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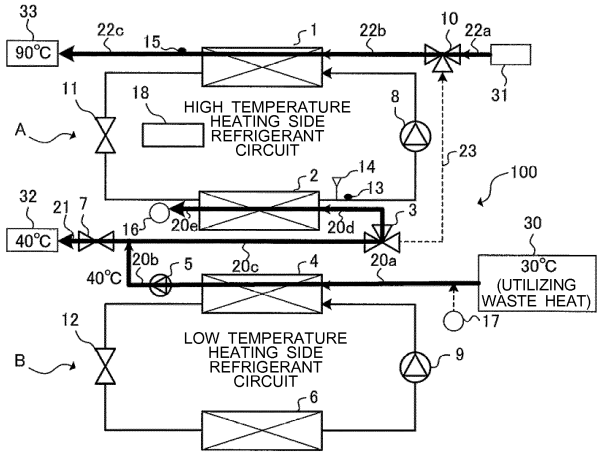
(54) **HEAT PUMP SYSTEM**

(57) A heat pump system of the present invention includes: a low temperature heating side refrigerant circuit; a high temperature heating side refrigerant circuit; a first pipe to connect a low temperature side liquid supply port, a low temperature heating side condenser, and a high temperature heating side evaporator in this order, thereby to circulate liquid; a second pipe configured to connect a high temperature side liquid supply port and a high temperature heating side condenser in this order, thereby to circulate the liquid; a pump provided in the first pipe and configured to feed the liquid heated in the low temperature heating side condenser to the high temperature heating side evaporator; a control valve provided in the first pipe between the low temperature heating side condenser and the high temperature heating side evaporator and configured to control a flow rate of the liquid circulated inside the first pipe; and a control unit configured to control at least one of the pump and the control valve, and control a flow rate of the liquid fed from the low temperature heating side condenser to the high temperature heating side evaporator.

FIG. 6



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Description

Technical Field

[0001] The present invention relates to a heat pump system in which two refrigeration cycles are connected.

Background Art

[0002] Conventionally, to generate high-temperature hot water using fluorocarbon-based refrigerant, a heat pump cycle using natural refrigerant for achieving high efficiency, or a cascade refrigeration cycle using fluorocarbon-based refrigerant such as R134a has been proposed (for example, see Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2012-42177

Summary of Invention

Technical Problem

[0004] Here, the heat pump cycle using the natural refrigerant described above has a serious problem in respect of techniques and costs since a pressure to compress refrigerant such as CO_2 is extremely high and combustible HC-based refrigerant is used.

[0005] On the other hand, in the heat pump of the cascade refrigeration cycle described in Patent Literature 1, an evaporation heat quantity of an evaporator of a high order side refrigerant circuit and a heating quantity of a condenser of a low order side refrigerant circuit need to be balanced at all times. Therefore, in the field of hot water supply in which the pressure inside the high order side refrigerant circuit is maintained high, keeping the balance mentioned above is a serious technical subject, and hence there is a problem that it is difficult to highly efficiently and stably generate high-temperature water.

[0006] The present invention has been attained to solve the above-described problems, and an object of the present invention is to provide a heat pump system that highly efficiently and stably generates high-temperature water without performing complicated control in a refrigerant circuit.

Solution to Problem

[0007] A heat pump system according to an embodiment of the present invention includes: a low temperature heating side refrigerant circuit in which a low temperature heating side compressor, a low temperature heating side condenser, a low temperature heating side expansion valve and a low temperature heating side evaporator are successively connected by a refrigerant pipe; a high temperature heating side refrigerant circuit in which a high temperature heating side compressor, a high order heating side condenser, a high order heating side expansion valve and a high temperature heating side evaporator are successively connected by a refrigerant pipe; a first pipe configured to connect a low temperature side liquid supply port, the low temperature heating side condenser, and the high temperature heating side evaporator in this order, thereby to circulate liquid; a second pipe configured to connect a high temperature side liquid supply port and the high temperature heating side condenser in this order, thereby to circulate the liquid; a pump provided in the first pipe and configured to feed the liquid heated in the low temperature heating side condenser to the high temperature heating side evaporator; a control valve provided in the first pipe between the low temperature heating side condenser and the high temperature heating side evaporator, thereby to control a flow rate of the liquid circulated inside the first pipe; and a control unit configured to control at least one of the pump and the control valve, thereby to control a flow rate of the liquid fed from the low temperature heating side condenser to the high temperature heating side evaporator.

Advantageous Effects of Invention

[0008] According to an embodiment of the present invention, since an evaporating pressure or an evaporating temperature of refrigerant inside a high temperature heating side evaporator can be stabilized, a heat pump system that highly efficiently and stably generates high-temperature water can be obtained.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a circuit diagram of a conventional heat pump system using a cascade refrigeration cycle.

[Fig. 2] Fig. 2 is a schematic block diagram of a heat pump system in an embodiment of the present invention.

[Fig. 3] Fig. 3 is a state diagram illustrating control relationship of a control unit of the heat pump system in the embodiment of the present invention.

[Fig. 4] Fig. 4 is a schematic block diagram at the time of operating a low temperature heating side refrigerant circuit of the heat pump system in the embodiment of the present invention.

[Fig. 5] Fig. 5 is a schematic block diagram at the time of operating a high temperature heating side refrigerant circuit of the heat pump system in the embodiment of the present invention.

[Fig. 6] Fig. 6 is a schematic block diagram at the time of taking out two kinds of hot water from the heat pump system in the embodiment of the present

invention. Description of Embodiments

[0010] An embodiment of a heat pump system of the present invention will be described hereinafter with reference to the drawings. Note that a form in the drawings is just an example and does not limit the present invention. In addition, components designated by the same signs in the individual drawings are the same or equivalents, and the same applies throughout the description. Further, in the following drawings, relationship of sizes of individual components is often different from the actual relationship.

Embodiment.

[0011] For easy understanding of the heat pump system according to the embodiment of the present invention, a heat pump system using a conventional cascade refrigeration cycle will be described first. Fig. 1 is a circuit diagram of the heat pump system using the conventional cascade refrigeration cycle.

[0012] As illustrated in Fig. 1, a heat pump system 200 includes a low order side refrigerant circuit C and a high order side refrigerant circuit D. The low order side refrigerant circuit C is configured such that a compressor 108, a refrigerant heat exchanger 101, an expansion valve 102, and an evaporator 103 are successively connected by a pipe. The high order side refrigerant circuit D is configured such that a compressor 104, a condenser 105, an expansion valve 106, and the refrigerant heat exchanger 101 are successively connected by a pipe. Refrigerant of the low order side refrigerant circuit C and refrigerant of the high order side refrigerant circuit D exchange heat with each other in the refrigerant heat exchanger 101, and thus the heat pump system 200 using the cascade refrigeration cycle is configured.

[0013] Note that R410A or other such refrigerants are suitable as the refrigerant of the low order side refrigerant circuit C in the heat pump system 200, and R134a or other such refrigerants are suitable as the refrigerant of the high order side refrigerant circuit D.

[0014] In the low order side refrigerant circuit C, high-temperature and high-pressure gas refrigerant compressed in the compressor 108 is cooled by heat exchange with the refrigerant of the high order side refrigerant circuit D in the refrigerant heat exchanger 101, and is condensed and liquefied. The condensed and liquefied high-pressure liquid refrigerant is, after being depressurized by the expansion valve 102, evaporated by heat exchange with outdoor air in the evaporator 103 to become low-temperature and low-pressure gas refrigerant, and then returns to the compressor 108 again. The refrigerant cycle is thus configured.

[0015] Similarly, in the high order side refrigerant circuit D, high-temperature and high-pressure gas refrigerant compressed in the compressor 104 is cooled, condensed and liquefied by temperature-decreased water on a load side in the condenser 105. The condensed and liquefied high-pressure liquid refrigerant is, after being depressurized by the expansion valve 106, evaporated by heat exchange with the refrigerant of the low order side refrigerant circuit C in the refrigerant heat exchanger 101, becomes low-temperature and low-pressure gas refrigerant, and then returns to the compressor 104 again. The refrigerant cycle is thus configured.

[0016] Here, water passing through a water circuit 107 exchanges heat with the refrigerant of the high order side refrigerant circuit D circulated through the condenser 105, and thus a temperature of the water is raised from 10 degrees C to 90 degrees C, for example.

[0017] In this way, in the conventional heat pump system 200 using the cascade refrigeration cycle, the high order side refrigerant circuit D and the low order side refrigerant circuit C are connected through the refrigerant heat exchanger 101. Then, in the high order side refrigerant circuit D, by allowing the water on the load side to pass through the condenser 105, the water at 10 degrees C is heated to hot water at 90 degrees C, for example. Thus, to stably heat the water on the load side, an evaporating temperature of the refrigerant in the refrigerant heat exchanger 101 of the high order side refrigerant circuit D and a condensing temperature of the refrigerant in the refrigerant heat exchanger 101 of the low order side refrigerant circuit C need to be optimally balanced at all times, posing a serious technical problem. As described above, in the conventional heat pump system using the cascade refrigeration cycle, it is difficult to highly efficiently and stably generate high-temperature water.

[Configuration of refrigerant circuit]

[0018] Fig. 2 is a schematic block diagram of the heat pump system in the embodiment of the present invention. As illustrated in Fig. 2, a heat pump system 100 includes a high temperature heating side refrigerant circuit A and a low temperature heating side refrigerant circuit B. The high temperature heating side refrigerant circuit A is configured such that a high temperature heating side compressor 8, a high temperature heating side condenser 1, a high temperature heating side expansion valve 11, and a high temperature heating side evaporator 2 are successively connected by a refrigerant pipe. In addition, the low temperature heating side refrigerant circuit B is configured such that a low temperature heating side compressor 9, a low temperature heating side condenser 4, a low temperature heating side expansion valve 12, and a low temperature heating side evaporator 6 are successively connected by a refrigerant pipe.

[0019] In the high temperature heating side refrigerant circuit A, high-temperature and high-pressure gas refrigerant compressed in the high temperature heating side compressor 8 is cooled by heat exchange with the water on the load side flowing from a pipe 22b to a pipe 22c, and is condensed and liquefied in the high temperature heating side condenser 1. The condensed and liquefied high-pressure liquid refrigerant is, after being depressu-

rized by the high temperature heating side expansion valve 11, evaporated by heat exchange with the water flowing from a pipe 20d to a pipe 20e in the high temperature heating side evaporator 2, becomes low-temperature and low-pressure gas refrigerant, and then returns to the high temperature heating side compressor 8 again. The refrigeration cycle is thus configured. Note that the water corresponds to "liquid" in the present invention.

[0020] In the low temperature heating side refrigerant circuit B, high-temperature and high-pressure gas refrigerant compressed in the low temperature heating side compressor 9 is cooled by heat exchange with the water on the load side flowing from a pipe 20a to a pipe 20b, and is condensed and liquefied in the low temperature heating side condenser 4. The condensed and liquefied high-pressure liquid refrigerant is, after being depressurized by the low temperature heating side expansion valve 12, evaporated by heat exchange with air or other media in the low temperature heating side evaporator 6, becomes low-temperature and low-pressure gas refrigerant, and then returns to the low temperature heating side compressor 9 again. The refrigeration cycle is thus configured.

[Configuration of water circuit]

[0021] The low temperature heating side refrigerant circuit B of the heat pump system 100 includes a low temperature side water supply port 30 configured to supply water heated by utilizing waste heat, and a low temperature side tank 32 configured to store the water that is supplied and heated in the low temperature heating side refrigerant circuit B. In addition, the high temperature heating side refrigerant circuit A of the heat pump system 100 includes a high temperature side water supply port 31 configured to supply water, and a high temperature side tank 33 configured to store the water that is supplied and heated in the high temperature heating side refrigerant circuit A.

[0022] Note that the low temperature side water supply port 30 corresponds to a "low temperature side liquid supply port" in the present invention. In addition, the high temperature side water supply port 31 corresponds to a "high temperature side liquid supply port" in the present invention.

[0023] As illustrated in Fig. 2, the low temperature side water supply port 30 and the low temperature heating side condenser 4 are connected through the pipe 20a. In addition, the low temperature heating side condenser 4 and a pipe 20c are connected through the pipe 20b. The pipe 20b is provided with a pump 5 to feed the water from the low temperature heating side condenser 4 to the pipe 20c and the high temperature heating side evaporator 2. One end of the pipe 20c is connected to a motor-operated valve 7, and the other end of the pipe 20c is connected to a three-way valve 3. The three-way valve 3 is provided between the pipe 20d on the side of the high temperature heating side evaporator 2 and the pipe 20c on the side of the low temperature heating side condenser 4, and is connected to the high temperature heating side evaporator 2 through the pipe 20d. The high temperature heating side evaporator 2 is connected to a water return port 16 through the pipe 20e. The water return port 16 communicates with a water return port 17 and the water return port 17 is connected to the pipe 20a so that the water that has passed through the high temperature heating side evaporator 2 and is having the waste heat joins the pipe 20a. Further, the three-way valve 3 and a three-way valve 10 are connected through a pipe 23. On the other hand, the motor-operated valve 7 and the low temperature side tank 32 are connected through a pipe 21.

[0024] Note that the pipe 20a, the pipe 20b, the pipe 20c, the pipe 20d, and the pipe 20e correspond to a "first pipe" in the present invention. In addition, the three-way valve 3 corresponds to a "control valve" and a "first three-way valve" in the present invention. Furthermore, the pipe 23 corresponds to a "third pipe" in the present invention. In addition, the three-way valve 10 corresponds to a "second three-way valve" in the present invention.

[0025] The high temperature side water supply port 31 and the three-way valve 10 are connected through a pipe 22a. In addition, the three-way valve 10 and the high temperature heating side condenser 1 are connected through the pipe 22b. Furthermore, the high temperature heating side condenser 1 and the high temperature side tank 33 are connected through the pipe 22c. Note that the pipe 22a, the pipe 22b and the pipe 22c correspond to a "second pipe" in the present invention.

[0026] In this way, by connecting devices configuring the heat pump system 100 by the individual pipes, the water circuit from the low temperature side water supply port 30 to the low temperature side tank 32 and the water circuit from the high temperature side water supply port 31 to the high temperature side tank 33 are formed. In addition, the water circuit from the low temperature side water supply port 30 through the low temperature heating side condenser 4 and the three-way valve 3 to the high temperature heating side evaporator 2 is also formed.

[0027] In addition, the heat pump system 100 includes a temperature sensor 13, a pressure sensor 14, a temperature sensor 15 and a control unit 18 to be described later in Fig. 3.

[Control unit]

[0028] Fig. 3 is a state diagram illustrating control relationship of a control unit of the heat pump system in the embodiment of the present invention. As illustrated in Fig. 3, the control unit 18 comprises a microcomputer, for example, and controls drive of the three-way valve 3, the pump 5, the motor-operated valve 7 and the three-way valve 10. In addition, the control unit 18 allows the pressure sensor 14 provided in the refrigerant pipe on a downstream side of the high temperature heating side evaporator 2 to detect an evaporating pressure of the

refrigerant in the high temperature heating side evaporator 2. Furthermore, the control unit 18 allows the temperature sensor 13 provided in the refrigerant pipe on the downstream side of the high temperature heating side evaporator 2 to detect an evaporating temperature of the refrigerant in the high temperature heating side evaporator 2. Further, the control unit 18 detects a temperature of the hot water flowing out from the high temperature heating side condenser 1 by the temperature sensor 15 provided in the pipe 22c on the downstream side of the high temperature heating side condenser 1. Note that the temperature sensor 13 and the temperature sensor 15 are configured by a thermistor, for example. Note that, while an example that the control unit 18 is provided inside the high temperature heating side refrigerant circuit A is illustrated in the present embodiment, the present invention is not limited thereto and the control unit 18 may be provided in a place other than the high temperature heating side refrigerant circuit A.

[Control example of control unit]

[0029] The control unit 18 determines an optimum value of the evaporating temperature or the evaporating pressure of the refrigerant on the downstream of the high temperature heating side evaporator 2, from a target hot water temperature of the hot water generated in the high temperature heating side refrigerant circuit A and a utilization temperature of the waste heat of the hot water utilizing the waste heat supplied from the low temperature side water supply port 30. For example, in the control unit 18, the temperature of the water heated in the high temperature heating side refrigerant circuit A or the temperature of the water heated in the low temperature heating side refrigerant circuit B is detected, and the pump 5 is controlled to attain a heating quantity required in the low temperature heating side condenser 4 by predetermined calculation. Or, in the control unit 18, power consumption of the high temperature heating side refrigerant circuit A and the low temperature heating side refrigerant circuit B is measured, and the pump 5 is controlled to attain the heating quantity required in the low temperature heating side condenser 4 by predetermined calculation.

[0030] In addition, the control unit 18 controls the three-way valve 3, and controls a flow rate of the water to the high temperature heating side evaporator 2 so that the evaporating temperature or the evaporating pressure of the high temperature heating side evaporator 2 becomes the optimum value. Furthermore, the control unit 18 controls the three-way valve 10 to allow the hot water heated in the low temperature heating side condenser 4 to flow into the three-way valve 10, to allow the water to be mixed with the water flowing from the high temperature side water supply port 31 into the high temperature heating side condenser 1.

[0031] In addition, as another control example of the control unit 18, the temperature of the water heated by the high temperature heating side condenser 1 and detected by the temperature sensor 15 and the evaporating temperature of the refrigerant detected by the temperature sensor 13 or the evaporating pressure of the refrigerant detected by the pressure sensor 14 are detected, and the pump 5 and the three-way valve 3 are controlled on the basis of predetermined calculation.

[0032] Furthermore, as another control example of the control unit 18, a target temperature of the water generated in the high temperature heating side refrigerant circuit A is detected, and operation of the low temperature heating side refrigerant circuit B and the high temperature heating side refrigerant circuit A and the three-way valve 3 are controlled.

[Operation of low temperature heating side refrigerant circuit B alone]

[0033] Fig. 4 is a schematic block diagram at the time of operating the low temperature heating side refrigerant circuit of the heat pump system in the embodiment of the present invention. Note that a thick solid line arrow in Fig. 4 indicates flow of the water. As illustrated in Fig. 4, the control unit 18 drives the pump 5, and makes the water flow from the low temperature side water supply port 30 through the pipe 20a into the low temperature heating side condenser 4. Then, the water flowing into the low temperature heating side condenser 4 exchanges heat with high-pressure and high-temperature refrigerant flowing into the low temperature heating side condenser 4 of the low temperature heating side refrigerant circuit B, and a liquid temperature rises from 30 degrees C to 40 degrees C, for example. The water flowing out from the low temperature heating side condenser 4 passes through the pipe 20b and the pipe 21 and is stored in the low temperature side tank 32.

[0034] In this way, there is a case where the target temperature of the water is set at about 40 degrees C for a heating use or other uses through contact input or other input from a remote controller or a central control panel, for example. At the time, the control unit 18 stops the high temperature heating side compressor 8, closes the three-way valve 3, drives the low temperature heating side compressor 9, opens the motor-operated valve 7, operates the low temperature heating side refrigerant circuit B alone, and generates low-temperature hot water in the water circuit.

[Operation of high temperature heating side refrigerant circuit A alone]

[0035] Fig. 5 is a schematic block diagram at the time of operating the high temperature heating side refrigerant circuit of the heat pump system in the embodiment of the present invention. Note that a thick solid line arrow in Fig. 5 indicates the flow of the water. As illustrated in Fig. 5, the control unit 18 control the three-way valve 10 so that the water is circulated from the pipe 22a to the pipe 22b,

and allows the water to be frown from the high temperature side water supply port 31 to the high temperature heating side condenser 1 through the pipe 22a and the pipe 22b. Then, the water flowing into the high temperature heating side condenser 1 exchanges the heat with the high-pressure and high-temperature refrigerant flowing into the high temperature heating side condenser 1 of the high temperature heating side refrigerant circuit A, and the liquid temperature rises to 90 degrees C that is higher than the liquid temperature of the hot water generated in the low temperature heating side refrigerant circuit B, for example. The water flowing out from the high temperature heating side condenser 1 passes through the pipe 22c and is stored in the high temperature side tank 33.

[0036] In this way, there is a case where the target temperature of the water is set at about 90 degrees C through contact input or other input from a remote controller or a central control panel or other devices, for example, and high-temperature waste water is stably obtained from the high temperature side water supply port 31. At this time, the control unit 18 stops the low temperature heating side compressor 9, performs control so that the three-way valve 10 circulates the water only from the pipe 22a to the pipe 22b, drives the high temperature heating side compressor 8, operates the high temperature heating side refrigerant circuit A alone, and generates high-temperature hot water in the water circuit.

[Operation of high temperature heating side refrigerant circuit A and low temperature heating side refrigerant circuit B]

[0037] Fig. 6 is a schematic block diagram at the time of taking out two kinds of hot water from the heat pump system in the embodiment of the present invention. Note that a thick solid line arrow in Fig. 6 indicates the flow of the water. As illustrated in Fig. 6, the control unit 18 drives the pump 5, opens the motor-operated valve 7, adjusts an opening degree of the three-way valve 3, and makes the water flow from the low temperature side water supply port 30 through the pipe 20a into the low temperature heating side condenser 4. Then, the water flowing into the low temperature heating side condenser 4 exchanges the heat with the high-pressure and high-temperature refrigerant flowing into the low temperature heating side condenser 4 of the low temperature heating side refrigerant circuit B, and the liquid temperature rises from 30 degrees C to 40 degrees C, for example. The water flowing out from the low temperature heating side condenser 4 passes through the pipe 20b and the pipe 21 and is separated into the water to be stored in the low temperature side tank 32 and the water to be sent to the three-way valve 3.

[0038] The control unit 18 controls the three-way valve 3 such that the water is circulated from the pipe 20c to the pipe 20d. Then, the water sent to the three-way valve 3 is sent to the high temperature heating side evaporator 2, exchanges the heat with the refrigerant circulated in the high temperature heating side evaporator 2 of the high temperature heating side refrigerant circuit A, and evaporates the refrigerant. Here, since the water sent to the high temperature heating side evaporator 2 is heated by the low temperature heating side condenser 4 and is at 40 degrees C stably, for example, the evaporating temperature and the evaporating pressure of the refrigerant in the high temperature heating side evaporator 2 can be stabilized.

[0039] The water sent to the high temperature heating side evaporator 2 flows out from the high temperature heating side evaporator 2, and is sent through the pipe 20e to the water return port 16. The water sent to the water return port 16 is sent to the water return port 17, joins the water utilizing the waste heat supplied from the low temperature side water supply port 30, and is sent to the low temperature heating side condenser 4 again. Here, the control unit 18 adjusts the opening degree of the three-way valve 3 by predetermined calculation so that the evaporating temperature of the refrigerant detected in the temperature sensor 13 or the evaporating pressure detected in the pressure sensor 14 becomes a fixed value or greater, thereby to bring the liquid temperature of the water heated in the high temperature heating side condenser 1 detected in the temperature sensor 15 close to the target liquid temperature.

[Defrosting operation]

[0040] When the heat pump system 100 is operated under a low outdoor air condition of a winter season or other conditions, frost adheres to the low temperature heating side evaporator 6 and a defrosting operation needs to be performed. At this time, the hot water from the high temperature side tank 33 storing the high-temperature water heated in the high temperature heating side refrigerant circuit A is made to pass through in the order of the pipe 22c, the pipe 22b, the three-way valve 10, the pipe 23, the three-way valve 3, the pipe 20c and the pipe 20b, and is made to flow back to the low temperature heating side condenser 4. In such a manner, the high-temperature water heated in the high temperature heating side refrigerant circuit A can be used as a heat source for defrosting the low temperature heating side refrigerant circuit B, and defrosting time can be shortened.

[0041] As described above, it is possible to take out technically easily, highly efficiently and stably the hot water that is needed not only in a house but also in a building or a factory or other facilities.

[0042] Note that, as the refrigerant used in the low temperature heating side refrigerant circuit B, R32, R410A, or R407C is used, for example. On the other hand, as the refrigerant used in the high temperature heating side refrigerant circuit A using ammonia, R1234yf, R1234ze, R245fa, or HC-based refrigerant is used, for example.

[Effects of embodiment]

[0043] From the above, the heat pump system 100 includes: the low temperature heating side refrigerant circuit B in which the low temperature heating side compressor 9, the low temperature heating side condenser 4, the low temperature heating side expansion valve 12 and the low temperature heating side evaporator 6 are successively connected by a refrigerant pipe; the high temperature heating side refrigerant circuit A in which the high temperature heating side compressor 8, the high temperature heating side condenser 1, the high temperature heating side expansion valve 11 and the high temperature heating side evaporator 2 are successively connected by a refrigerant pipe; the first pipe configured to connect a low temperature side liquid supply port, the low temperature heating side condenser 4, and the high temperature heating side evaporator 2 in this order, thereby to circulate the liquid; the second pipe configured to connect a high temperature side liquid supply port and the high temperature heating side condenser 1 in this order, thereby to circulate the liquid; the pump provided in the first pipe and configured to feed the liquid heated in the low temperature heating side condenser 4 to the high temperature heating side evaporator 2; the control valve provided in the first pipe between the low temperature heating side condenser 4 and the high temperature heating side evaporator 2 and configured to control the flow rate of the liquid circulated inside the first pipe; and the control unit 18 configured to control at least one of the pump 5 and the control valve, and control the flow rate of the liquid fed from the low temperature heating side condenser 4 to the high temperature heating side evaporator 2.

[0044] In such a manner, since the evaporating pressure or the evaporating temperature of the refrigerant inside the high temperature heating side evaporator 2 can be stabilized, the heat pump system that highly efficiently and stably generates high-temperature water can be obtained.

[0045] In addition, the control unit 18 controls the pump 5 and the control valve based on the temperature of the liquid heated by the high temperature heating side condenser 1, and the evaporating temperature of the refrigerant in the high temperature heating side evaporator 2 or the evaporating pressure of the refrigerant in the high temperature heating side evaporator 2.

[0046] In such a manner, since the evaporating pressure or the evaporating temperature of the refrigerant inside the high temperature heating side evaporator 2 can be stabilized, the heat pump system that highly efficiently and stably generates high-temperature water can be obtained.

[0047] In addition, the control unit 18 detects the target temperature of the liquid generated in the high temperature heating side refrigerant circuit A, and controls the operation of the low temperature heating side refrigerant circuit B and the high temperature heating side refrigerant circuit A, and the control valve.

[0048] In such a manner, like the operation of the high temperature heating side refrigerant circuit A alone or the operation of the low temperature heating side refrigerant circuit B alone, adapting to the operation demanded by a user can be flexibly performed.

[0049] Furthermore, the temperature of the liquid circulated in the second pipe and heated in the high temperature heating side condenser 1 is higher than the temperature of the liquid circulated in the first pipe and heated in the low temperature heating side condenser 4.

[0050] In such a manner, the hot water at different temperatures can be obtained in one heat pump system 100.

[0051] In addition, the control valve is a first three-way valve, and the heat pump system 100 further includes: the second three-way valve provided in the second pipe between the high temperature side liquid supply port and the high temperature heating side condenser 1; and the third pipe configured to connect the first three-way valve and the second three-way valve.

[0052] In such a manner, the stable high-temperature water can be supplied from the first three-way valve to the second pipe, and the temperature of the water circulated in the second pipe can be elevated.

[0053] Furthermore, the liquid heated in the high temperature heating side refrigerant circuit A is circulated through the second pipe, the third pipe and the first pipe to the low temperature heating side condenser 4.

[0054] In such a manner, the high-temperature water heated in the high temperature heating side refrigerant circuit A can be turned to the heat source for defrosting the low temperature heating side refrigerant circuit B, and the defrosting time can be shortened.

Reference Signs List

[0055] 1 high temperature heating side condenser 2 high temperature heating side evaporator 3 three-way valve 4 low temperature heating side condenser 5 pump 6 low temperature heating side evaporator 7 motor-operated valve 8 high temperature heating side compressor 9 low temperature heating side compressor 10 three-way valve 11 high temperature heating side expansion valve 12 low temperature heating side expansion valve 13 temperature sensor 14 pressure sensor 15 temperature sensor 16 water return port 17 water return port 18 control unit 20a pipe 20b pipe 20c pipe 20d pipe 20e pipe 21 pipe 22a pipe 22b pipe 22c pipe 23 pipe 30 low temperature side water supply port 31 high temperature side water supply port 32 low temperature side tank 33 high temperature side tank 100 heat pump system 101 refrigerant heat exchanger 102 expansion valve 103 evaporator 104 compressor 105 condenser 106 expansion valve 107 water circuit 108 compressor 200 heat pump system A high temperature heating side refrigerant circuit B low temperature heating side refrigerant circuit C low order side refrigerant circuit D high order side refrigerant circuit

Claims

1. A heat pump system comprising:

   a low temperature heating side refrigerant circuit in which a low temperature heating side compressor, a low temperature heating side condenser, a low temperature heating side expansion valve and a low temperature heating side evaporator are successively connected by a refrigerant pipe;
   a high temperature heating side refrigerant circuit in which a high temperature heating side compressor, a high temperature heating side condenser, a high temperature heating side expansion valve and a high temperature heating side evaporator are successively connected by a refrigerant pipe;
   a first pipe configured to connect a low temperature side liquid supply port, the low temperature heating side condenser, and the high temperature heating side evaporator in this order, thereby to circulate liquid;
   a second pipe configured to connect a high temperature side liquid supply port and the high temperature heating side condenser in this order, thereby to circulate the liquid;
   a pump provided in the first pipe and configured to feed the liquid heated in the low temperature heating side condenser to the high temperature heating side evaporator;
   a control valve provided in the first pipe between the low temperature heating side condenser and the high temperature heating side evaporator and configured to control a flow rate of the liquid circulated inside the first pipe; and
   a control unit configured to control at least one of the pump and the control valve, and control a flow rate of the liquid fed from the low temperature heating side condenser to the high temperature heating side evaporator.

2. The heat pump system of claim 1,
   wherein the control unit is configured to control the pump and the control valve based on a temperature of the liquid heated by the high temperature heating side condenser, and an evaporating temperature of refrigerant in the high temperature heating side evaporator or an evaporating pressure of the refrigerant in the high temperature heating side evaporator.

3. The heat pump system of claim 1 or 2,
   wherein the control unit is configured to detect a target temperature of the liquid generated in the high temperature heating side refrigerant circuit, and control operation of the low temperature heating side refrigerant circuit and the high temperature heating side refrigerant circuit, and the control valve.

4. The heat pump system of any one of claims 1 to 3, wherein a temperature of the liquid circulated in the second pipe and heated in the high temperature heating side condenser is higher than a temperature of the liquid circulated in the first pipe and heated in the low temperature heating side condenser.

5. The heat pump system of any one of claims 1 to 4, wherein the control valve is a first three-way valve, the heat pump system further comprising:

   a second three-way valve provided in the second pipe between the high temperature side liquid supply port and the high temperature heating side condenser; and
   a third pipe configured to connect the first three-way valve and the second three-way valve.

6. The heat pump system of claim 5,
   wherein the liquid heated in the high temperature heating side refrigerant circuit is circulated through the second pipe, the third pipe and the first pipe to the low temperature heating side condenser.

FIG. 1

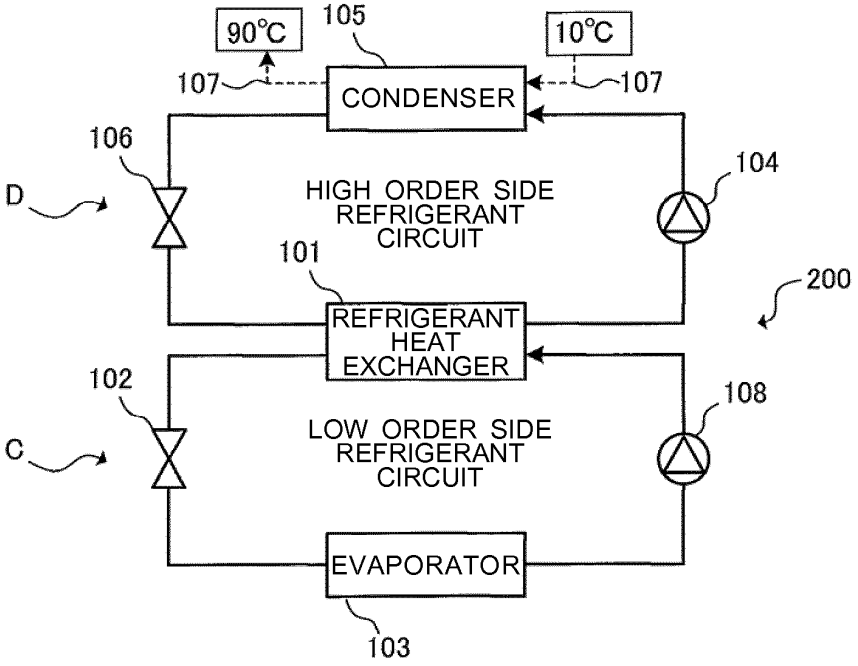

90℃
105
10℃
107
CONDENSER
107
106
104
D
HIGH ORDER SIDE REFRIGERANT CIRCUIT
101
200
REFRIGERANT HEAT EXCHANGER
102
108
C
LOW ORDER SIDE REFRIGERANT CIRCUIT
EVAPORATOR
103

FIG. 2

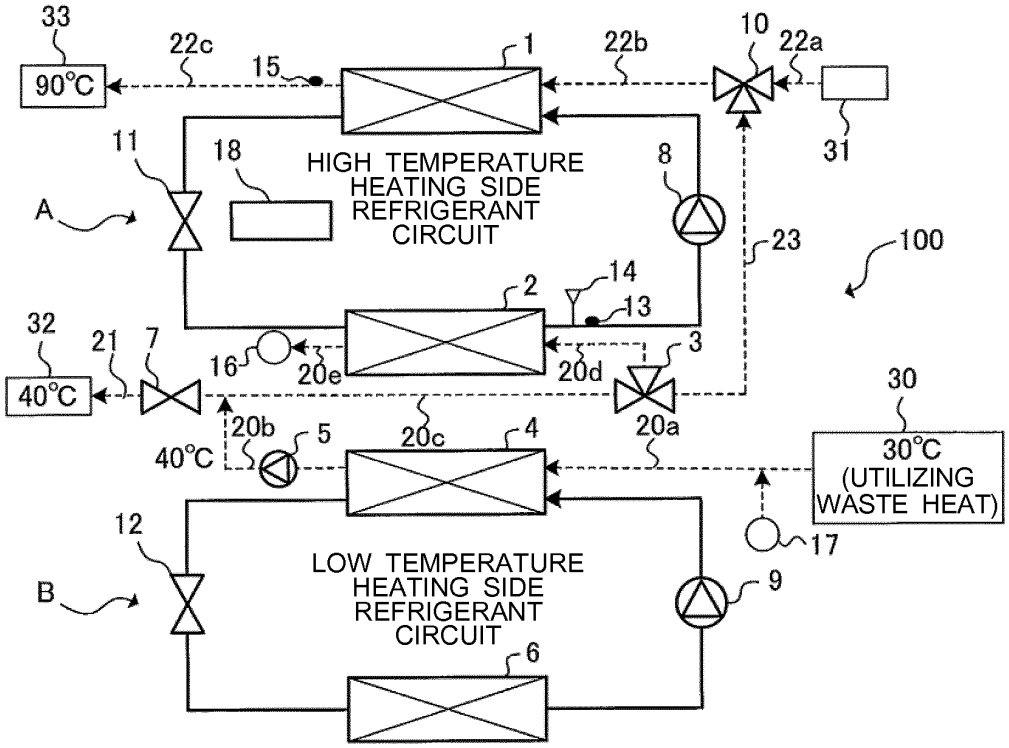
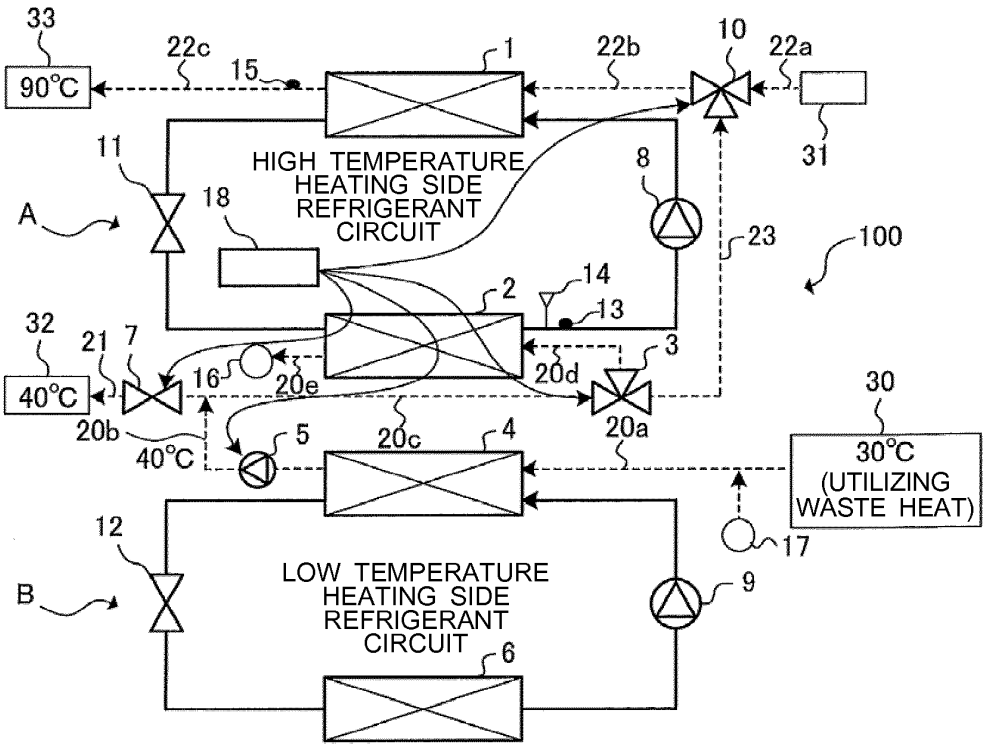

33
90℃
22c
15
1
22b
10
22a
31
11
18
HIGH TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
8
A
23
100
2
14
13
32
21
7
16
20e
20d
3
40℃
30
20b
5
20c
4
20a
40℃
30℃ (UTILIZING WASTE HEAT)
17
12
LOW TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
9
B
6

FIG. 3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22c
15
1
22b
10
22a
31
11
HIGH TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
8
A
18
23
100
2
14
13
32
21
7
3
16
20e
20d
40°C
30
20b
40°C
5
20c
4
20a
30°C (UTILIZING WASTE HEAT)
17
12
LOW TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
9
B
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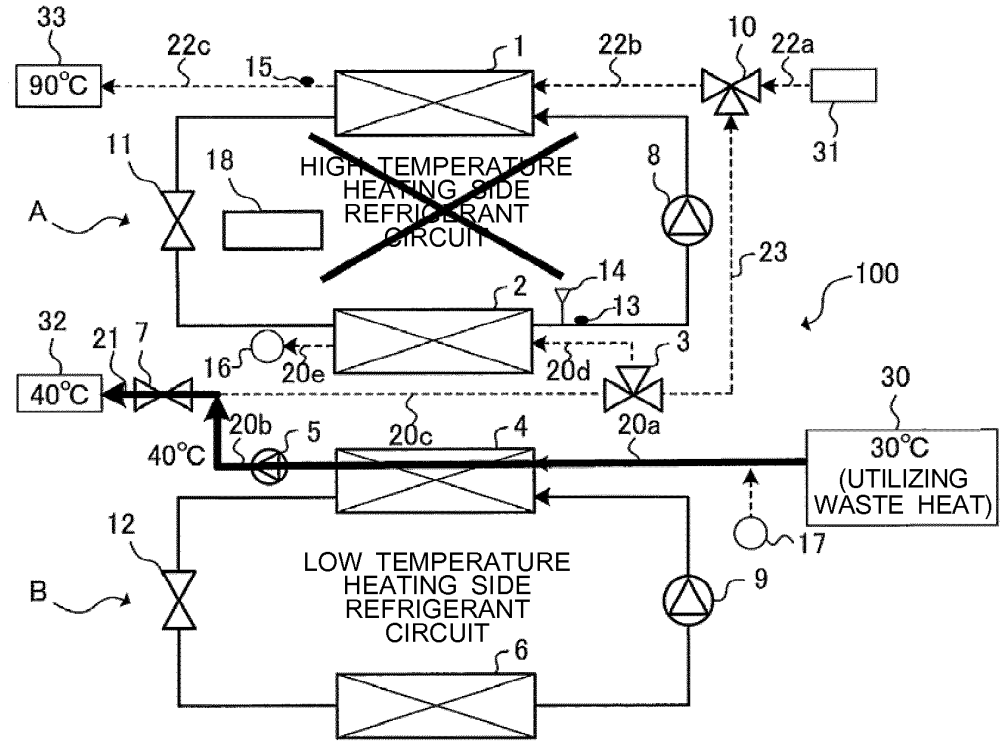
FIG. 4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90°C
22c
15
1
22b
10
22a
31
11
18
HIGH TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
8
A
23
100
2
14
13
32
21
7
3
16
20e
20d
40°C
30
20b
40°C
5
20c
4
20a
30°C (UTILIZING WASTE HEAT)
17
12
LOW TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
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B
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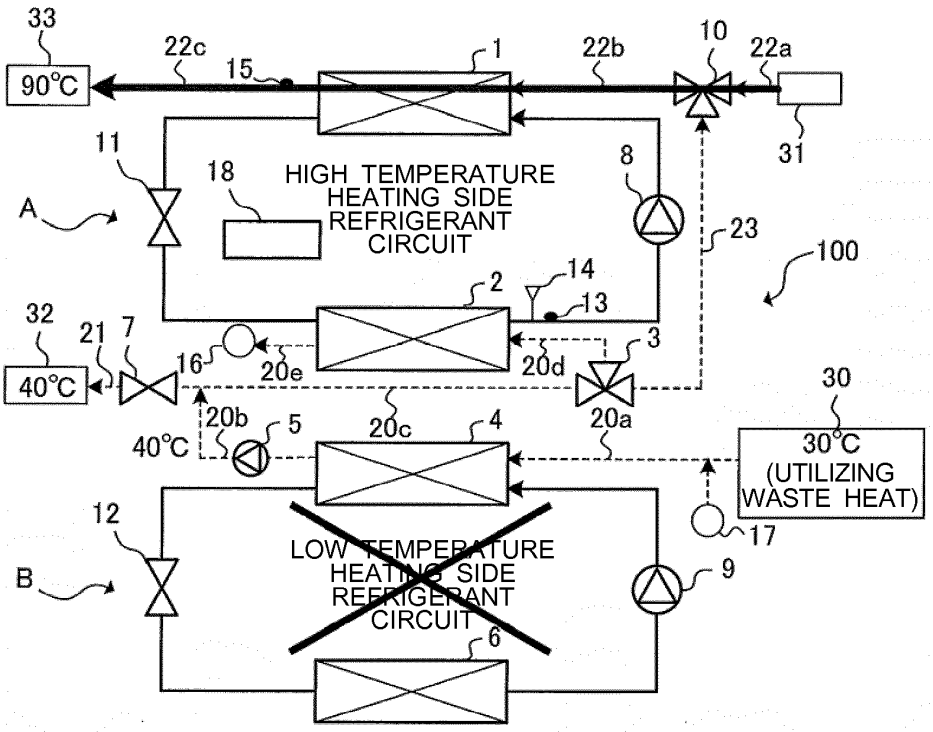
FIG. 5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HIGH TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
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100
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13
32
21
7
16
20e
20d
3
40℃
30
20b
5
20c
4
20a
40℃
30℃ (UTILIZING WASTE HEAT)
17
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LOW TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
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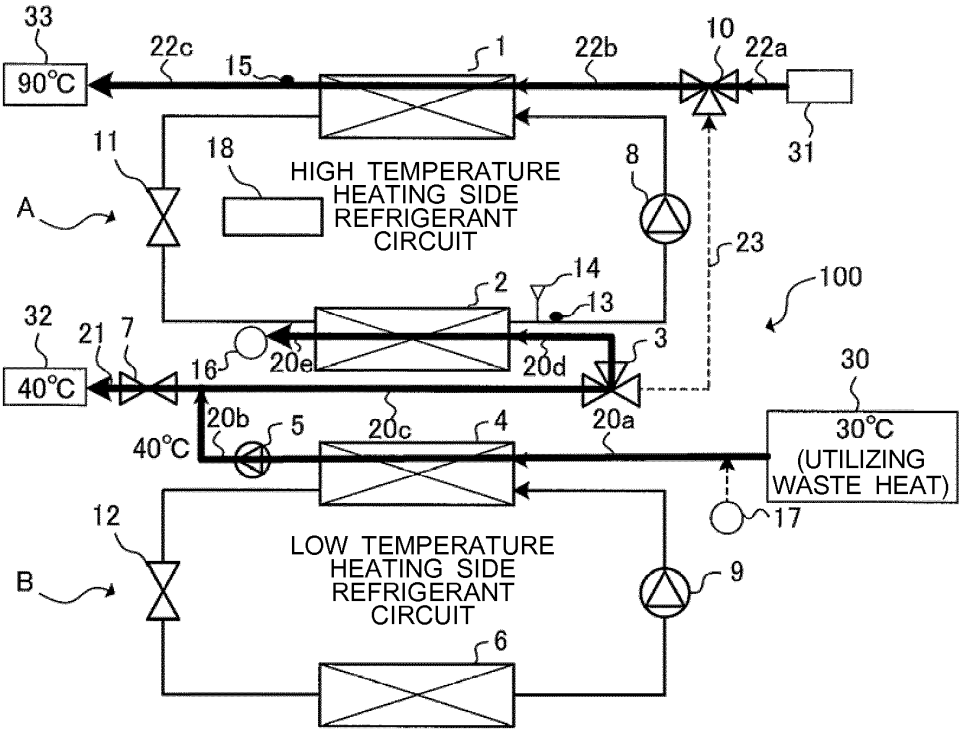
FIG. 6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22c
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22b
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HIGH TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
8
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23
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32
21
7
16
20e
20d
3
40℃
30
20b
5
20c
4
20a
40℃
30℃ (UTILIZING WASTE HEAT)
17
12
LOW TEMPERATURE HEATING SIDE REFRIGERANT CIRCUIT
9
B
6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/063892

A. CLASSIFICATION OF SUBJECT MATTER
F25B7/00(2006.01)i, *F25B1/00*(2006.01)i, *F25B30/02*(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)
F25B7/00, F25B1/00, F25B30/02

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	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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 2011-257036 A (Mitsubishi Heavy Industries, Ltd.), 22 December 2011 (22.12.2011), paragraphs [0048] to [0051]; fig. 7 to 10 (Family: none)	1 1-6
Y	WO 2010/013590 A1 (Mayekawa Mfg., Co., Ltd.), 04 February 2010 (04.02.2010), paragraph [0041]; fig. 2 & EP 2320158 A1 paragraph [0040]; fig. 2	1-6
Y	JP 3-36467 A (Ebara Corp.), 18 February 1991 (18.02.1991), page 4, upper right column, lines 9 to 12; fig. 1 (Family: none)	1-6

☒ 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
29 July 2016 (29.07.16)	09 August 2016 (09.08.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/063892

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 1-314864 A (Sanden Corp.), 20 December 1989 (20.12.1989), page 3, upper right column, line 5 to page 5, lower left column, line 3; fig. 1 to 4 (Family: none)	2-6

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2012042177 A **[0003]**