Hence, when the hot water supply auxiliary operation is executed, it is preferable that the heating ability of the heat pump device 30 is made greater (e.g., 20 kW) than that when the hot water supply auxiliary operation is not carried out.

[0208] When the hot water supply auxiliary operation is executed in a state where the control device 50 detects that an amount of heat medium in the high temperature region in the tank 11 is smaller than a predetermined value, it is preferable that the control device 50 controls such that the heating ability of the heat pump device 30

becomes the maximum.

[0209] In the hot water supply auxiliary operation, since a flowing direction of refrigerant flowing through the refrigerant flow path 60a and a flowing direction of refrigerant flowing through the heat medium flow path 60b are the same, the operation efficiency of the heat pump device 30 is deteriorated. Hence, it is preferable that the remote control includes selecting means for selecting whether the hot water supply auxiliary operation should automatically be executed. That is, it is preferable that the water heater includes means for prohibiting that the water heater automatically executes the hot water supply auxiliary operation. According to this, a user can select whether the hot water supply auxiliary operation having lower operation efficiency than that of the hot water supplying operation should be executed. Hence, it is possible to enhance the usability of the water heater.

[0210] The water heater in the eighth embodiment can use water including much hard component. A reason thereof will be described below.

[0211] In Japan where a ground form is generally precipitous and lengths of rivers are short, an amount of hard component dissolved in water flowing through the river is small, and there are many places where water supplied from water pipes is soft water. Depending upon areas, places where an amount of hard component in water is high exist. Ground water includes much hard component in some cases.

[0212] On the other hand, in Europe and China where ground forms are gentle and lengths of rivers are long, an amount of hard component dissolved in water flowing through the river is large, and water supplied from water pipe is harder than that of Japan in many cases.

[0213] Many hard components such as calcium carbonate are dissolved in this hard water. The hard component has such characteristics that as the temperature of water becomes higher, solubility becomes lower, and the hard component is precipitated as scale. According to this, scale is precipitated on the high temperature portion of the water heater and the flow path is closed in some cases. Even if the flow path is not closed, if scale adheres to the flow path, a pressure loss increases, and operation efficiency of the water heater is deteriorated.

[0214] For example, calcium carbonate (CaCO_3) which is one of the hard components has such a tendency that if temperature of water rises, solubility of the calcium carbonate is lowered as shown in Fig. 2. That is, the higher the temperature of water becomes, the more the hard component is precipitated as scale, and the hard component is prone to adhere to a flow path.

[0215] Further, in a state where supply of water including much hard component is continued, since precipitation of scale and adhesion of scale are continuously generated, scale is prone to become deposited. The precipitation of scale is prone to be generated in the heat medium flow path 60b in the vicinity of the refrigerant flow path 60a of the water heater where high temperature refrigerant flows. Scale is prone to become deposited

when supply of water having much hard component to the heat medium flow path 60b is continued.

[0216] In the other hand, in the water heater of this embodiment, the heat medium circuit 4 is the closed circuit. Therefore, when pressure in the heat medium circuit 4 rises and a small amount of heat medium is discharged from the pipe 21, water is newly recruited to the heat medium circuit 4.

[0217] Hence, heat medium circulating through the heat medium circuit 4 is used for a long term without being exchanged, and new hard component is not supplied. Therefore, it is possible to suppress the precipitation and deposition of scale in the heat medium flow path 60b.

[0218] Fresh water is always supplied to the hot water supply flow path 60c of the three-way heat exchanger 60. Temperature of hot water to be supplied to the hot water supply terminal 17 such as a faucet, a bathtub and a shower head is about 50° at the highest. Hence, in the hot water supply heat exchanger having lower temperature than that of the heat medium flow path 60b, precipitation of scale is less prone to be generated.

[0219] The water-entering pipe 18 branches off from the hot water supply circuit 16 located upstream of the three-way heat exchanger 60, and is connected to the lower portion of the tank 11, and the pressure reducing valve 19 is placed in the water-entering pipe 18. If the water heater is operated and the heat medium expands and pressure in the heat medium circuit 4 rises, a portion of the expanded heat medium is discharged from the pipe 21 having the pressure relief valve 20. If the amount of heat medium in the heat medium circuit 4 is reduced and pressure in the heat medium circuit 4 is reduced by a given value or more, water flows into the water-entering pipe 18 from the hot water supply circuit 16, and water (heat medium) is recruited to the heat medium circuit 4. According to this, pressure in the heat medium circuit 4 is automatically adjusted. Hence, it is unnecessary for a user to recruit the heat medium. When the closing valve is used instead of the pressure reducing valve 19, by opening the closing valve, it is possible to supply water (heat medium) to the heat medium circuit 4 whose pressure is lowered by a given value or more.

[0220] In the heat pump unit 1 of this embodiment, the compressor 5, the decompressor 6, the evaporator 7 and the blast fan 9 are placed. The heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23 through which refrigerant flows. Hence, the heat pump unit 1 has the same configuration as that of an outdoor unit of an air conditioner. According to this, the outdoor unit of the air conditioner and the heat pump unit 1 can commonly be used. If refrigerant is R410A refrigerant which is usually used in an air conditioner, a connecting operation of the connecting pipe 23 at the time of an installation operation becomes easy.

[0221] Since the heat pump unit 1 and the tank unit 2 are connected to each other through the connecting pipe 23 through which refrigerant flows, refrigerant in the con-

necting pipe 23 does not freeze, and it is unnecessary to carry out a freezing-preventing operation.

(Ninth Embodiment)

[0222] Figs. 10 are schematic block diagrams of the three-way heat exchanger 60 of a water heater in a ninth embodiment of the present invention. In the ninth embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0223] As shown in Figs. 10, the water heater of the ninth embodiment includes the three-way heat exchanger 60 including the refrigerant flow path 60a, the heat medium flow path 60b and the hot water supply flow path 60c, and these flow paths are in contact with each other. According to this, refrigerant flowing through the refrigerant flow path 60a, heat medium flowing through the heat medium flow path 60b and water flowing through the hot water supply flow path 60c can exchange heat with each other.

[0224] Next, an operation of the water heater in this embodiment will be described.

[0225] In the heating operation, refrigerant flows through the refrigerant flow path 60a, and heat medium flows through the heat medium flow path 60b. According to this, refrigerant and heat medium exchange heat with each other. At this time, refrigerant and heat medium flow in the opposed directions.

[0226] In the hot water supplying operation on the other hand, heat medium flows through the heat medium flow path 60b and water flows through the hot water supply flow path 60c. According to this, heat medium and water exchange heat with each other. At this time, heat medium and water flow in the opposed directions

[0227] In the hot water supply auxiliary operation, refrigerant flows through the refrigerant flow path 60a, heat medium flows through the heat medium flow path 60b and water flows through the hot water supply flow path 60c. According to this, water flowing through the hot water supply flow path 60c sucks heat from both refrigerant and heat medium. That is, water can be heated by both high temperature and high pressure refrigerant and high temperature heat medium. At this time, refrigerant and heat medium flow in the same direction, and flowing directions of refrigerant and heat medium and a flowing direction of water which flows through the hot water supply flow path are opposed to each other. According to this, since hot water can be produced even when an amount of heat medium in the tank 11 is small, usability of the hot water is enhanced.

[0228] Next, an emergency hot water supplying operation will be described. In the emergency hot water supplying operation, in the three-way heat exchanger 60 refrigerant flowing through the refrigerant flow path 60a and water flowing through the hot water supply flow path 60c exchange heat with each other, and hot water is produced.

[0229] If the hot water supplying operation is carried out in a state where heat medium in the high temperature region does not exist in the tank 11, it is not possible to sufficiently heat water which flows through the hot water supply circuit 16 even if heat exchange between heat medium and water carried out in the heat exchanger 60 is utilized.

[0230] When it becomes necessary to supply hot water to the hot water supply terminal 17, the control device 50 first detect temperature of heat medium in the tank 11 by the thermistors 22a to 22c mounted on the tank 11, and compares this detection value and temperature of hot water supplied to the hot water supply terminal 17 with each other. Temperature (set temperature) of hot water to be supplied to the hot water supply terminal 17 may be set by a user by means of the remote control (not shown), and the temperature (set temperature) may previously be set.

[0231] When the control device 50 determines that temperature of heat medium in the tank 11 is lower than temperature of water to be supplied to the hot water supply terminal 17, the control device 50 operates the heat pump device 30 to flow high temperature and high pressure refrigerant into the three-way heat exchanger 60. According to this, high temperature and high pressure refrigerant flows through the refrigerant flow path 60a of the three-way heat exchanger 60. Hence, in the three-way heat exchanger 60 refrigerant flowing through the refrigerant flow path 60a and water flowing through the hot water supply flow path 60c exchange heat with each other, and hot water is produced. At this time, as shown in Fig. 10, a flowing direction of refrigerant and a flowing direction of water are opposed to each other.

(Tenth Embodiment)

[0232] Fig. 11 is a schematic block diagram of a water heater in a tenth embodiment of the present invention. In the tenth embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0233] The water heater of the tenth embodiment includes the integral unit 25 in which the heat pump device 30, the heat medium circuit 4, the hot water supply circuit 16, the water-entering pipe 18 and the pipe 21 are placed.

[0234] According to this, since there is no connecting pipe, installation time when the water heater is installed can be shortened. Further, since there is no connecting pipe, it is possible to prevent heat radiation from the connecting pipe.

[0235] The water heater of the tenth embodiment uses carbon dioxide. Carbon dioxide having zero (0) global warming potential can be used as refrigerant which circulates through the refrigerant circuit 3. Carbon dioxide has a lower critical point temperature than that of conventionally used HFC refrigerant such as R410A and R32. Hence, if carbon dioxide is used as refrigerant, a supercritical cycle in which pressure on the high pressure

side of the refrigerant circuit 3 exceeds the critical point is configured.

[0236] According to this, heat medium can be heated to high temperature (e.g., 85°) as compared with HFC refrigerant such as R410A and R32. Since the heat medium can be heated to high temperature, heat quantity accumulated in the tank 11 can be increased, and the tank 11 can be reduced in size.

[0237] If carbon dioxide is used as refrigerant, pressure on the high pressure side of the refrigerant circuit 3 becomes high (e.g., 8 MPa) as compared with a case where HFC refrigerant is used. Hence, it is necessary to enhance pressure resistance of the refrigerant pipe, and especially it is necessary to enhance the pressure resistance of connecting pipe which must be installed. The water heater of this embodiment does not have the connecting pipe. Hence, it is unnecessary to take the pressure resistance of the connecting pipe into consideration.

[0238] According to this, the installation operation when the water heater is installed can be made easy. Further, since the refrigerant circuit 3, the heat medium circuit 4 and the hot water supply circuit 16 are accommodated in the integral unit 25, lengths of pipes which connect the various constituent parts can be shortened. Heat insulation material is wound around each of pipes accommodated in the integral unit 25. According to this, heat radiation loss can be reduced, and operation efficiency of the water heater can be enhanced.

(Eleventh Embodiment)

[0239] Fig. 12 is a schematic block diagram of a water heater in an eleventh embodiment of the present invention. In the eleventh embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0240] The water heater in the eleventh embodiment includes the reversible pump 31 as a pump for sending heat medium under pressure.

[0241] The reversible pump 31 has a function to reverse a circulating direction of heat medium flowing through the heat medium circuit 4. That is, the reversible pump 31 functions as a changeover device which reverses the circulating direction of heat medium. Hence, it is possible to change the circulating direction of heat medium without using the changeover valve.

[0242] In the heating operation, the control device 50 controls the reversible pump 31 such that heat medium circulates in directions of solid line arrow shown in Fig. 12. Heat medium in the heat medium circuit 4 flows through the lower portion of the tank 11, the reversible pump 31, the three-way heat exchanger 60 and the upper portion of the tank 11 in this order.

[0243] At this time, the control device 50 controls the heat pump device 30 such that high temperature and high pressure refrigerant flows into the three-way heat exchanger 60. According to this, heat medium and refrigerant which flows into the three-way heat exchanger

60 exchange heat with each other, and high temperature heat medium is produced. The produced heat medium flows through the heat medium circuit 4, and flows into the tank 11 from its upper portion. Hence, high temperature heat medium is stored in the tank 11. The control device 50 may control the reversible pump 31 and the heat pump device 30 such that a detection value of the thermistor 22e becomes equal to a predetermined value.

[0244] In the hot water supplying operation, the control device 50 controls the reversible pump 31 such that heat medium circulates in directions of broken line arrows shown in Fig. 12. Heat medium in the heat medium circuit 4 flows through the upper portion of the tank 11, the three-way heat exchanger 60, the reversible pump 31 and the lower portion of the tank 11 in this order.

[0245] Heat medium flowing through the heat medium circuit 4 exchanges heat with water which flows through the hot water supply circuit 16 in the three-way heat exchanger 60. According to this, hot water is produced.

[0246] When a user sets temperature of hot water flowing out from the hot water supply terminal 17 by means of the remote control, the control device 50 can detect temperature of hot water flowing into the hot water supply heat exchanger 13 by the thermistor 22e, and based on the detection value, the control device 50 can control the number of rotations of the reversible pump 31 such that temperature of hot water detected by the thermistor 22d becomes equal to the set temperature. Here, when the temperature detected by the thermistor 22d is lower than the set temperature, the control device 50 reduces the number of rotations of the reversible pump 31. On the other hand, when the temperature detected by the thermistor 22d is higher than the set temperature, the control device 50 increases the number of rotations of the reversible pump 31.

[0247] When it is possible to adjust the temperature by the hot water supply terminal 17, the control device 50 does not need to appropriately control the number of rotations of the reversible pump 31 in order to adjust the temperature of hot water supplied to the hot water supply terminal 17, and it is only necessary to supply hot water having predetermined temperature or higher to the hot water supply terminal 17.

[0248] In the hot water supply auxiliary operation, the control device 50 controls the heat pump device 30 such that high temperature and high pressure refrigerant flows into the three-way heat exchanger 60. The control device 50 controls the reversible pump 31 such that heat medium circulates in the broken line arrow directions shown in Fig. 12. Heat medium in the heat medium circuit 4 flows through the upper portion of the tank 11, the three-way heat exchanger 60, the reversible pump 31 and the lower portion of the tank 11 in this order.

[0249] By changing over the circulating directions of heat medium by the reversible pump 31 in this manner, it is possible to execute the heating operation, the hot water supplying operation and the hot water supply auxiliary operation by the one heat medium circuit 4 and the

one reversible pump 31.

(Twelfth Embodiment)

[0250] Fig. 13 is a schematic block diagram of a water heater in a twelfth embodiment of the present invention. In the twelfth embodiment, the same symbols as those of the members in the previous embodiments are used, and explanation thereof will be omitted.

[0251] As shown in Fig. 13, the water heater of the twelfth embodiment includes the supply pipe 27 connected to the upper portion of the tank 11 and having the closing valve 26. The closing valve 26 can close and open the flow path.

[0252] The tank 11 includes the liquid level sensor 28 which detects an amount of heat medium stored in the tank 11. The control device 50 can detect reduction in an amount of heat medium by means of the liquid level sensor 28, display a result thereof on the remote control, and inform a user of this result.

[0253] Further, the heat medium circuit 4 is a closed circuit formed by annularly connecting the tank 11, the changeover valve 15, the pump 14 and the three-way heat exchanger 60 to one another. According to this, water having much hard component does not flow into the three-way heat exchanger 60. It is possible to suppress the precipitation and deposition of scale. An expansion tank 29 is placed on the heat medium circuit 4 between the radiator 8 and the upper portion of the tank 11. When heat medium expands, the expansion tank 29 adjusts pressure in the heat medium circuit 4.

[0254] When an amount of heat medium is reduced, the closing valve 26 is opened and it is possible to recruit heat medium into the tank 11 from the supply pipe 27.

[0255] As heat medium, antifreeze liquid circulates through the heat medium circuit 4. Water may be main component as the heat medium, or the heat medium having higher specific heat or thermal conductivity than those of water may be used. For example, it is possible to use, as the heat medium, galinstan which is eutectic alloy of gallium, indium and tin. According to this, it is possible to prevent heat medium flowing through the heat medium circuit 4 from freezing.

[INDUSTRIAL APPLICABILITY]

[0256] As described above, the water heater of the present invention can use water including much hard component, and the water heater can be reduced in size and cost. Therefore, the present invention can be applied to domestic and professional-use water heaters.

[EXPLANATION OF SYMBOLS]

[0257]

- 1 heat pump unit
- 2 tank unit

- 3 refrigerant circuit
- 4 heat medium circuit
- 5 compressor
- 6 decompressor
- 5 7 evaporator
- 8 radiator
- 8b heat medium flow path (heating portion)
- 9 blast fan
- 11 tank
- 10 13 hot water supply heat exchanger
- 14 pump
- 15 changeover valve (changeover device)
- 16 hot water supply circuit
- 17 hot water supply terminal
- 15 18 water-entering pipe
- 19 pressure reducing valve
- 20 pressure relief valve
- 21 pipe
- 26 closing valve
- 20 27 supply pipe
- 28 liquid level sensor
- 30 heat pump device (heating device)
- 31 reversible pump (changeover device)
- 50 control device
- 25 60 three-way heat exchanger

Claims

- 30 1. A water heater comprising: a heat medium circuit in which a lower portion and an upper portion of a tank storing heat medium therein are annularly connected to each other through a heat medium pipe and the heat medium circulating through the heat medium circuit;
- 35 a heating device for heating the heat medium;
- a pump placed on the heat medium circuit and circulating the heat medium therethrough; and
- 40 a hot water supply circuit in which water supplied from a water pipe flows to a hot water supply terminal, wherein the water heater includes a heat exchanger which exchanges heat between the heat medium flowing through the heat medium circuit and the water flowing through the hot water supply circuit.
- 45 2. The water heater according to claim 1, wherein the heat medium circuit is provided with a heating portion in which the heat medium is heated by the heating device, and the heat exchanger is a hot water supply heat exchanger including a heat medium flow path through which the heat medium flows and a water flow path through which the water flows.
- 50 3. The water heater according to claim 2, wherein the heating device is a heat pump device having a refrigerant circuit formed by annularly connecting a
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compressor, a radiator, a decompressor and an evaporator to one another, refrigerant circulates through the refrigerant circuit, and the radiator exchanges heat between the refrigerant flowing through the refrigerant circuit and the heat medium flowing through the heat medium circuit.

4. The water heater according to claim 3, further comprising a control device, wherein the control device executes a heating operation in which the refrigerant and heat medium flow in opposed directions in the radiator, and a hot water supplying operation in which the heat medium and the water flow in opposed directions in the hot water supply heat exchanger.
5. The water heater according to claim 4, wherein the control device executes a hot water supply auxiliary operation in which the refrigerant and the heat medium exchange heat with each other in the radiator and the heat medium and the water exchange heat with each other in the hot water supply heat exchanger.
6. The water heater according to claim 1, wherein the heating device is a heat pump device having a refrigerant circuit through which refrigerant circulates, and heating the heat medium, and the heat exchanger is a three-way heat exchanger including a refrigerant flow path configuring the refrigerant circuit, a heat medium flow path configuring the heat medium circuit, and a hot water supply flow path configuring the hot water supply circuit.
7. The water heater according to claim 6, wherein the three-way heat exchanger has such a configuration that the refrigerant flow path, the heat medium flow path and the hot water supply flow path come into contact with each other.
8. The water heater according to claim 7, further comprising a control device, wherein the control device executes a heating operation in which the refrigerant and heat medium flow in opposed directions in the three-way heat exchanger, and a hot water supplying operation in which the heat medium and the water flow in opposed directions in the three-way heat exchanger.
9. The water heater according to claim 8, wherein the control device executes a hot water supply auxiliary operation in which the refrigerant, the heat medium and the water flow into the three-way heat exchanger, and the water is heated.
10. The water heater according to claim 8 or 9, further comprising a thermistor for detecting temperature of the heat medium stored in the tank, wherein

when hot water is supplied to the hot water supply terminal in a state where temperature of the hot water supplied to the hot water supply terminal is higher than the temperature of the heat medium in the tank, the control device executes an emergency hot water supplying operation in which the refrigerant and the water flow in opposed directions in the three-way heat exchanger.

11. The water heater according to any one of claims 1 to 10, wherein the heat medium circuit includes a changeover valve for changing over circulating directions of the heat medium.
12. The water heater according to any one of claims 1 to 10, wherein the pump is a reversible pump capable of reversing a circulating direction of the heat medium.
13. The water heater according to any one of claims 1 to 12, further comprising a supply pipe which includes a closing valve for closing a flow path, and which is connected to a position above the tank.
14. The water heater according to any one of claims 1 to 12, further comprising a water-entering pipe which includes a pressure reducing valve or a closing valve for closing a flow path, which branches off from the hot water supply circuit at a location upstream of the three-way heat exchanger, and which is connected to the lower portion of the tank.

Amended claims under Art. 19.1 PCT

1. A water heater comprising: a heat medium circuit in which a lower portion and an upper portion of a tank storing heat medium therein are annularly connected to each other through a heat medium pipe and the heat medium circulating through the heat medium circuit;
a heating device including a heating portion which is provided on the heat medium circuit for heating the heat medium;
a pump placed on the heat medium circuit and circulating the heat medium therethrough; and
a hot water supply circuit in which water supplied from a water pipe flows to a hot water supply terminal, wherein
the water heater includes a hot water supply heat exchanger which exchanges heat between the heat medium flowing through the heat medium circuit and the water flowing through the hot water supply circuit, the heat medium circuit is formed by connecting the lower portion of the tank, the hot water supply heat exchanger, the radiator and the upper portion of the tank to one another through the heat medium pipe in this order, and

the pump and a changeover device for changing over circulating directions of the heat medium are provided on the heat medium circuit between the lower portion of the tank and the hot water supply heat exchanger.

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2. The water heater according to claim 1, wherein the heating device is a heat pump device having a refrigerant circuit formed by annularly connecting a compressor, a radiator, a decompressor and an evaporator to one another, refrigerant circulates through the refrigerant circuit, and the radiator exchanges heat between the refrigerant flowing through the refrigerant circuit and the heat medium flowing through the heating portion.

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3. The water heater according to claim 2, further comprising a control device, wherein the control device executes a heating operation in which the refrigerant and heat medium flow in opposed directions in the radiator, and a hot water supplying operation in which the heat medium and the water flow in opposed directions in the hot water supply heat exchanger.

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4. The water heater according to claim 3, wherein the control device executes a hot water supply auxiliary operation in which the refrigerant and the heat medium exchange heat with each other in the radiator and the heat medium and the water exchange heat with each other in the hot water supply heat exchanger.

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5. The water heater according to any one of claims 1 to 4, wherein the changeover device is a changeover valve for changing over circulating directions of the heat medium.

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6. The water heater according to any one of claims 1 to 4, wherein the pump is a reversible pump which functions as the changeover device for reversing a circulating direction of the heat medium.

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7. The water heater according to any one of claims 1 to 6, further comprising a supply pipe which includes a closing valve for closing a flow path, and which is connected to a position above the tank.

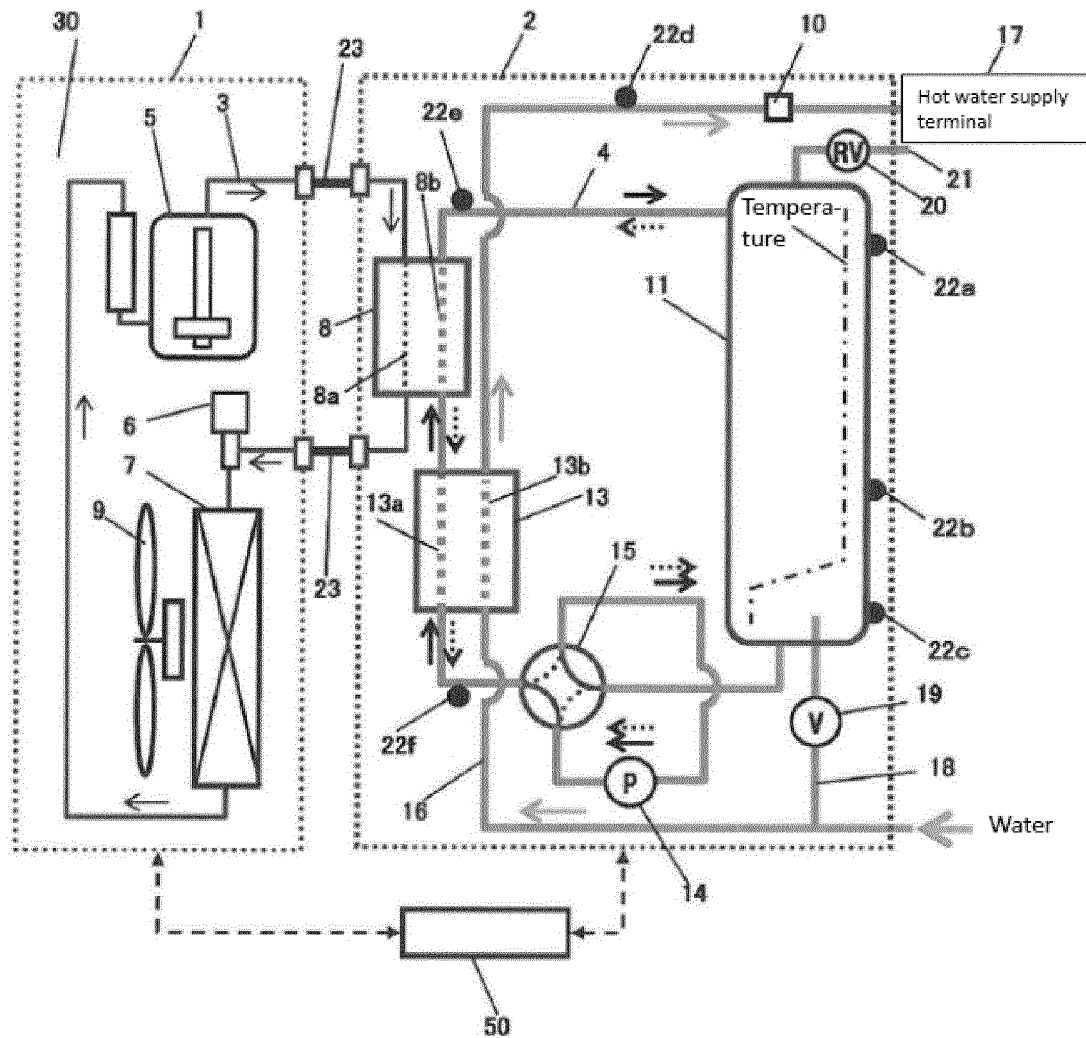
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8. The water heater according to any one of claims 1 to 6, further comprising a water-entering pipe which includes a pressure reducing valve or a closing valve for closing a flow path, which branches off from the hot water supply circuit at a location upstream of the hot water supply heat exchanger, and which is connected to the lower portion of the tank.

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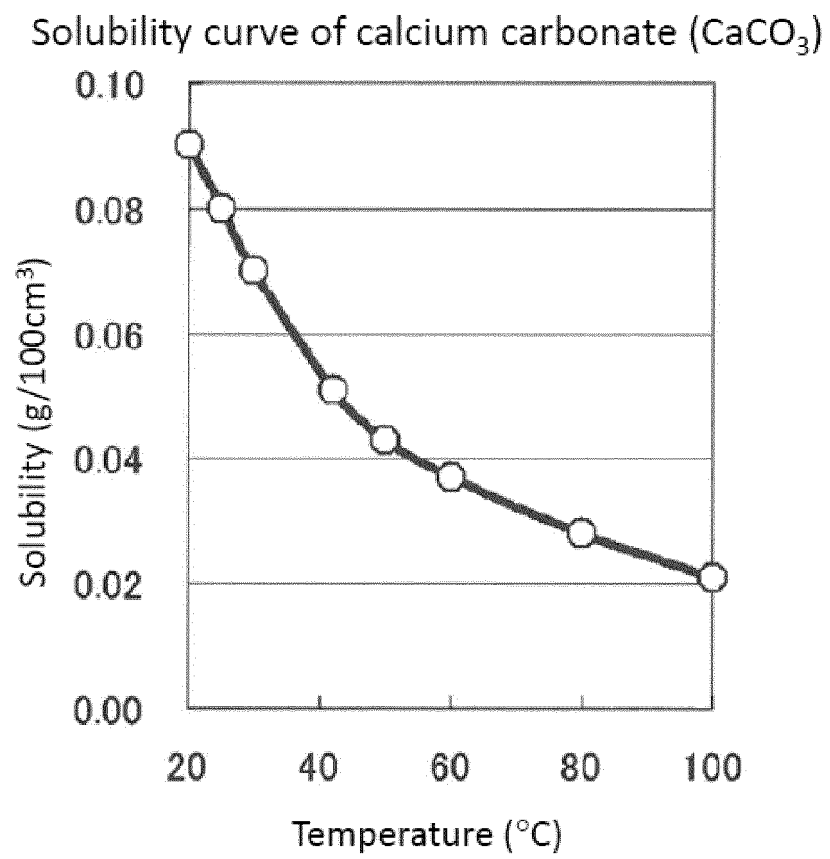
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[Fig. 1]

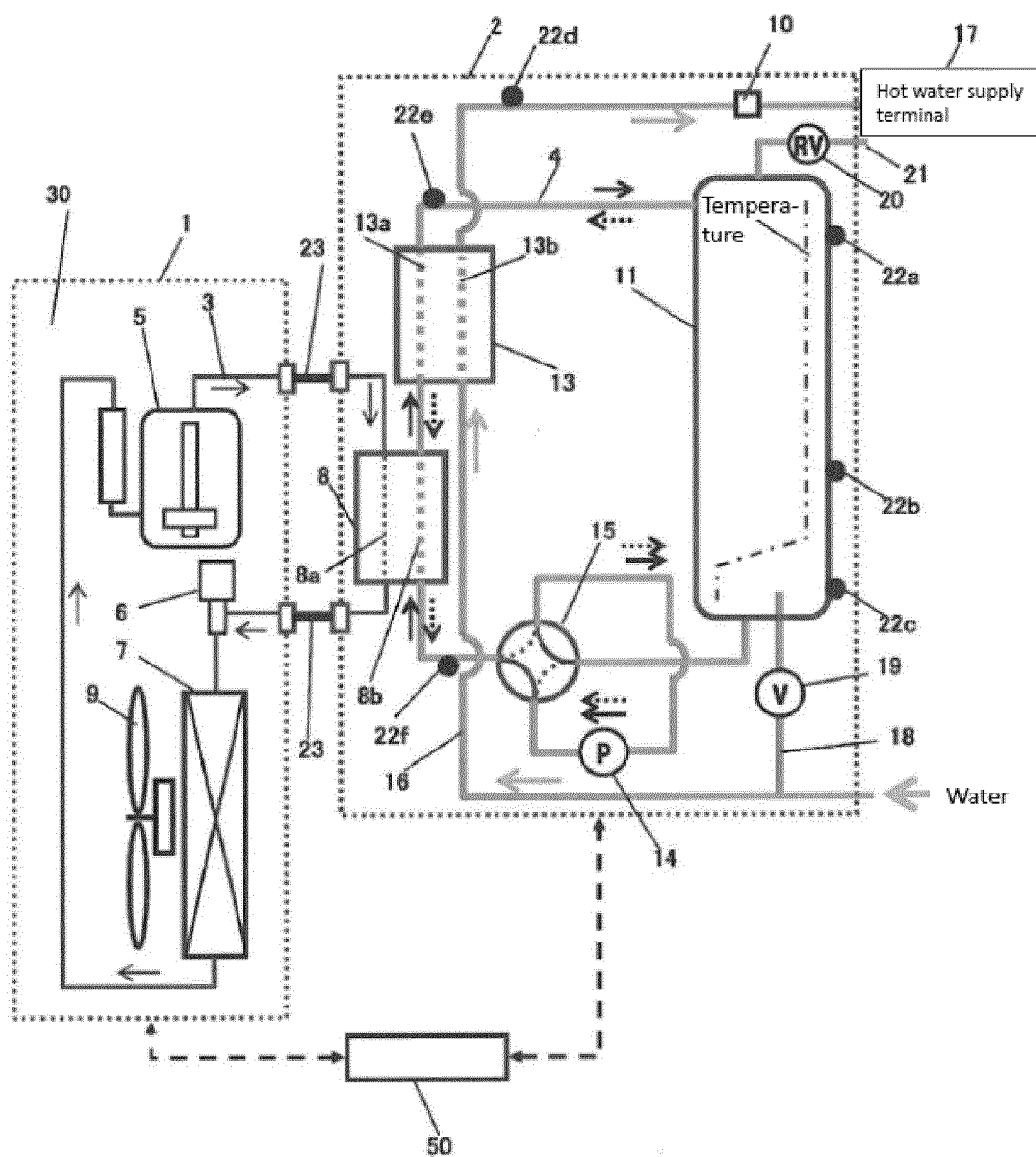


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|---|---|
| 1 Heat pump unit | 13 Hot water supply heat exchanger |
| 2 Tank unit | 14 Pump |
| 3 Refrigerant circuit | 15 Changeover valve (changeover device) |
| 4 Heat medium circuit | 16 Hot water supply circuit |
| 5 Compressor | 17 Hot water supply terminal |
| 6 Decompressor | 18 Water-entering pipe |
| 7 Evaporator | 19 Pressure reducing valve |
| 8 Radiator | 20 Pressure relief valve |
| 8b Heat medium flow path
(heating portion) | 21 Pipe |
| 9 Blast fan | 22a to 22f Thermistor |
| 10 Flow switch | 23 Connecting pipe |
| 11 Tank | 30 Heat pump device |
| | 50 Control device |

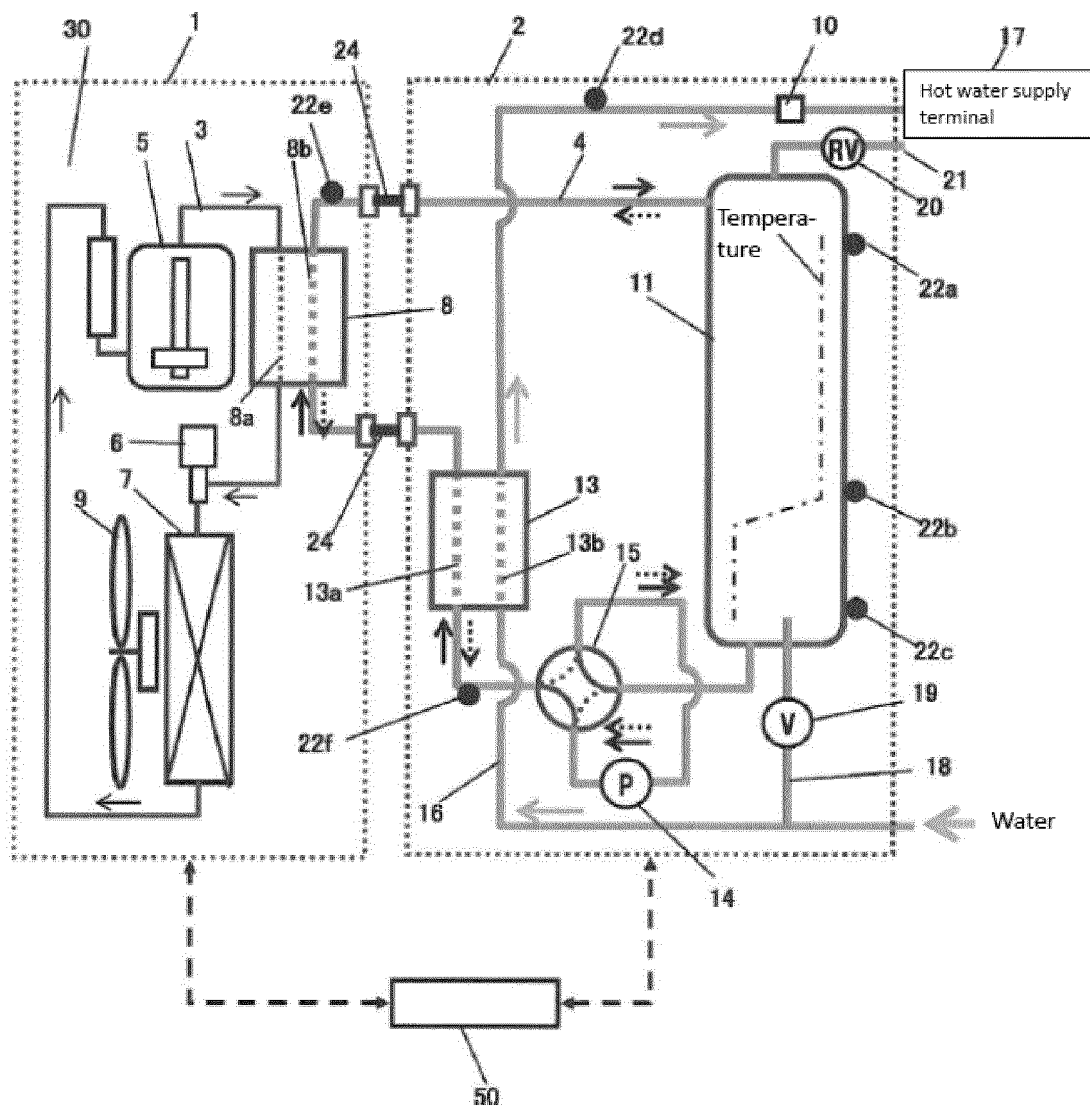
[Fig. 2]



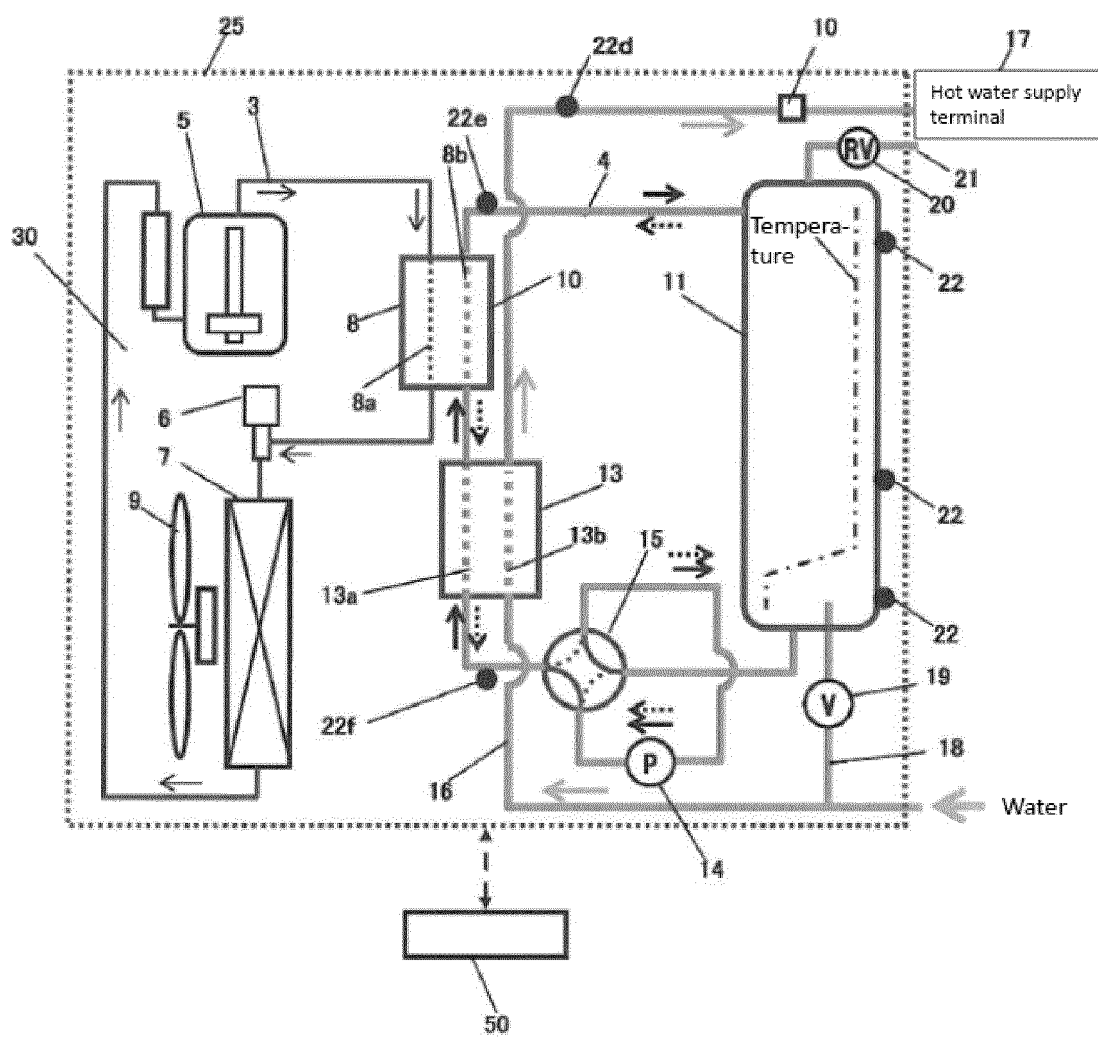
[Fig. 3]



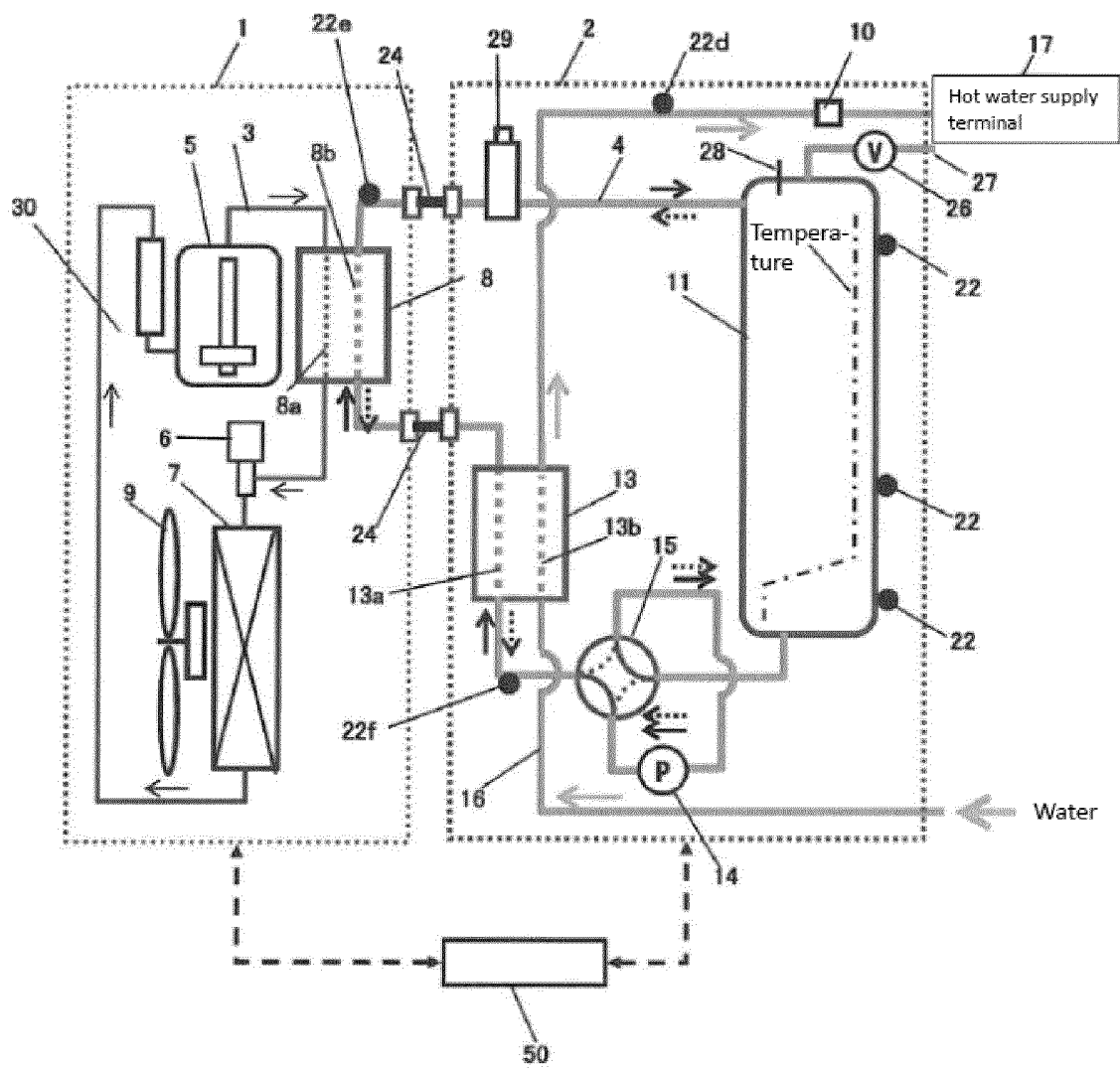
[Fig. 4]



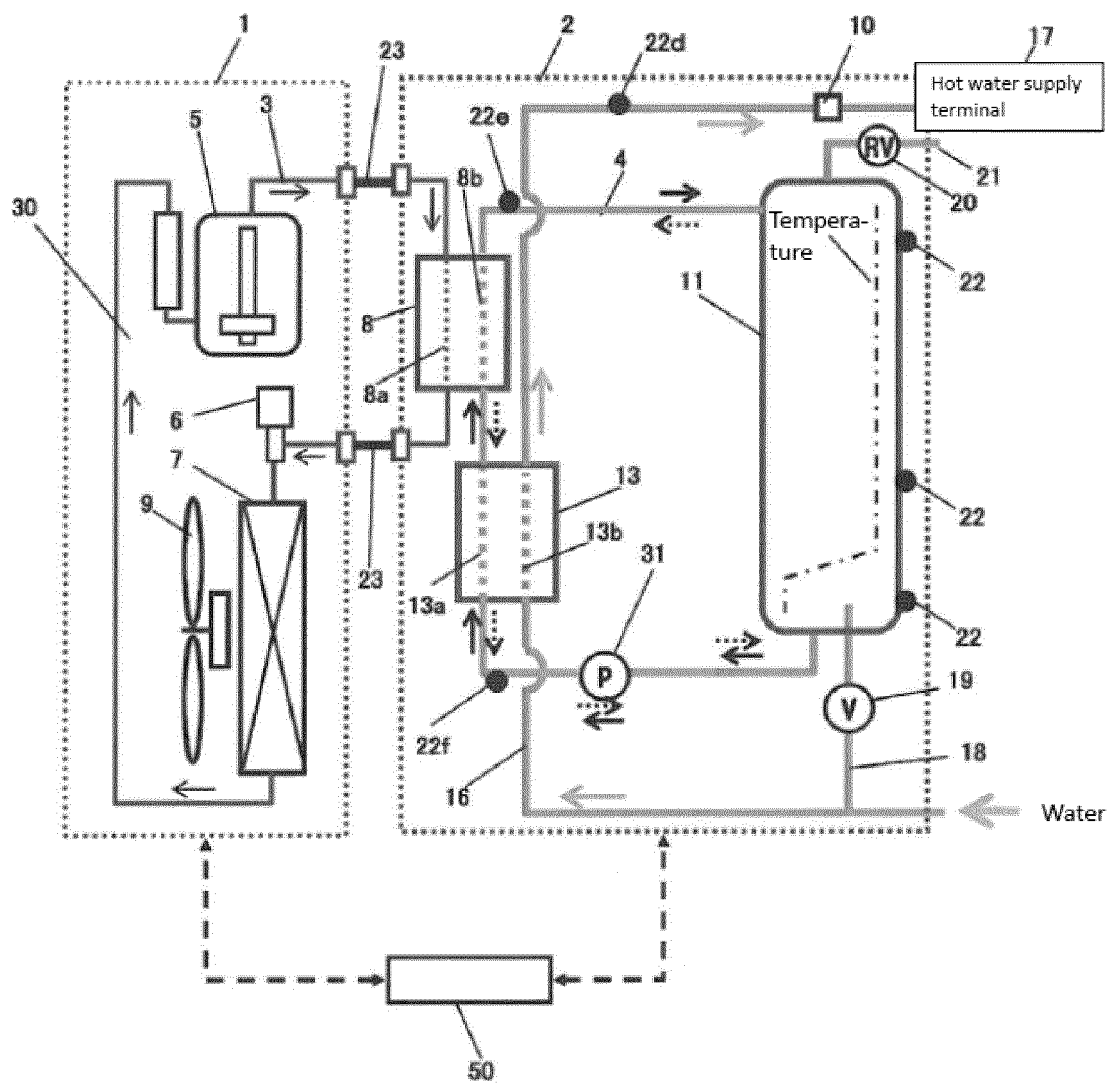
[Fig. 5]



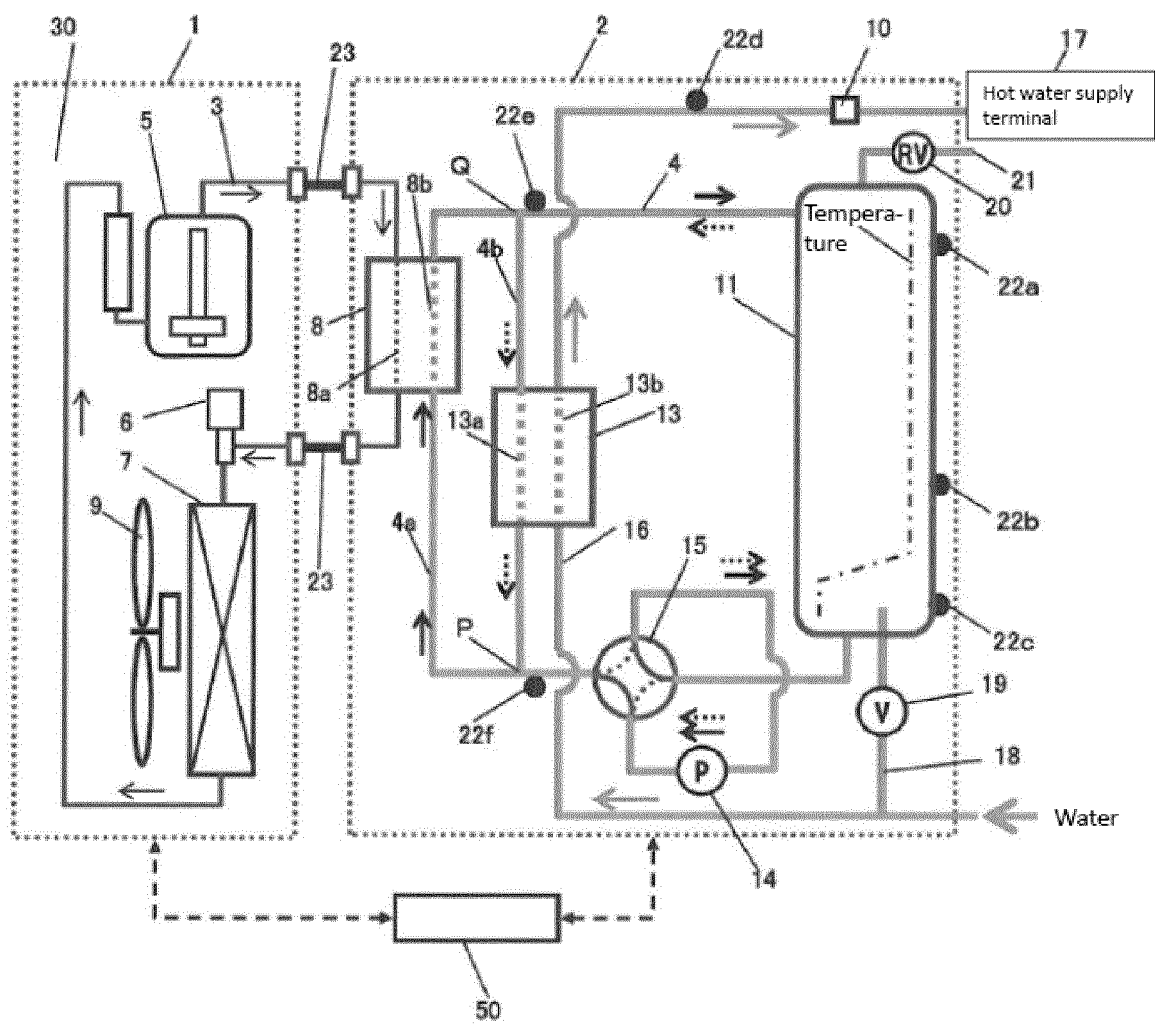
[Fig. 6]



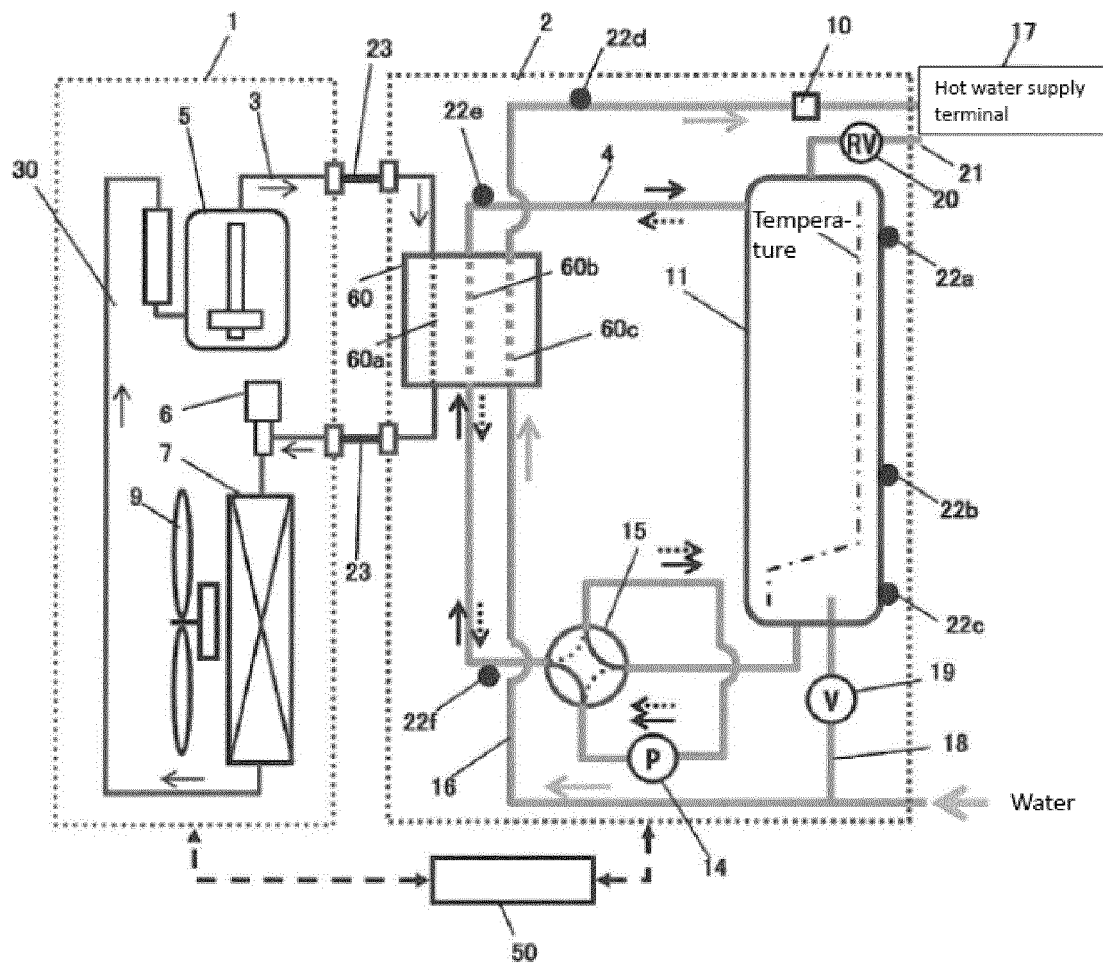
[Fig. 7]



[Fig. 8]



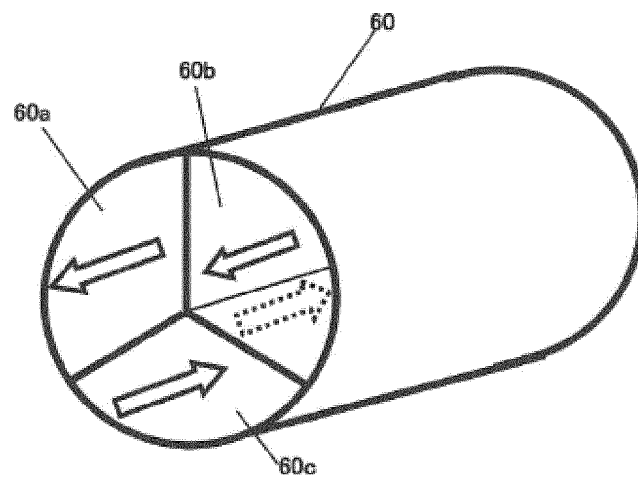
[Fig. 9]



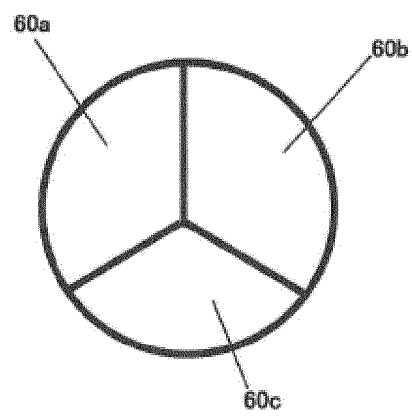
- | | |
|--|--|
| 1 Heat pump unit | 17 Hot water supply terminal |
| 2 Tank unit | 18 Water-entering pipe |
| 3 Refrigerant circuit | 19 Pressure reducing valve |
| 4 Heat medium circuit | 20 Pressure relief valve |
| 5 Compressor | 21 Pipe |
| 6 Decompressor | 22a to 22f Thermistor |
| 7 Evaporator | 23 Connecting pipe |
| 9 Blast fan | 30 Heat pump device |
| 10 Flow switch | 50 Control device |
| 11 Tank | 60 Three-way heat exchanger |
| 14 Pump | 60a Refrigerant flow path |
| 15 Changeover valve
(changeover device) | 60b Heat medium flow path
(heating portion) |
| 16 Hot water supply circuit | 60c Hot water supply flow path |

[Fig. 10]

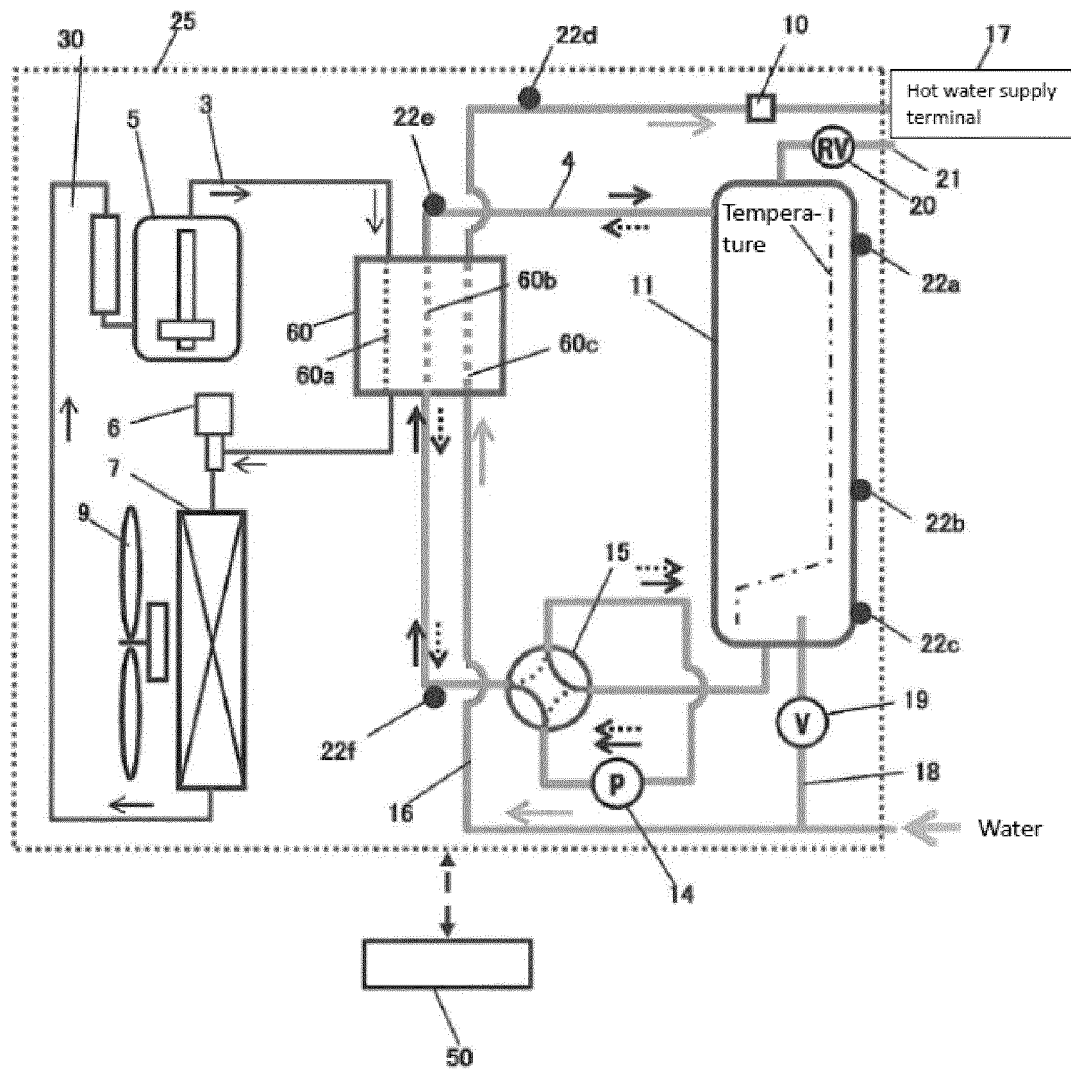
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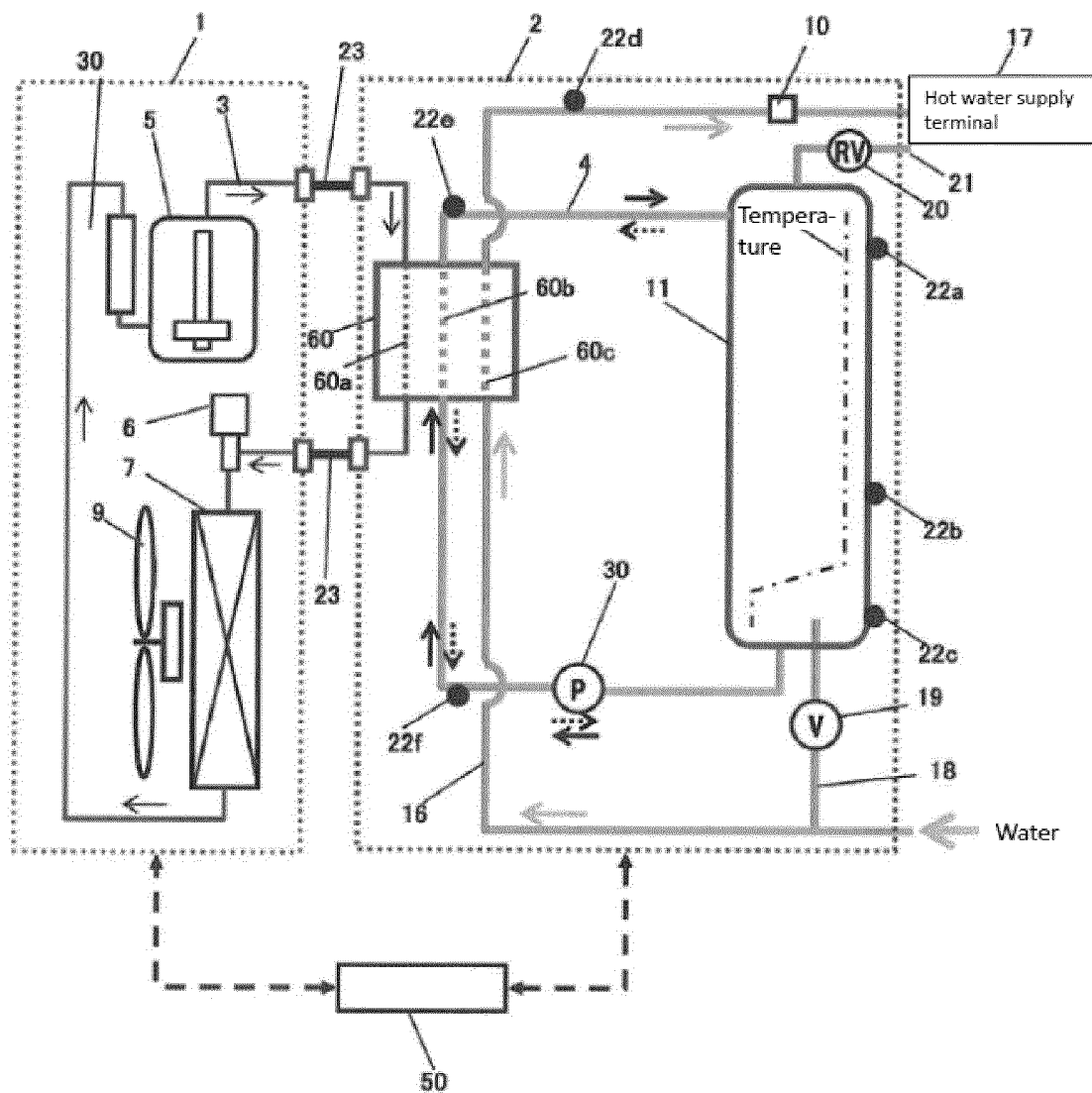
(b)



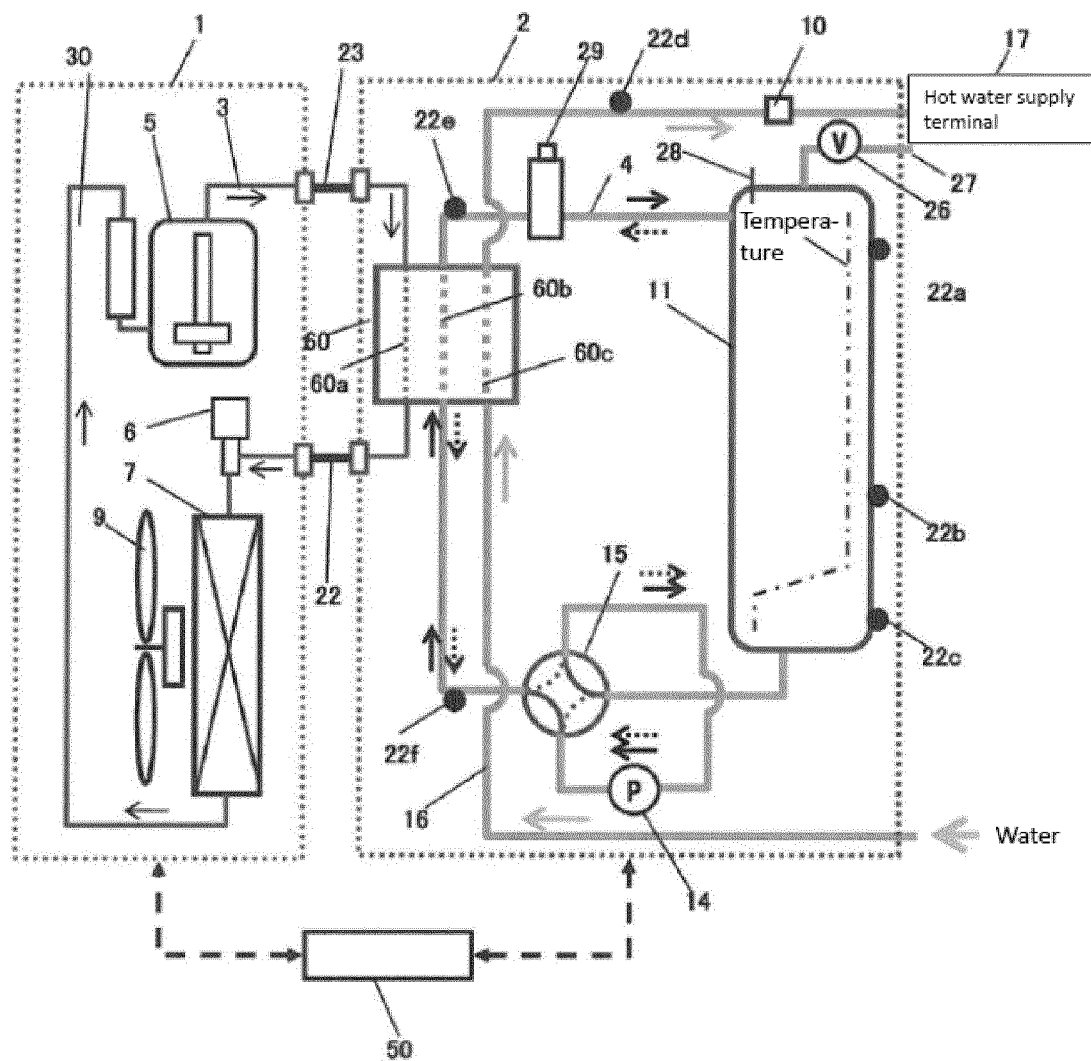
[Fig. 11]



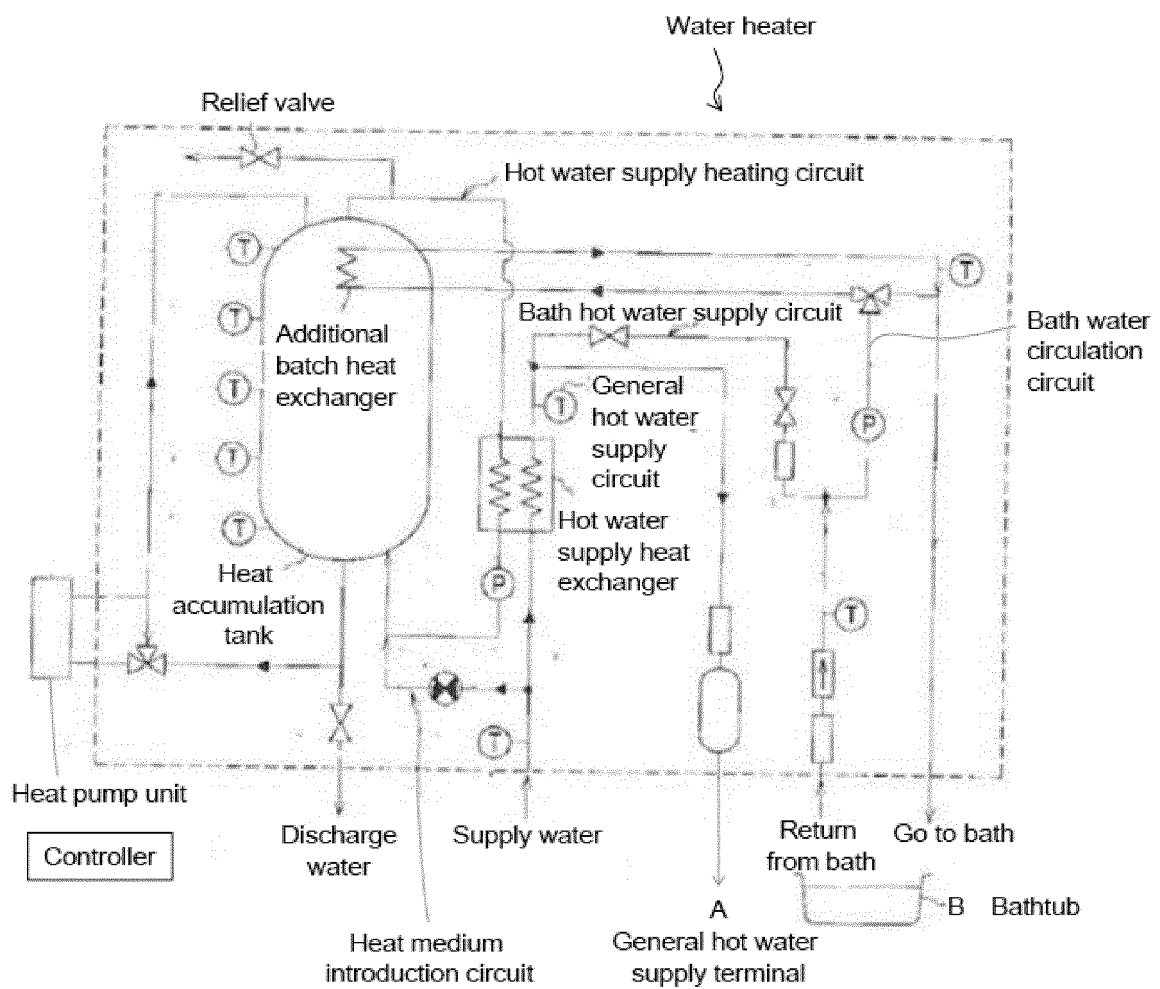
[Fig. 12]



[Fig. 13]



[Fig. 14]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/001270

A. CLASSIFICATION OF SUBJECT MATTER

F24H1/18(2006.01)i, F24H1/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24H1/18, F24H1/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014

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	JP 2012-7802 A (Hitachi Appliances, Inc.),	1
Y	12 January 2012 (12.01.2012), entire text; all drawings & CN 102297505 A & KR 10-2011-0140093 A	2-14
Y	JP 2009-174753 A (Mitsubishi Electric Corp.), 06 August 2009 (06.08.2009), entire text; all drawings (Family: none)	2-14
Y	JP 2012-17900 A (Mitsubishi Electric Corp.), 26 January 2012 (26.01.2012), entire text; all drawings (Family: none)	2-14

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

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Date of the actual completion of the international search

20 May, 2014 (20.05.14)

Date of mailing of the international search report

27 May, 2014 (27.05.14)

Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/001270

C (Continuation). 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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Y	JP 7-269964 A (Toshiba Corp.), 20 October 1995 (20.10.1995), paragraphs [0009], [0027] & US 5784893 A & EP 675331 A2 & KR 10-0157693 B & CN 1117568 A	11-14
Y	JP 4-126924 A (Takenaka Corp.), 27 April 1992 (27.04.1992), page 3, upper right column, lines 6 to 9; fig. 1 (Family: none)	13

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

REFERENCES CITED IN THE DESCRIPTION

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