(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 306 111 A1

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

(43) Date of publication:
06.04.2011 Bulletin 2011/14

(21) Application number: **09758278.7**

(22) Date of filing: **01.06.2009**

(51) Int Cl.:
F24H 1/00 *(2006.01)* ***F24D 3/08*** *(2006.01)*
F24D 3/18 *(2006.01)* ***F25B 39/00*** *(2006.01)*
F25B 40/00 *(2006.01)* ***F25B 47/02*** *(2006.01)*

(86) International application number:
PCT/JP2009/059960

(87) International publication number:
WO 2009/148011 (10.12.2009 Gazette 2009/50)

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

(30) Priority: **06.06.2008 JP 2008149139**
11.07.2008 JP 2008181385

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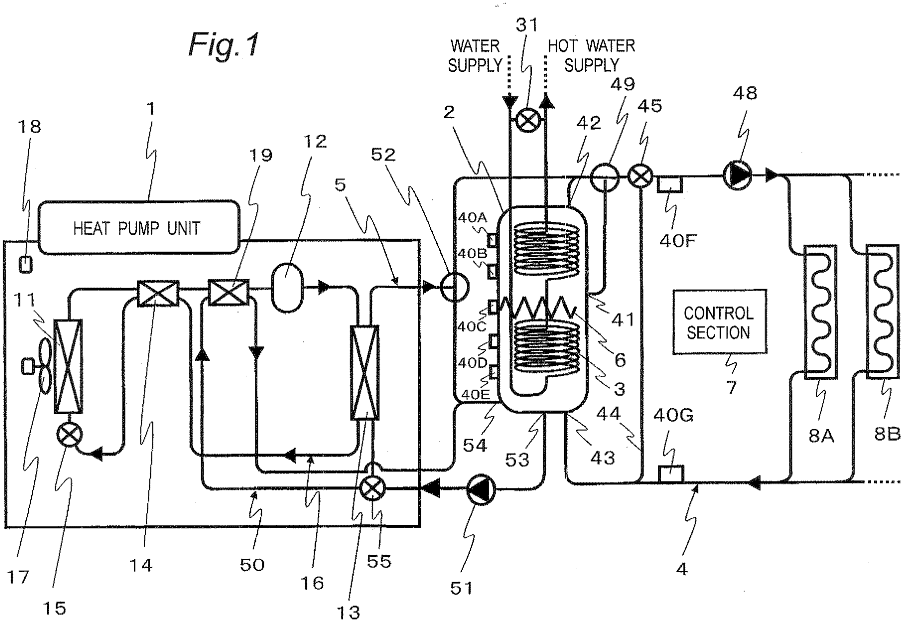
(54) **HOT WATER SYSTEM**

(57) A heat pump unit 1 has a refrigerant circuit 16, and an evaporator 11, a compressor 12, a condenser 13, an expansion mechanism 15 and a defrosting heat exchanger 19 provided in the refrigerant circuit 16. The defrosting heat exchanger 19 is provided downstream of the evaporator 11 and upstream of the compressor 12. During defrosting operation, hot water within the hot-water storage tank 2 flows through a defrosting circulation circuit 50 to enter into the defrosting heat exchanger 19. A branch valve 55 for controlling flow of hot water flow through the defrosting circulation circuit 50 is provided in the defrosting circulation circuit 50.

Fig.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a hot water system for, for example, hot water supply apparatuses or space-heating and hot water supply apparatuses.

BACKGROUND ART

[0002] Conventionally, there has been provided a space-heating and hot water supply apparatus including a heat pump unit placed outdoors, and a hot-water storage tank for storing hot water heated by the heat pump unit.

[0003] In this heat pump unit, which has an evaporator for capturing heat from outside air, frost may be deposited on the evaporator. With frost deposited on the evaporator, the evaporator deteriorates in heat exchange performance, leading to incapability of sufficient space-heating. Therefore, it becomes indispensable to run defrosting operation for removing the frost from the evaporator.

[0004] There has been an issue that water in the hot-water storage tank cannot be boiled up by the heat pump unit during the running of the defrosting operation.

[0005] As a solution for solving this issue, a space-heating and hot water supply apparatus is described in JP 2004-108597 A (Patent Literature 1). This space-heating and hot water supply apparatus includes a heat pump unit, a hot-water storage tank and a space-heating terminal.

[0006] The heat pump unit has a fan, a first evaporator, a second evaporator, a compressor, a condenser, and an expansion valve.

[0007] The first evaporator is located upstream of the compressor and downstream of the second evaporator. The first evaporator receives outside air fed from the fan, and takes in heat from the outside air.

[0008] According to the space-heating and hot water supply apparatus constructed as described above, hot water in the hot-water storage tank is fed to the second evaporator by a pump during the boil-up of the water in the hot-water storage tank by the heat pump unit. As a result of this, a refrigerant that is just before entering the first evaporator is heated by the hot water, so that the frost deposited on the first evaporator can be melted down.

[0009] However, in the space-heating and hot water supply apparatus of Patent Literature 1 shown above, since the refrigerant heated by the second evaporator enters into the first condenser, the evaporating temperature of the first evaporator increases.

[0010] As a result, the quantity of heat taken in from outside air in the first evaporator decreases, causing a problem that COP (Coefficient Of Performance) of the heat pump unit decreases.

Citation List:

Patent Literature

[0011] Patent Literature 1: JP 2004-108597 A

SUMMARY OF INVENTION

Technical Problem

[0012] Accordingly, an object of the present invention is to provide a hot water system which allows the defrosting operation to be performed during the boil-up of water in the hot-water storage tank, and yet which allows the heat pump unit to be improved in COP even if such defrosting operation is performed.

Solution to Problem

[0013] In order to achieve the object, a hot water system according to the present invention comprises:

a heat pump unit having a refrigerant circuit as well as a first evaporator, a compressor, a condenser and an expansion mechanism provided in the refrigerant circuit;
a hot-water storage tank for storing hot water;
a heating circulation circuit for circulating water within the hot-water storage tank by heating and passing the water through the condenser and thereafter returning the water again into the hot-water storage tank;
a second evaporator provided on the refrigerant circuit;
a defrosting circulation circuit for circulating hot water stored in the hot-water storage tank by passing the hot water through the second evaporator and thereafter returning the hot water again into the hot-water storage tank; and
a flow control section which is provided on the defrosting circulation circuit and which controls flow of hot water flowing through the defrosting circulation circuit.

[0014] According to the hot water system of this construction, in performing defrosting operation for removing frost of the first evaporator, hot water within the hot-water storage tank is thrown into flow through the defrosting circulation circuit by control of the flow control section. As a result, the hot water passes through the second evaporator and thereafter returns again into the hot-water storage tank. In this process, the refrigerant that has come into the second evaporator is heated by the hot water, and thereafter flows toward the first evaporator. As a result, the refrigerant entering into the first evaporator increases in temperature, so that frost deposited on the first evaporator can be melted.

[0015] Also, even while the heat pump unit is boiling up hot water within the hot-water storage tank, the hot water within the hot-water storage tank can be put into flow through the defrosting circulation circuit. Thus, defrosting operation can be performed while the hot water within the hot-water storage tank is being boiled up.

[0016] Also, in the case where the defrosting operation is performed by supplying hot water within the hot-water storage tank to the second evaporator, the hot water is lowered in temperature by the second evaporator and thereafter returns to the hot-water storage tank. As a result, when the hot water within the hot-water storage tank is boiled up after an end of the defrosting operation, low-temperature hot water obtained by the defrosting operation can be supplied to the heat pump unit.

[0017] Therefore, the COP of the heat pump unit is improved in the boil-up operation after the defrosting operation, so that improvement in the COP of the heat pump unit for total operation can be expected.

[0018] The hot water system of one embodiment further comprises:

a hot-water supplying heat exchanger which is placed within the hot-water storage tank and in which supply hot water flows inside; and
a space-heating circulation circuit for circulating hot water stored in the hot-water storage tank by passing space-heating terminals outside the hot-water storage tank and thereafter returning the hot water again into the hot-water storage tank.

[0019] According to the hot water system of this embodiment, when space-heating operation is started, hot water stored in the hot-water storage tank flows through the space-heating circulation circuit to space-heating terminals and returns again to the hot-water storage tank. As a result, heat of the hot water is radiated indoors via the space-heating terminals. That is, the space-heating terminals directly take out heat within the hot-water storage tank and radiate indoors.

[0020] Therefore, since the heat of hot water within the hot-water storage tank can be efficiently supplied to the space-heating terminals, enough space-heating can be fulfilled even in regions of high space-heating loads, for example, in Nordic countries.

[0021] Conventionally, it would be the case that heat is taken out via heat exchangers within the hot-water storage tank and supplied to space-heating terminals, thus resulting in worse efficiency and incapability of enough space-heating.

[0022] In the hot water system of one embodiment, the second evaporator is placed downstream of the first evaporator and upstream of the compressor.

[0023] According to the hot water system of this embodiment, the second evaporator is placed downstream of the first evaporator and upstream of the compressor. Therefore, the refrigerant increased in temperature by the first evaporator is heat-exchanged with hot water supplied from the hot-water storage tank to the second evaporator.

[0024] Thus, hot water supplied from the hot-water storage tank to the second evaporator can be prevented from freezing due to heat exchange with excessively cold refrigerant.

[0025] The hot water system of one embodiment further comprises a supercooling heat exchanger placed downstream of the first evaporator and upstream of the second evaporator.

[0026] According to the hot water system of this embodiment, a supercooling heat exchanger is placed downstream of the first evaporator and upstream of the second evaporator. Therefore, the refrigerant increased in temperature by the first evaporator is further increased in temperature by the supercooling heat exchanger. Then, the refrigerant further increased in temperature by the supercooling heat exchanger enters into the second evaporator, heat exchanging with hot water supplied from the hot-water storage tank to the second evaporator.

[0027] Thus, the hot water supplied from the hot-water storage tank to the second evaporator is less likely to freeze than in the case where no supercooling heat exchanger is placed downstream of the first evaporator and upstream of the second evaporator.

[0028] In the hot water system of one embodiment, the second evaporator serve also as a supercooling heat exchanger.

[0029] According to the hot water system of this embodiment, the second evaporator serve also as a supercooling heat exchanger. Therefore, a supercooling heat exchanger does not need to be provided in addition to the second evaporator, so that the heat pump unit can be downsized.

[0030] In the hot water system of one embodiment, the second evaporator has

a container through which a refrigerant flowing through the refrigerant circuit passes; and
a heat exchanger pipe which is placed within the container and through which hot water derived from the hot-water storage tank flows inside.

[0031] According to the hot water system of this embodiment, the heat exchanger pipe is placed within the container. Therefore, the refrigerant that has come into the container is put into contact with the whole surface of the heat exchanger pipe.

[0032] Thus, heat of the hot water derived from the hot-water storage tank is efficiently transferred to the refrigerant within the container via the heat exchanger pipe.

[0033] In the hot water system of one embodiment, the refrigerant flowing through the refrigerant circuit is a CO_2 refrigerant.

[0034] According to the hot water system of this embodiment, since the refrigerant flowing through the refrigerant circuit is a CO_2 refrigerant, the heat pump unit is enabled to output high-temperature hot water.

[0035] In the hot water system of one embodiment, a part of the heating circulation circuit on an upstream side of the condenser serves also as a part of the defrosting circulation circuit on an upstream side of the second evaporator,

the flow control section is provided at a branch portion between the heating circulation circuit and the defrosting circulation circuit to control a flow rate of hot water flowing from a part of the heating circulation circuit on the upstream side of the condenser to the condenser and a flow rate of hot water flowing from a part of the heating circulation circuit on the upstream side of the condenser to the second evaporator.

[0036] According to the hot water system of this embodiment, a part of the heating circulation circuit on an upstream side of the condenser serves also as a part of the defrosting circulation circuit on an upstream side of the second evaporator. Therefore, if the part of the heating circulation circuit on the upstream side of the condenser is constructed, it is not necessary to construct the part of the defrosting circulation circuit on the upstream side of the second evaporator.

[0037] Thus, time and labor associated with construction of the heating circulation circuit and the defrosting circulation circuit are reduced, so that constructional workability of the heating circulation circuit and the defrosting circulation circuit can be improved.

[0038] Also, the flow control section is provided at a branch portion between the heating circulation circuit and the defrosting circulation circuit. Therefore, the flow of hot water through the heating circulation circuit and the flow of hot water through the defrosting circulation circuit can be controlled by one flow control section.

[0039] Thus, flow control for the flow of hot water through the heating circulation circuit and for the flow of hot water through the defrosting circulation circuit can be prevented from being complicated.

[0040] Besides, during non-defrosting operation, by giving a flow of a necessary minimum quantity of hot water through the second evaporator by the flow control section, it becomes possible to prevent cooling and freezing of hot water within the defrosting circulation circuit.

[0041] The hot water system of one embodiment further comprises a control section for controlling the flow control section so that a quantity of hot water flowing into the second evaporator during defrosting operation of the first evaporator becomes larger than a quantity of hot water flowing into the second evaporator during non-defrosting operation of the first evaporator.

[0042] According to the hot water system of this embodiment, the control section controls the flow control section so that a quantity of hot water flowing into the second evaporator during defrosting operation of the first evaporator becomes larger than a quantity of hot water flowing into the second evaporator during non-defrosting operation of the first evaporator. As a result, the temperature of the refrigerant that has come into the second evaporator can reliably be increased up to a temperature that allows the defrosting of the first evaporator to be achieved.

[0043] The hot water system of one embodiment further comprises

a temperature sensing part for sensing a temperature of hot water that has come out from the second evaporator, wherein

the control section controls the flow control section based on an output of the temperature sensing part.

[0044] According to the hot water system of this embodiment, the temperature sensing part senses a temperature of hot water that has come out from the second evaporator and directed toward the hot-water storage tank. In this case, the control section controls the flow control section based on an output of the temperature sensing part so that the temperature of hot water coming out from the second evaporator and directed toward the hot-water storage tank is kept from becoming, for example, 0°C or lower. This makes it possible to reliably prevent cooling and freezing of hot water within the defrosting circulation circuit.

Advantageous Effects of Invention

[0045] According to the hot water system of the present invention, in performing defrosting operation for removing frost of the first evaporator in the heat pump unit, hot water within the hot-water storage tank is thrown into flow through the defrosting circulation circuit so as to enter into the second evaporator, by control of the flow control section. As a result, the refrigerant coming into the second evaporator is heated by the hot water, increasing in temperature.

[0046] Thus, the refrigerant entering into the second evaporator, after coming out from the second evaporator, flows through the refrigerant circuit and returns to the first evaporator, so that the frost deposited on the first evaporator can be melted.

[0047] Also, even while the heat pump unit is boiling up hot water within the hot-water storage tank, the hot water within the hot-water storage tank can be put into flow through the defrosting circulation circuit. Thus, defrosting operation can be performed while the hot water within the hot-water storage tank is being boiled up.

[0048] Also, in the case where the defrosting operation is performed by supplying hot water within the hot-water storage tank to the second evaporator, the hot water is lowered in temperature by the second evaporator and thereafter returns to the hot-water storage tank. As a result, when the hot water within the hot-water storage tank is boiled up after an end of the defrosting operation, low-temperature hot water obtained by the defrosting operation can be supplied to the heat pump unit.

[0049] Therefore, the COP of the heat pump unit is improved in the boil-up operation after the defrosting operation, so that the COP of the heat pump unit for total operation can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0050] Fig. 1 is a schematic view of a space-heating and hot water supply apparatus according to a first embodiment of the present invention;

Fig. 2 is a schematic view of a space-heating and hot water supply apparatus according to a second embodiment of the invention;
Fig. 3 is a schematic view of a space-heating and hot water supply apparatus according to a third embodiment of the invention; and
Fig. 4 is a schematic view of a space-heating and hot water supply apparatus according to a fourth embodiment of the invention.

DESCRIPTION OF EMBODIMENTS

[0051] Hereinbelow, the hot water system of the present invention will be described in detail by embodiments thereof illustrated in the accompanying drawings.

(First Embodiment)

[0052] Fig. 1 is a schematic view showing a construction of a space-heating and hot water supply apparatus according to a first embodiment of the invention.

[0053] The space-heating and hot water supply apparatus includes a heat pump unit 1, a hot-water storage tank 2, a hot-water supplying heat exchanger 3, a space-heating circulation circuit 4, a boil-up circulation circuit 5 as an example of a heating circulation circuit, and a defrosting circulation circuit 50.

[0054] First, the heat pump unit 1 is described below. The heat pump unit 1, which includes a refrigerant circuit 16 and an electric blower 17, boils up the water in the hot-water storage tank 2 to make hot water. The heat pump unit 1 is connected to the hot-water storage tank 2 via the boil-up circulation circuit 5.

[0055] The refrigerant circuit 16 has an evaporator 11, a compressor 12, a condenser 13, a supercooling heat exchanger 14, an expansion valve 15, and a defrosting heat exchanger 19. In this refrigerant circuit 16, a CO_2 refrigerant circulates. In addition, the evaporator 11 is an example of the first evaporator, the expansion valve 15 is an example of the expansion mechanism, and the defrosting heat exchanger 19 is an example of the second evaporator.

[0056] The supercooling heat exchanger 14 is placed downstream of the evaporator 11 and upstream of the defrosting heat exchanger 19. This arrangement makes it possible to lower the temperature of the CO_2 refrigerant directed from the condenser 13 toward the expansion valve 15.

[0057] The defrosting heat exchanger 19 is placed downstream of the supercooling heat exchanger 14 and upstream of the compressor 12. The defrosting heat exchanger 19 is connected to the hot-water storage tank 2 via the defrosting circulation circuit 50. As a result, hot water in the hot-water storage tank 2 can be supplied to the defrosting heat exchanger 19 so that the temperature of the CO_2 refrigerant directed from the supercooling heat exchanger 14 toward the compressor 12 can be raised.

[0058] In the evaporator 11, the CO_2 refrigerant absorbs heat in the air fed from the electric blower 17 so as to be increased in temperature. Then, the CO_2 refrigerant is compressed by the compressor 12 so as to be further increased in temperature, and thereafter enters into the condenser 13 via the defrosting heat exchanger 19, dissipating heat. As a result, the CO_2 refrigerant becomes lower in temperature than that before entering into the condenser 13, and flows toward the supercooling heat exchanger 14. Then, the CO_2 refrigerant is further cooled by the supercooling heat exchanger 14, thereafter passing through the expansion valve 15 to return to the evaporator 11.

[0059] During defrosting operation for removing the frost of the evaporator 11, hot water in the hot-water storage tank 2 is supplied to the defrosting heat exchanger 19 via the defrosting circulation circuit 50. Therefore, the CO_2 refrigerant that has entered into the defrosting heat exchanger 19 is heat-exchanged with hot water derived from the hot-water storage tank 2 so as to be further increased in temperature.

[0060] During non-defrosting operation, on the other hand, the defrosting heat exchanger 19 is supplied with no hot water from the hot-water storage tank 2, so that the CO_2 refrigerant is not increased in temperature in the defrosting heat exchanger 19.

[0061] Next described is the defrosting circulation circuit 50. In this defrosting circulation circuit 50, a branch valve 55 is provided. This branch valve 55 has an inlet for inflow of hot water from the hot-water storage tank 2, and two outlets for outflow of hot water. One of the two outlets is connected to the condenser 13, and the other outlet is connected to the defrosting heat exchanger 19. By controlling a degree of opening of the one outlet, the quantity of the hot water that enters into the condenser 13 can be controlled. Also, by controlling the degree of opening of the other outlet, the quantity of the hot water that enters into the defrosting heat exchanger 19 can be controlled. The degree of opening of each of the outlets of the branch valve 7 is controlled by a control section 7. In addition, the branch valve 55 is an example of the flow control section.

[0062] Next described is the boil-up circulation circuit 5. In this boil-up circulation circuit 5, a boil-up circulating pump 51 and a boil-up three-way valve 52 are provided. Then, the boil-up circulation circuit 5 is connected to a second space-heating-forward connection port 42, a boil-up supply port 53, and an antifreezing water turn-back connection port 54.

[0063] To the antifreezing water turn-back connection port 54, hot water flows up from the condenser 13 or hot water flows up from the defrosting heat exchanger 19.

[0064] A part of the boil-up circulation circuit 5 on the upstream side of the condenser 13 serves also as a part of the defrosting circulation circuit 50 on the upstream side of the defrosting heat exchanger 19. That is, a part between the hot-water storage tank 2 and the branch valve 55 where hot water flows is not only a part of the boil-up circulation circuit 5 but also a part of the defrosting circulation circuit 50. The branch valve 55 is provided at a branch portion between the boil-up circulation circuit 5 and the defrosting circulation circuit 50.

[0065] The supply port 53 is provided at a lower portion of the hot-water storage tank 2. As a result of this, hot water in lower region within the hot-water storage tank 2 can be supplied to the boil-up circulating pump 51 via the supply port 53.

[0066] The boil-up circulating pump 51 sucks hot water in the lower part of the hot-water storage tank 2 and discharges the hot water toward the branch valve 55. As the boil-up circulating pump 51, a variable flow rate pump or a constant flow rate circulating pump may be adopted.

[0067] In the condenser 13, heat of the CO_2 refrigerant is transferred to the hot water, so that the hot water becomes high temperature (e.g., 60°C - 85°C). The high-temperature hot water coming out from the condenser 13 is directed toward the boil-up three-way valve 52.

[0068] During hot water supply operation and space-heating operation, the boil-up three-way valve 52 makes a flow of the high-temperature hot water derived from the condenser 13 into an upper part within the hot-water storage tank 2 via the second space-heating-forward connection port 42. Since hot water coming out from the condenser 13 of the heat pump unit 1 has not yet become high temperature enough at start-up of the heat pump unit 1, the boil-up three-way valve 52 makes a flow of the high-temperature hot water derived from the condenser 13 into the lower region within the hot-water storage tank 2 via the antifreezing water turn-back connection port 54. As a result, it can be prevented that hot water that has not become high temperature enough in the condenser 13 turns back to the upper region within the hot-water storage tank 2 to disturb the temperature distribution within the hot-water storage tank 2.

[0069] Next, the hot-water storage tank 2 is described. This hot-water storage tank 2 is for storing hot water heated by the heat pump unit 1. A heater 6 is placed generally at a central portion with regard to vertical direction within the hot-water storage tank 2, and the heater 6 directly heats the hot water in the hot-water storage tank 2. Also, a plurality of temperature sensors 40A, 40B, ..., 40E are provided on the hot-water storage tank 2 to detect hot-water temperatures of individual portions within the hot-water storage tank 2. These plural temperature sensors 40A, 40B, ..., 40E detect hot-water temperatures of individual portions within the hot-water Storage tank 2 and transmit signals indicative of those temperatures to the control section 7.

[0070] Next, the hot-water supplying heat exchanger 3 is described. The hot-water supplying heat exchanger 3, formed of a coiled pipe, is placed so as to stretch from lower to upper regions in the hot-water storage tank 2. Supply hot water is heated by flowing through within the hot-water supplying heat exchanger 3. More specifically, the supply hot water enters into the hot-water storage tank 2 at a lower portion of the hot-water storage tank 2, then flowing upward through the hot-water supplying heat exchanger 3 placed in the lower region within the hot-water storage tank 2. The supply hot water then flows upward through the hot-water supplying heat exchanger 3 placed in the upper region within the hot-water storage tank 2, thereafter going out of the hot-water storage tank 2 from an upper portion of the hot-water storage tank 2.

[0071] When the supply hot water that has come out of the hot-water storage tank 2 is too high in temperature, a supply-hot-water mixing valve 31 is opened so that the supply hot water having come out of the hot-water storage tank 2 and supply hot water that is before flowing into the hot-water storage tank 2 are mixed together. As a result, the supply hot water coming out of the hot-water storage tank 2 can be decreased in temperature.

[0072] Next, the space-heating circulation circuit 4 is described. The space-heating circulation circuit 4 is for circulating hot water stored in the hot-water storage tank 2 by making the hot water passed through a plurality of space-heating terminals 8A, 8B, ... outside the hot-water storage tank 2 and thereafter turned back again into the hot-water storage tank 2. The space-heating circulation circuit 4 is connected to the first, second space-heating-forward connection ports 41, 42 and a space-heating-backward connection port 43.

[0073] The first space-heating-forward connection port 41 is for taking out hot water in the hot-water storage tank 2. The first space-heating-forward connection port 41 is provided generally at a central portion with regard to vertical direction within the hot-water storage tank 2 so as to be located near and above the heater 6. As a result, hot water immediately after being heated by the heater 6 can be taken out from the first space-heating-forward connection port 41 so as to be fed to the plurality of space-heating terminals 8A, 8B, ...

[0074] The second space-heating-forward connection port 42 is also for taking out hot water in the hot-water storage tank 2, like the first space-heating-forward connection port 41. The second space-heating-forward connection port 42 is provided at an upper portion of the hot-water storage tank 2. As a result, hot water in the upper region within the hot-water storage tank 2 can be taken out from the second space-heating-forward connection port 42 so as to be fed to the plurality of space-heating terminals 8A, 8B, ... The second space-heating-forward connection port 42 serves also as a boil-up turn-back connection port.

[0075] Each of the space-heating terminals 8A, 8B, ... directly takes out the heat of hot water that has flowed up from the hot-water storage tank 2 and radiates the heat indoors. Then, the hot water lowers in temperature, going out of the space-heating terminals 8A, 8B, ... and flowing toward the space-heating-backward connection port 43.

[0076] The space-heating-backward connection port 43 is provided at a lower portion of the hot-water storage tank 2. As a result, the hot water that has come out from the space-heating-backward connection port 43 can be mixed with the hot water in the lower region within the hot-water storage tank 2.

[0077] Provided in the space-heating circulation circuit 4 are a bypass pipe 44, a space-heating mixing valve 45, temperature sensors 40F, 40G, a space-heating circulating pump 48, and a space-heating three-way valve 49.

[0078] The bypass pipe 44 guides part of the hot water, which flows from the space-heating terminals 8A, 8B, ... to the space-heating-backward connection port 43, to the space-heating mixing valve 45.

[0079] The space-heating mixing valve 45 has an inlet for inflow of hot water from the hot-water storage tank 2, and an inlet for inflow of hot water from the bypass pipe 44. As will be detailed later, the degree of opening of each of the inlets of the space-heating mixing valve 45 is controlled by the control section 7.

[0080] The control section 7 receives an output signal of an outside air temperature sensor 18, and output signals of the temperature sensors 40A, 40B, ..., 40G. The control section 7 also receives a signal indicative of an indoor temperature from an indoor temperature sensor (not shown). It is noted here that an output signal of the outside air temperature sensor 18 is a signal indicating a temperature of outside air, output signals of the temperature sensors 40A, 40B are signals indicating temperatures of hot water in the upper region within the hot-water storage tank 2, an output signal of the temperature sensor 40C is a signal indicating a temperature of hot water in a intermediate region with regard to vertical direction within the hot-water storage tank 2, and output signals of the temperature sensors 40D, 40E are signals indicating temperatures of hot water in the lower region within the hot-water storage tank 2. Also, an output signal of the temperature sensor 40F is a signal indicating a temperature of hot water directed from the hot-water storage tank 2 toward the space-heating terminals 8A, 8B, ... An output signal of the temperature sensor 40G is a signal indicating a temperature of hot water directed from the space-heating terminals 8A, 8B, ... toward the hot-water storage tank 2.

[0081] The space-heating circulating pump 48 sucks hot water within the hot-water storage tank 2 via the second space-heating-forward connection port 42 or the first space-heating-forward connection port 41, and discharges the hot water toward the plural space-heating terminals 8A, 8B,

[0082] The space-heating three-way valve 49 takes out hot water from the first space-heating-forward connection port 41 on condition that a high-temperature region of hot water within the hot-water storage tank 2 is present near the first space-heating-forward connection port 41. Also, the space-heating three-way valve 49 takes out hot water from the second space-heating-forward connection port 42 on condition that a high-temperature region of hot water within the hot-water storage tank 2 is absent near the first space-heating-forward connection port 41. This switching of the space-heating three-way valve 49 is fulfilled by the control section 7. That is, the control section 7 switches over the space-heating three-way valve 49 based on signals from a plurality of temperature sensors for detecting temperatures of hot water in individual parts within the hot-water storage tank 2.

[0083] According to the space-heating and hot water supply apparatus constructed as described above, as the space-heating operation starts, the control section 7 turns ON the space-heating circulating pump 48. As a result of this, hot water stored in the hot-water storage tank 2 is fed to the plural space-heating terminals 8A, 8B, ..., and returns again to the hot-water storage tank 2. During this process, the heat of the hot water is radiated indoors via the space-heating terminals 8. That is, the space-heating terminals 8A, 8B, ... directly take out heat of the hot water within the hot-water storage tank 2 to radiate the heat indoors.

[0084] Therefore, since the heat of hot water within the hot-water storage tank 2 can be efficiently supplied to the space-heating terminals 8A, 8B, ..., enough space-heating can be fulfilled even in regions of high space-heating loads, for example, in Nordic countries.

[0085] During the space-heating operation, the control section 7 controls the compressor 12, the expansion valve 15, the boil-up circulating pump 51 and the branch valve 55 based on signals of the outside air temperature sensor 18, the temperature sensors 40A, 40B, ..., 40E and the indoor temperature sensor.

[0086] For instance, when deciding from the output signals of the temperature sensors 40A, 40B, ..., 40E that the high-temperature hot water in the upper region within the hot-water storage tank 2 has become small in quantity, the control section 7 boils up the hot water within the hot-water storage tank 2 by the heat pump unit 1. More specifically, the control section 7 turns ON the compressor 12 and the boil-up circulating pump 51 and moreover opens the expansion valve 15. In this case, the control section 7 fully opens the condenser 13-side outlet of the branch valve 55, while the control section 7 fully closes the defrosting heat exchanger 19-side outlet of the branch valve 55. As a result, the hot water present in the lower region within the hot-water storage tank 2 flows to the condenser 13, and the hot water heated to higher temperature by the condenser 13 is returned into the hot-water storage tank 2 via the second space-heating-forward connection port 42.

[0087] Then, while the hot water within the hot-water storage tank 2 is boiled up by the heat pump unit 1, the control section 7 starts defrosting operation on condition that the control section 7 decides from an output of the outside air temperature sensor 18 that defrosting operation for removing the frost of the evaporator 11 is needed.

[0088] Upon start of the defrosting operation, the control section 7 increases the degree of opening of the expansion valve 15 while opening the defrosting heat exchanger 19-side outlet of the branch valve 55. As a result, middle-temperature (e.g., 30°C - 50°C) hot water in the lower region within the hot-water storage tank 2 flows to both the condenser 13 and the defrosting heat exchanger 19. The middle-temperature hot water that has come into the defrosting heat exchanger 19 gives heat to the CO_2 refrigerant directed toward the compressor 12, resulting in low-temperature hot water. This low-temperature hot water returns into the hot-water storage tank 2 via the antifreezing water turn-back connection port 54.

[0089] In this way, as the middle-temperature hot water passes through the defrosting heat exchanger 19 and then returns again into the hot-water storage tank 2, the CO_2 refrigerant coming into the evaporator 11 becomes appropriately high temperature. As a result of this, frost can be removed from the evaporator 11.

[0090] During the defrosting operation, heat is not taken in from the outside air, but heat is taken in from the middle-temperature hot water in the lower region within the hot-water storage tank 2. This heat is heat of hot water boiled up by the heat pump unit 1 before the defrosting operation. Therefore, the COP of the heat pump unit 1 becomes worse as far as the defrosting operation is concerned. However, this is also the case even in conventional defrosting operation, in which the middle-temperature hot water in the lower region within the hot-water storage tank 2 is not used.

[0091] However, in the case of defrosting operation in which middle-temperature hot water in the lower region within the hot-water storage tank 2 is used, the middle-temperature hot water, because of passing through the defrosting heat exchanger 19, decreases in temperature so as to be low-temperature hot water, returning to the lower region within the hot-water storage tank 2. Accordingly, when the hot water within the hot-water storage tank 2 is boiled up after an end of the defrosting operation, the low-temperature hot water in the lower region within the hot-water storage tank 2 is supplied to the heat pump unit 1. As a result of this, the COP of the heat pump unit 1 is improved, thus making it expectable to improve the COP of the heat pump unit 1 for total operation.

[0092] Also, since the defrosting heat exchanger 19 is placed on the downstream side of the supercooling heat exchanger 14, the CO_2 refrigerant that has been increased in temperature by the evaporator 11 and the supercooling heat exchanger 14 absorbs heat from the middle-temperature hot water flowing through the defrosting circulation circuit 50. That is, the middle-temperature hot water is cooled by the CO_2 refrigerant.

[0093] As shown above, the middle-temperature hot water is cooled by the CO_2 refrigerant. However, because the CO_2 refrigerant has been increased in temperature by the evaporator 11 and the supercooling heat exchanger 14 so as not to be excessively cold, the middle-temperature hot water can be prevented from being frozen.

[0094] If the defrosting heat exchanger 19 is placed between the evaporator 11 and the expansion valve 15, excessively cold CO_2 refrigerant directed from the expansion valve 15 toward the evaporator 11 cools the middle-temperature hot water flowing through the defrosting circulation circuit 50, so that the middle-temperature hot water may be frozen, making it impossible to continue the defrosting operation.

[0095] Further, since the heat pump unit 1 uses the CO_2 refrigerant, high-temperature hot water can be obtained from the condenser 13.

[0096] Also, a part of the boil-up circulation circuit 5 on the upstream side of the condenser 13 serves also as a part of the defrosting circulation circuit 50 on the upstream side of the defrosting heat exchanger 19. Therefore, if the part of the boil-up circulation circuit 5 on the upstream side of the condenser 13 is constructed, it is not necessary to construct the part of the defrosting circulation circuit 50 on the upstream side of the defrosting heat exchanger 19.

[0097] Therefore, time and labor associated with construction of the boil-up circulation circuit 5 and the defrosting circulation circuit 50 are reduced, so that constructional workability of the boil-up circulation circuit 5 and the defrosting circulation circuit 50 is successful.

[0098] Further, the flow of hot water through the boil-up circulation circuit 5 as well as the flow of hot water through the defrosting circulation circuit 50 are controlled by one branch valve 55 alone. Thus, flow control for those members can be prevented from being complicated.

[0099] Further, during non-defrosting operation in which space-heating operation is not performed, the control section 7 turns ON the boil-up circulating pump 51 and opens the defrosting heat exchanger 19-side outlet of the branch valve 55, allowing a small quantity of hot water to flow to the defrosting circulation circuit 50. This makes it possible to prevent cooling and freezing of hot water remaining within the defrosting circulation circuit 50.

(Second Embodiment)

[0100] Fig. 1 is a schematic view showing a construction of a space-heating and hot water supply apparatus according to a second embodiment of the invention. In Fig. 2, the same component members as those of the first embodiment shown in Fig. 1 are designated by the same reference signs as those of the component members in Fig. 1, with their description omitted.

[0101] The space-heating and hot water supply apparatus includes a defrosting heat exchanger 219 instead of the supercooling heat exchanger 14 and the defrosting heat exchanger 19 of the first embodiment.

[0102] The defrosting heat exchanger 219 uses hot water within the defrosting circulation circuit 50 to heat the CO_2 refrigerant directed from the evaporator 11 toward the compressor 12 as well as to cool the CO_2 refrigerant directed from the condenser 13 toward the expansion valve 15. That is, the defrosting heat exchanger 219 has functions of both the supercooling heat exchanger 14 and the defrosting heat exchanger 19 of the first embodiment.

[0103] More specifically, in the defrosting heat exchanger 219, part of the refrigerant circuit 16 between the evaporator 11 and the compressor 12 is brazed to part of the refrigerant circuit 16 between the condenser 13 and the expansion valve 15. In addition, part of the defrosting circulation circuit 50 is also brazed to part of the refrigerant circuit 16 between the condenser 13 and the expansion valve 15.

[0104] According to the space-heating and hot water supply apparatus having the above construction, only the defrosting heat exchanger 219 is placed between the evaporator 11 and the compressor 12. Therefore, the heat pump unit 1 can be downsized, compared with the first embodiment.

(Third Embodiment)

[0105] Fig. 3 is a schematic view showing a construction of a space-heating and hot water supply apparatus according to a third embodiment of the invention. In Fig. 3, the same component members as those of the second embodiment shown in Fig. 2 are designated by the same reference signs as those of the component members in Fig. 2, with their description omitted.

[0106] The space-heating and hot water supply apparatus includes a temperature sensor 40H as an example of a temperature sensing part. This temperature sensor 40H is provided on the defrosting circulation circuit 50 so as to be positioned on downstream side of the defrosting heat exchanger 219. The temperature sensor 40H detects a temperature of low-temperature hot water directed from the defrosting heat exchanger 19 toward the hot-water storage tank 2, and outputs a signal indicative of the temperature to the control section 7.

[0107] According to the space-heating and hot water supply apparatus having the above construction, when hot water flows within the defrosting circulation circuit 50, the control section 7 controls the degree of opening of the defrosting heat exchanger 219-side outlet of the branch valve 55 based on a signal derived from the temperature sensor 40H so that the temperature of low-temperature hot water directed from the defrosting heat exchanger 19 toward the hot-water storage tank 2 is kept from going 0°C or lower as an example.

[0108] As a result, there can be prevented an occurrence that hot water frozen within the defrosting circulation circuit 50 causes the defrosting operation to be no longer implementable.

(Fourth Embodiment)

[0109] Fig. 4 is a schematic view showing a construction of a space-heating and hot water supply apparatus according to a fourth embodiment of the invention. In Fig. 4, the same component members as those of the first embodiment shown in Fig. 1 are designated by the same reference signs as those of the component members in Fig. 1, with their description omitted.

[0110] The space-heating and hot water supply apparatus includes a defrosting heat exchanger 419 instead of the defrosting heat exchanger 19 of the first embodiment. This defrosting heat exchanger 419 has a container 461, and a coiled heat exchanger pipe 462 placed within the container 461.

[0111] According to the space-heating and hot water supply apparatus having the above construction, the CO_2 refrigerant coming out from the evaporator 11 passes through the supercooling heat exchanger 14 and then enters the container 461. Since the heat exchanger pipe 462 is placed within the container 461, the CO_2 refrigerant comes into contact with the whole surface of the heat exchanger pipe 462.

[0112] Therefore, heat of the middle-temperature hot water derived from the hot-water storage tank 2 is efficiently transferred to the CO_2 refrigerant within the container 461 via the heat exchanger pipe 462.

[0113] In the first to fourth embodiments, the heat pump unit 1 employs CO_2 refrigerant. However, NH_3 refrigerant, R22 refrigerant and the like may also be used.

[0114] Further, the first to fourth embodiments may be combined in their contents as embodiments of the invention.

[0115] Further, the space-heating terminals 8A, BB, ... as well as the space-heating circulation circuit 4 and the like associated therewith may be omitted from the first to fourth embodiments to provide a hot water supply apparatus. That is, the present invention may be applied to hot water supply apparatuses dedicated exclusively to supply of hot water without being limited to space-heating and hot water supply apparatuses.

Reference Signs List:

[0116]

1	heat pump unit
2	hot-water storage tank
3	hot-water supplying heat exchanger
5	boil-up circulation circuit
8A, 8B, ...	space-heating terminal
11	evaporator
12	compressor
13	condenser
14	supercooling heat exchanger
15	expansion valve
16	refrigerant circuit
19, 219, 419	defrosting heat exchanger

40H	temperature sensor
50	defrosting circulation circuit
55	branch valve
461	container
462	heat exchanger pipe

Claims

1. A hot water system comprising:

a heat pump unit (1) having a refrigerant circuit (16) as well as a first evaporator (11), a compressor (12), a condenser (13) and an expansion mechanism (15) provided in the refrigerant circuit (16);
a hot-water storage tank (2) for storing hot water;
a heating circulation circuit (5) for circulating water within the hot-water storage tank (2) by heating and passing the water through the condenser (13) and thereafter returning the water again into the hot-water storage tank (2);
a second evaporator (19, 219, 419) provided on the refrigerant circuit (16);
a defrosting circulation circuit (50) for circulating hot water stored in the hot-water storage tank (2) by passing the hot water through the second evaporator (19, 219, 419) and thereafter returning the hot water again into the hot-water storage tank (2); and
a flow control section (55) which is provided on the defrosting circulation circuit (50) and which controls flow of hot water flowing through the defrosting circulation circuit (50).

2. The hot water system as claimed in Claim 1, further comprising:

a hot-water supplying heat exchanger (3) which is placed within the hot-water storage tank (2) and in which supply hot water flows inside; and
a space-heating circulation circuit (4) for circulating hot water stored in the hot-water storage tank by passing space-heating terminals outside the hot-water storage tank and thereafter returning the hot water again into the hot-water storage tank.

3. The hot water system as claimed in Claim 1 or 2, wherein
the second evaporator (19, 219, 419) is placed downstream of the first evaporator (11) and upstream of the compressor (12).

4. The hot water system as claimed in Claim 1 or 2, further comprising
a supercooling heat exchanger (14) placed downstream of the first evaporator (11) and upstream of the second evaporator (19, 419).

5. The hot water system as claimed in Claim 1 or 2, wherein
the second evaporator (219) serve also as a supercooling heat exchanger.

6. The hot water system as claimed in Claim 1 or 2, wherein
the second evaporator (419) has
a container (461) through which a refrigerant flowing through the refrigerant circuit (16) passes; and
a heat exchanger pipe (462) which is placed within the container (461) and through which hot water derived from the hot-water storage tank (2) flows inside.

7. The hot water system as claimed in Claim 1 or 2, wherein
the refrigerant flowing through the refrigerant circuit (16) is a CO_2 refrigerant.

8. The hot water system as claimed in Claim 1 or 2, wherein
a part of the heating circulation circuit (5) on an upstream side of the condenser (13) serves also as a part of the defrosting circulation circuit (50) on an upstream side of the second evaporator (19, 219, 419),
the flow control section (55) is provided at a branch portion between the heating circulation circuit (5) and the defrosting circulation circuit (50) to control a flow rate of hot water flowing from a part of the heating circulation circuit (5) on the upstream side of the condenser (13) to the condenser (13) and a flow rate of hot water flowing from a part of the heating circulation circuit (5) on the upstream side of the condenser (13) to the second evaporator (19, 219, 419).

9. The hot water system as claimed in Claim 8, further comprising
a control section (7) for controlling the flow control section (55) so that a quantity of hot water flowing into the second evaporator (19, 219, 419) during defrosting operation of the first evaporator (11) becomes larger than a quantity of hot water flowing into the second evaporator (19, 219, 419) during non-defrosting operation of the first evaporator (11).

10. The hot water system as claimed in Claim 9, further comprising
a temperature sensing part (40H) for sensing a temperature of hot water that has come out from the second evaporator (19, 219, 419), wherein
the control section (7) controls the flow control section (55) based on an output of the temperature sensing part (40H).

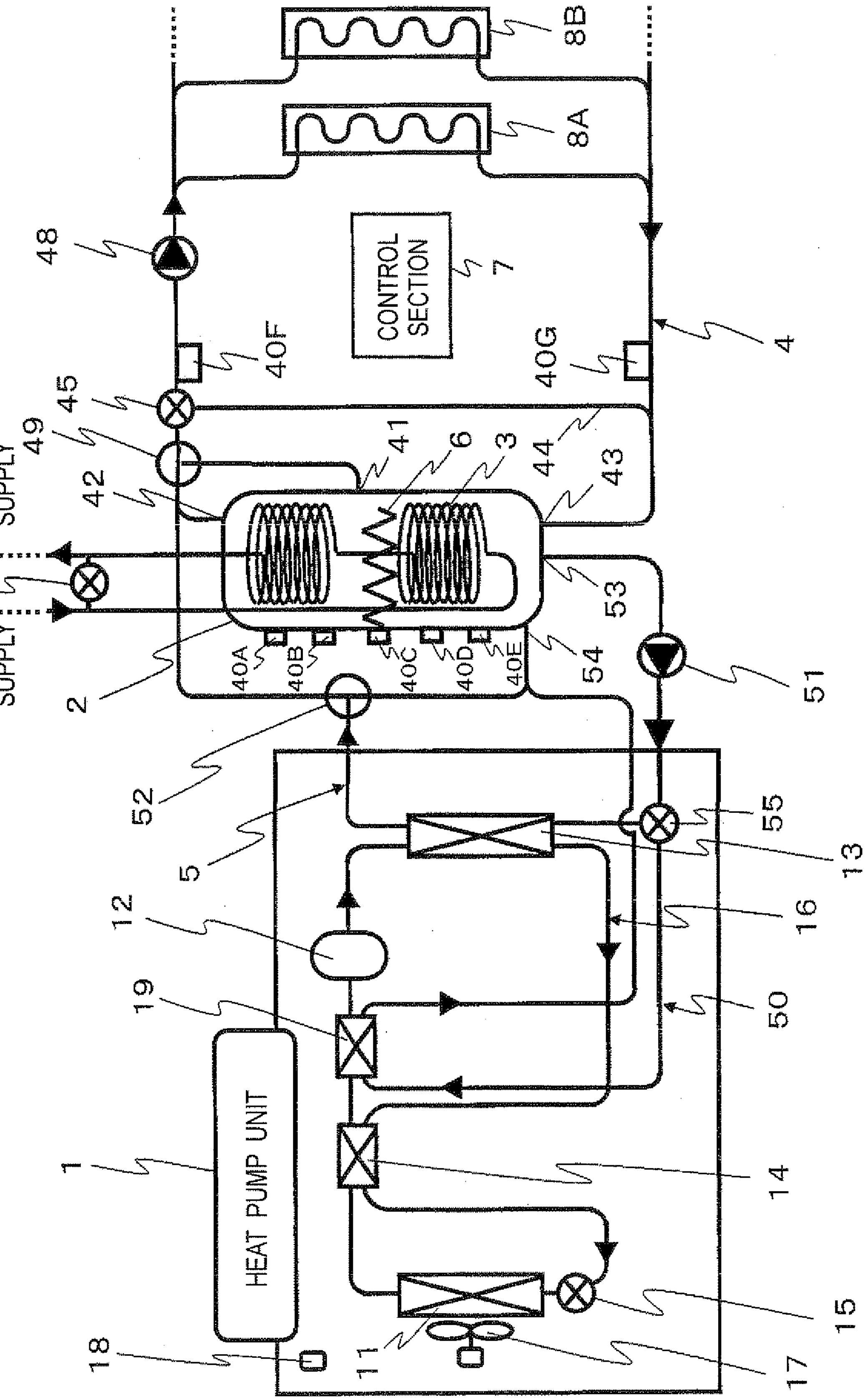
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Fig.1

Fig.2

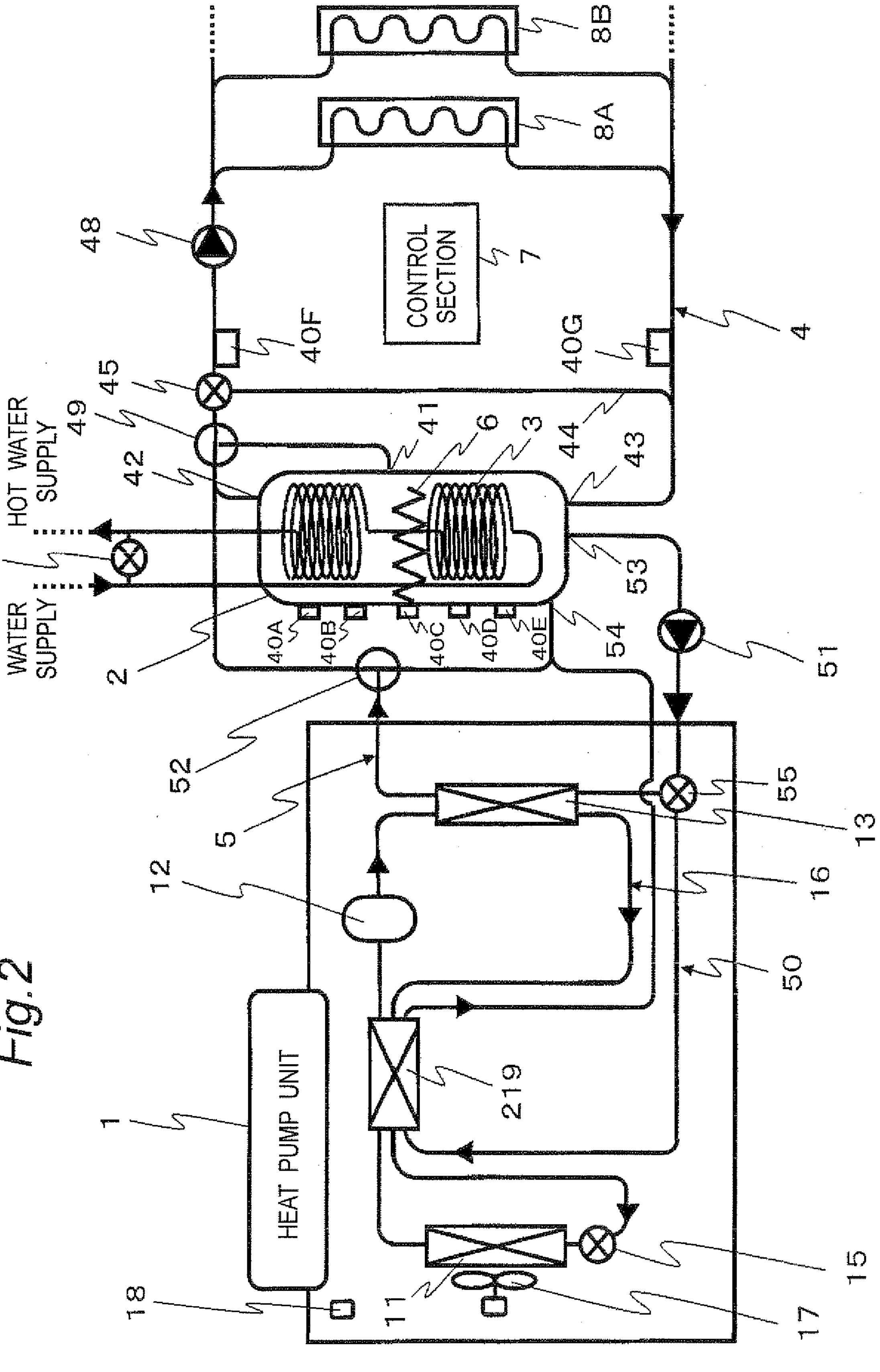
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Fig.3

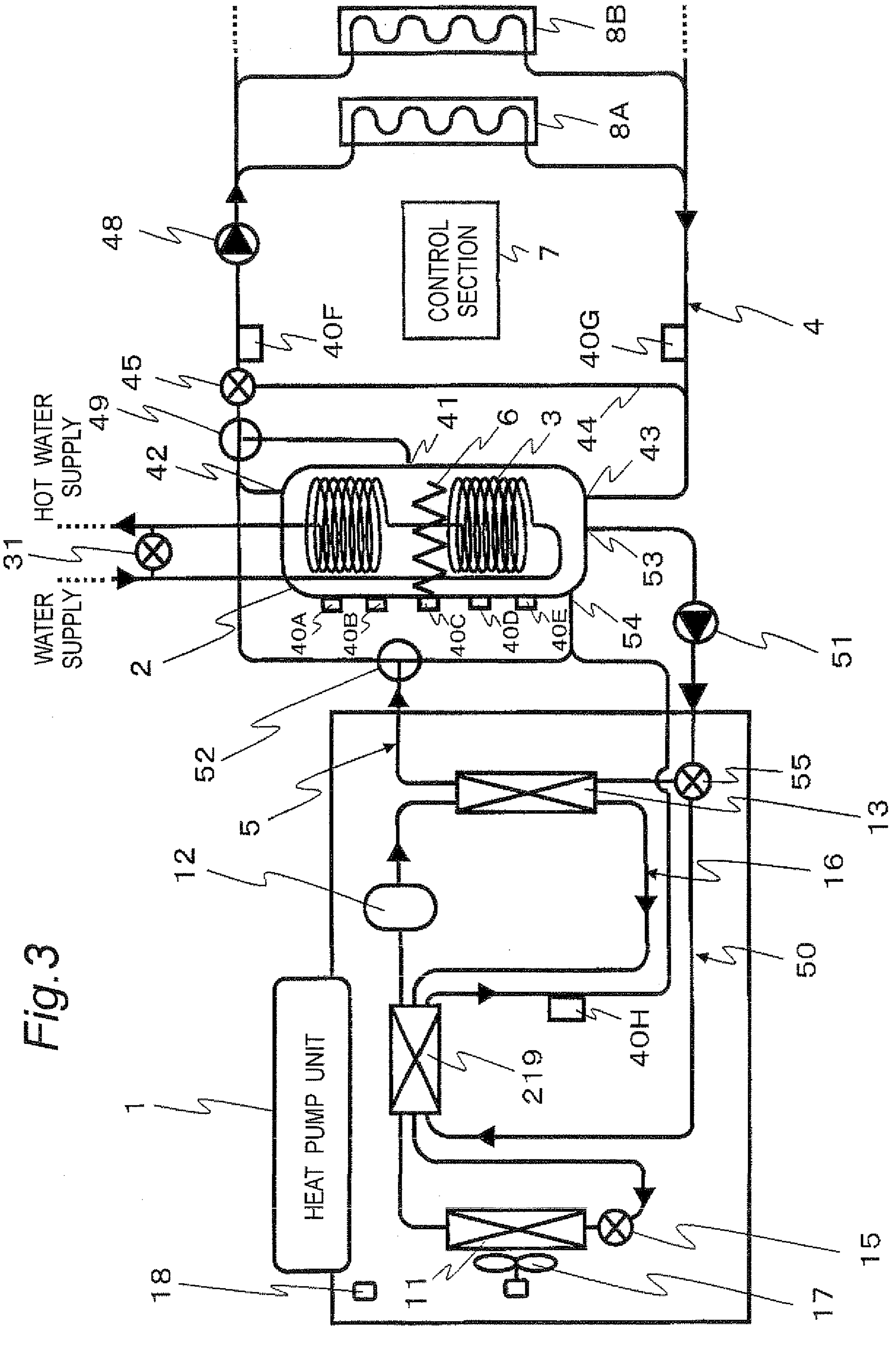
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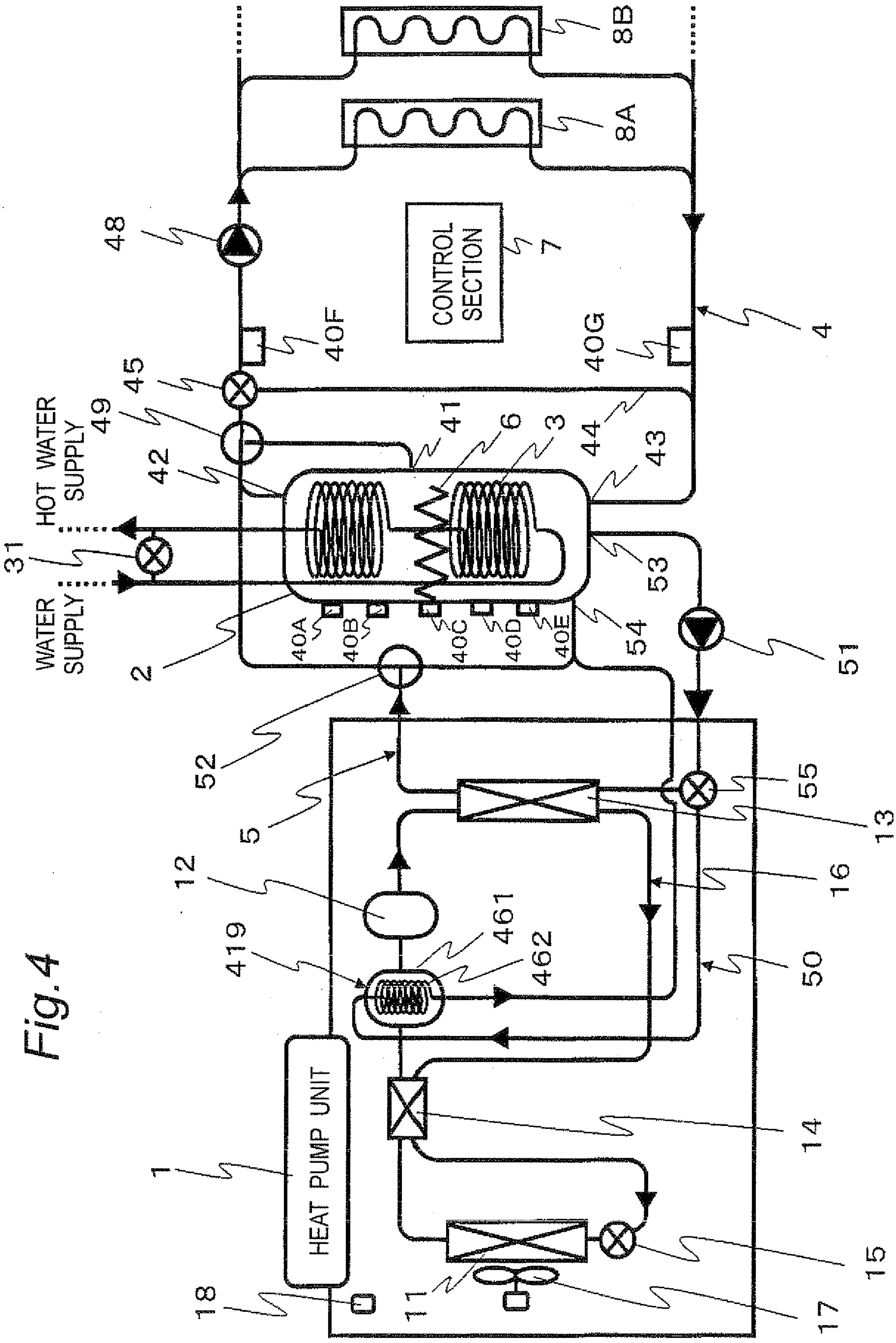
Fig.4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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/059960

A. CLASSIFICATION OF SUBJECT MATTER
F24H1/00(2006.01)i, *F24D3/08*(2006.01)i, *F24D3/18*(2006.01)i, *F25B39/00* (2006.01)i, *F25B40/00*(2006.01)i, *F25B47/02*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24H1/00, F24D3/08, F24D3/18, F25B39/00, F25B40/00, F25B47/02

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	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2007-010207 A (Daikin Industries, Ltd.), 18 January, 2007 (18.01.07), Page 7, line 6 to page 9, line 3; page 11, line 11 to page 12, line 1; Fig. 1 & US 2009/0113911 A1 & EP 1914485 A1 & WO 2007/000931 A1 & KR 2008/0017429 A & CN 101208564 A	1 2-10
Y	JP 2007-198637 A (Corona Corp.), 09 August, 2007 (09.08.07), Fig. 1 (Family: none)	2-10
Y	JP 2004-198037 A (Sanyo Electric Co., Ltd.), 15 July, 2004 (15.07.04), Fig. 2 (Family: none)	4-5

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 August, 2009 (17.08.09)	25 August, 2009 (25.08.09)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/059960

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-90637 A (Sekisui Chemical Co., Ltd.), 28 March, 2003 (28.03.03), Column 4, line 38 to column 6, line 2; Fig. 1 (Family: none)	6
Y	JP 2005-147610 A (Matsushita Electric Industrial Co., Ltd.), 09 June, 2005 (09.06.05), Page 5, lines 28 to 33; Fig. 3 (Family: none)	8-10
A	JP 2005-164087 A (Matsushita Electric Industrial Co., Ltd.), 23 June, 2005 (23.06.05), Full text; all drawings (Family: none)	1-10
A	JP 59-180228 A (Matsushita Electric Industrial Co., Ltd.), 13 October, 1984 (13.10.84), Full text; all drawings (Family: none)	1-10

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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