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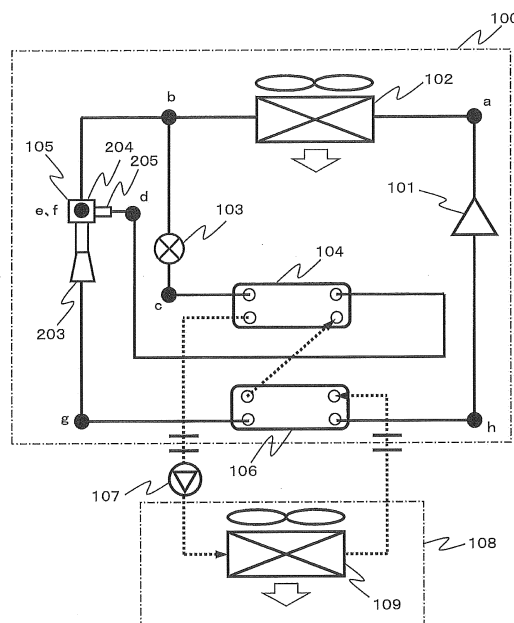
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(54) **REFRIGERATION CYCLE DEVICE**

(57) A refrigeration cycle apparatus includes a first refrigerant circuit connecting a refrigerant discharging part of a compressor 101, a condenser 102, a first expansion valve 103, a first evaporator 104, and a refrigerant suction portion 205 of an ejector 105; a second refrigerant circuit branching off from connection piping between an outlet side of the condenser 102 and the first expansion valve 103 and connecting to a refrigerant inflow portion 204 of the ejector 105; and a third refrigerant circuit connecting to a diffuser (a refrigerant outflow portion) 203 of the ejector 105, a second evaporator 106, and a refrigerant suction portion of the compressor 101. Each of the first evaporator 104 and the second evaporator 106 is a water heat exchanger to exchange heat between refrigerant flowing in a refrigerant circuit including the evaporator and a liquid heat medium different from the refrigerant. The liquid heat medium is supplied from outside, and flows out through the second evaporator 106 and the first evaporator 104 in this order.

F I G. 1



Description

Technical Field

[0001] The present invention relates to a refrigeration cycle apparatus including a refrigerant circuit.

Background Art

[0002] A conventional chilling unit is known that is composed of a plurality of compressors that are connected in parallel and a plurality of evaporators of a water heat exchanger type. In the chilling unit, to the evaporators are connected in series with each other via water pipes. Coolant water is gradually cooled through heat exchange with refrigerant in the evaporators, and thus, the evaporating temperature of the refrigerant gradually decreases from the inlet side. Consequently, an average evaporating temperature is higher than that in the case of cooling with a refrigerating machine composed of one compressor. This configuration contributes to improving the COP of a refrigeration cycle and efficient operation of the refrigeration cycle (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2006-329601

Summary of Invention

Technical Problem

[0004] The conventional chilling unit described above requires a plurality of compressors, and thus increased cost is required. In addition, in the case of employing inverters in order to control the operation capacity of the compressors in accordance with a variation of a cooling load, a plurality of control boards need to be mounted in accordance with the number of the compressors, resulting in an increase in size and cost of the unit.

[0005] It is therefore an object of the present invention to increase the efficiency of a refrigeration cycle with reduced increase in size and cost of a system. Solution to Problem

[0006] A refrigeration cycle apparatus according to the present invention includes: a first refrigerant circuit connected to a refrigerant discharging part of a compressor, a condenser, a first expansion valve, a first evaporator, and a refrigerant suction portion of an ejector; a second refrigerant circuit branching off from connection piping between an outlet side of the condenser and the first expansion valve and connected to a refrigerant inflow portion of the ejector; and a third refrigerant circuit connected to a refrigerant outflow portion of the ejector, a second evaporator, and a refrigerant suction portion of

the compressor, wherein the first evaporator is a water heat exchanger that exchanges heat between refrigerant flowing in a refrigerant circuit including the first evaporator and a liquid heat medium different from the refrigerant, the second evaporator is a water heat exchanger that exchanges heat between refrigerant flowing in a refrigerant circuit including the second evaporator and a liquid heat medium different from the refrigerant, and the liquid heat medium is supplied from outside, flows in the second evaporator and the first evaporator in this order, and then flows out to the outside.

Advantageous Effects of Invention

[0007] In the refrigeration cycle apparatus of the present invention, the evaporating temperature of the second evaporator can be higher than the evaporating temperature of the first evaporator by utilizing a pressure rise effect of the ejector. In addition, since refrigerant flows in the water heat exchanger in the order from the second evaporator to the first evaporator, the temperature of the liquid heat medium can be gradually reduced. In this manner, refrigerant at an evaporating temperature higher than that of refrigerant in the first evaporator is sucked into the compressor, and thus, the COP of the refrigeration cycle increases, resulting in enhancement of the operation efficiency. In addition, since only one compressor is needed, the resulting refrigerant circuit is more economic than a conventional system using two compressors.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 illustrates a configuration of a refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 illustrates an ejector used in Embodiment 1.

[Fig. 3] Fig. 3 illustrates a water heat exchanger used in Embodiment 1.

[Fig. 4] Fig. 4 illustrates a condenser (an air heat exchanger) used in Embodiment 1.

[Fig. 5] Fig. 5 is a mollier chart showing an operating state of the refrigeration cycle apparatus illustrated in Fig. 1.

[Fig. 6] Fig. 6 shows temperature distribution in flow directions of a liquid heat medium (water) and refrigerant in a first evaporator and a second evaporator illustrated in Fig. 1.

[Fig. 7] Fig. 7 shows capacity characteristics of a first evaporator and a second evaporator according to Embodiment 2 of the present invention.

[Fig. 8] Fig. 8 illustrates a first example of layout of a first evaporator, a second evaporator, and an ejector in Embodiment 3 of the present invention.

[Fig. 9] Fig. 9 illustrates a second example of layout

of the first evaporator, the second evaporator, and the ejector in Embodiment 3.

[Fig. 10] Fig. 10 illustrates a third example of layout of the first evaporator, the second evaporator, and the ejector in Embodiment 3.

[Fig. 11] Fig. 11 illustrates a fourth example of layout of the first evaporator, the second evaporator, and the ejector in Embodiment 3.

[Fig. 12] Fig. 12 illustrates a configuration of a refrigeration cycle apparatus according to Embodiment 4 of the present invention.

[Fig. 13] Fig. 13 is a perspective view illustrating an example of a high and low pressure heat exchanger used in Embodiment 4.

[Fig. 14] Fig. 14 is a mollier chart showing an operating state of the refrigeration cycle apparatus illustrated in Fig. 12.

[Fig. 15] Fig. 15 shows comparison of operation between the case of using no high and low pressure heat exchanger and the case of using a high and low pressure heat exchanger in the refrigeration cycle apparatus illustrated in Fig. 12.

[Fig. 16] Fig. 16 is a graph showing a relationship between the length and the COP ratio in a heat exchange part of the high and low pressure heat exchanger.

[Fig. 17] Fig. 17 illustrates a configuration of a refrigeration cycle apparatus according to Embodiment 5 of the present invention.

[Fig. 18] Fig. 18 illustrates an example of a gas-liquid separator used in Embodiment 5.

[Fig. 19] Fig. 19 is a mollier chart showing an operating state of the refrigeration cycle apparatus illustrated in Fig. 17.

[Fig. 20] Fig. 20 illustrates a configuration of a refrigeration cycle apparatus according to Embodiment 6 of the present invention.

[Fig. 21] Fig. 21 is a mollier chart showing an operating state of the refrigeration cycle apparatus illustrated in Fig. 20.

[Fig. 22] Fig. 22 illustrates an example of configurations of the first evaporator and the second evaporator in Embodiment 2.

Description of Embodiments

Embodiment 1

(Configuration)

[0009] A refrigeration cycle apparatus according to Embodiment 1 of the present invention is described with reference to Fig. 1. The refrigeration cycle apparatus illustrated in Fig. 1 is configured as an outdoor unit 100 including a compressor 101, a condenser 102, a first expansion valve 103, first and second evaporators 104 and 106 that perform heat exchange between refrigerant and a liquid heat medium different from the refrigerant, and

an ejector 105. The condenser 102 is an air heat exchanger that exchanges heat between refrigerant and air. The first evaporator 104 and the second evaporator 106 exchange heat between refrigerant and a liquid heat medium (liquid such as water or brine) and will be hereinafter also referred to as water heat exchangers.

[0010] The compressor 101, the condenser 102, the first expansion valve 103, the first evaporator 104, and a refrigerant suction portion 205 of the ejector 105 are connected together by refrigerant pipes and form a first refrigerant circuit. A pipe branching off from the refrigerant pipe between the condenser 102 and the first expansion valve 103 is connected to a refrigerant inflow portion 204 of the ejector 105 and constitutes a second refrigerant circuit. A refrigerant outflow portion 203 of the ejector 105, the second evaporator 106, and a refrigerant suction portion of the compressor 101 are connected together by refrigerant pipes and form a third refrigerant circuit. These elements and pipes connecting the elements are housed in a casing.

[0011] As illustrated in the drawing, the first evaporator 104 and the second evaporator 106 are configured such that refrigerant and the liquid heat medium flow in opposite directions so as to exchange heat. Inlet/outlet parts of the first evaporator 104 and the second evaporator 106 for the liquid heat medium project from the casing in order to establish connection to the outside (e.g., an indoor unit 108).

[0012] The first evaporator 104 and the second evaporator 106 are connected to an indoor heat exchanger 109 of the indoor unit 108 on a heat load side, and form a liquid heat medium circulation circuit together with a water supply 107 for transferring the liquid heat medium. The water supply 107 is disposed such that the liquid heat medium flows from the second evaporator 106 to the first evaporator 104.

[0013] Fig. 2 illustrates an example of the ejector 105. Fig. 2 also shows an internal pressure distribution corresponding to the configuration of the ejector 105. The ejector 105 includes a nozzle 201, a mixer 202, a diffuser (a refrigerant outflow portion) 203, a refrigerant inflow portion 204, and a refrigerant suction portion 205. The nozzle 201 includes a pressure reducing portion 201 a, a nozzle throat 201 b, and a flared portion 201 c. In Fig. 2, "e" and "f" denote points in a mollier chart that will be described later.

[0014] The ejector 105 illustrated in Fig. 2 operates in the following manner. Refrigerant that has flowed from the refrigerant inflow portion 204 expands in the pressure reducing portion 201 a under reduced pressure as the channel area decreases. Thereafter, the speed of the refrigerant increases under reduced pressure and reaches an acoustic speed in the nozzle throat 201 b. The pressure of the refrigerant at the acoustic speed decreases with a further increase in the speed in the flared portion 201 c. In this manner, ultrafast two-phase gas-liquid refrigerant flows out of the nozzle 201. On the other hand, refrigerant sucked from the refrigerant suction portion

205 of the ejector 105 is drawn into the ultrafast refrigerant (suction refrigerant) due to the pressure difference between the refrigerant suction portion 205 and the outlet of the nozzle 201. From the outlet of the nozzle 201, that is, the inlet of the mixer 202, the ultrafast refrigerant and the low-speed suction refrigerant start being mixed (a refrigerant mixture). The pressure of the refrigerant mixture restores (increases) through exchange of momenta between the ultrafast refrigerant and the suction refrigerant. In the diffuser (the refrigerant outflow portion) 203, the speed reduction due to the channel enlargement causes a dynamic pressure to be converted into a static pressure and the pressure increases. Consequently, the refrigerant mixture flows out of the diffuser (the refrigerant outflow portion) 203.

[0015] The first evaporator 104 and the second evaporator 106 may be plate heat exchangers as disclosed in, for example, Japanese Unexamined Patent Application Publication No. 2012-2425. As illustrated in Fig. 3, in a plate heat exchanger, heat transmission plates 1042 and heat transmission plates 1043 are alternately stacked. A reinforcing side plate 1041 is disposed as the frontmost plate, and a reinforcing side plate 1044 is disposed as the rearmost plate. The reinforcing side plate 1041 is a substantially rectangular plate and includes a first inlet pipe 1045, a first outlet pipe 1046, a second outlet pipe 1047, and a second inlet pipe 1048 at the four corners, respectively.

[0016] In a manner similar to the reinforcing side plate 1041, each of the heat transmission plates 1042 and 1043 is also a substantially rectangular plate and includes a first inlet, a first outlet, a second inlet, and a second outlet at the four corners, respectively. The heat transmission plates 1042 and 1043 have wave shapes that are substantially V shaped when viewed from the direction in which the heat transmission plates 1042 and 1043 are stacked, and the heat transmission plates 1042 and 1043 are so stacked that the wave shapes of one of the heat transmission heat transmission plates 1042 and 1043 are displaced from those of the other one. The substantially V shaped form of the wave shapes of the heat transmission plates 1042 are inverted from those of the wave shapes of the heat transmission plates 1043.

[0017] In a manner similar to the reinforcing side plate 1041, for example, the rearmost reinforcing side plate 1044 is a substantially rectangular plate. The rearmost reinforcing side plate 1044, however, includes none of a first inlet pipe, a first outlet pipe, a second inlet pipe, and a second outlet pipe.

[0018] In the stack of the heat transmission plates 1042 and the heat transmission plates 1043, the inversely oriented V-shaped wave shapes are overlaid on each other, so that channels where a complicated flow occurs are formed between the heat transmission plates 1042 and the heat transmission plates 1043.

[0019] A first channel through which first fluid (e.g., water) that has flowed from the first inlet pipe 1045 flows out of the first outlet pipe 1046 is formed between the

rear surface of the heat transmission plates 1043 and the front surface of the heat transmission plates 1042. Similarly, a second channel through which second fluid (e.g., refrigerant) that has flowed from the second inlet pipe 1048 flows out of the second outlet pipe 1047 is formed between the rear surfaces of the heat transmission plates 1042 and the front surfaces of the heat transmission plates 1043.

[0020] The first fluid that has flowed from the outside into the first inlet pipe 1045 flows through passages formed by overlaying the first inlets of the heat transmission plates 1042 and 1043 on each other, and flows into the first channels. The first fluid that has flowed into the first channels gradually expands along the shorter axis flows along the longer axis, and flows out of the first outlets. The first fluid that has flowed out from the first outlets flows in passages formed by overlaying the first outlets on each other, and flows out through the first outlet pipe 1046.

[0021] Similarly, the second fluid that has flowed from the outside into the second inlet pipe 1048 flows through passages formed by overlaying the second inlets of the heat transmission plates 1042 and 1043 on each other, and flows into the second channels. The second fluid that has flowed into the second channels gradually expands along the shorter axis flows along the longer axis, and flows out of the second outlets. The second fluid that has flowed out from the second outlets flows in passages formed by overlaying the second outlets on each other, and flows out through the second outlet pipe 1047.

[0022] The first fluid flowing in the first channels and the second fluid flowing in the second channels exchange heat through the heat transmission plates 1042 and 1043 when passing through the portions of wave shapes. In the first channels and the second channels, the portions of wave shapes will be referred to as heat exchange channels.

[0023] As illustrated in, for example, Fig. 4, the condenser 102 includes a fan 1026 and an air heat exchanger 1027. The fan 1026 is a combination of a wing type propeller and a motor that drives and rotates the propeller. The motor and the propeller rotate at predetermined numbers of revolution with electric power supplied from the outside. The air heat exchanger 1027 is made of a long refrigerant pipe which is bent into the shape of an L-shaped flat plate and with which a large number of fins made of aluminum thin plates are in close contact. Refrigerant in the refrigerant pipe and air around the fins exchange heat. The airflow rate of air passing between the fins is increased and adjusted by the fan 1026, and the amount of heat exchange is increased and adjusted.

(Operation)

[0024] Fig. 5 is a mollier chart showing an operating state of a refrigeration cycle apparatus of Embodiment 1. Alphabets with black circles in Fig. 5 refer to the locations of the black circles in Fig. 1. High-temperature high-

pressure gas refrigerant in a state that has been delivered by the compressor 101 is condensed through heat exchange with outdoor air in the condenser 102 and becomes high-temperature high-pressure liquid refrigerant (in a state b). The refrigerant in the state b is divided into a portion flowing toward the first expansion valve 103 and a portion flowing toward the ejector 105. The refrigerant flowing toward the first expansion valve 103 is subjected to pressure reduction in the first expansion valve 103 and becomes a state c, then heated and vaporized by a liquid heat medium at a relatively low temperature cooled by the second evaporator 106 and becomes a state d in the first evaporator 104, and then is sucked into the refrigerant suction portion 205 of the ejector 105. On the other hand, the refrigerant flowing from the condenser 102 into the refrigerant inflow portion 204 of the ejector 105 is subjected to pressure reduction (state e) in the nozzle 201 of the ejector 105, and merges with refrigerant vaporized in the first evaporator 104 to be in a state f. The refrigerant is then subjected to a pressure rise in the mixer 202 of the ejector 105 and the diffuser (the refrigerant outflow portion) 203 to be in a state g, and flows into the second evaporator 106. In the second evaporator 106, the refrigerant is vaporized through heat exchange with a liquid heat medium at a relatively high temperature heated by the indoor heat exchanger 109 to be in a state h, and is sucked into the compressor 101. The foregoing states are repeated, thereby forming a refrigeration cycle.

(Temperature Distribution in Flow Directions of Refrigerant and Liquid Heat Medium in First Evaporator 104 and Second Evaporator 106)

[0025] Fig. 6 shows temperature distribution in the flow directions of refrigerant and a liquid heat medium in the first evaporator 104 and the second evaporator 106 illustrated in Fig. 1. In Fig. 6, reference numeral 601 denotes the temperature of a liquid heat medium, reference numeral 602 denotes the refrigerant temperature of the first evaporator 104, and reference numeral 603 denotes a refrigerant temperature of the second evaporator 106. The liquid heat medium that has reached a high temperature in the indoor heat exchanger 109 and has returned to the outdoor unit 100 is cooled and has its temperature reduced while passing through the first evaporator 104 and the second evaporator 106. Since the refrigerant has not been subjected to the pressure rise yet in the ejector 105, the evaporating temperature in the first evaporator 104 is relatively lower than the evaporating temperature in the second evaporator 106. However, when refrigerant that has flowed from the first evaporator 104 is subjected to a pressure rise in the ejector 105 and is caused to flow into the second evaporator 106, the evaporating temperature can be increased by ΔT_{eje} . Then, the refrigerant that has flowed from the second evaporator 106 is caused to return to a suction side of the compressor 101.

(Advantages)

[0026] The pressure rise effect in the ejector 105 can cause the evaporating temperature in the second evaporator 106 to be higher than the evaporating temperature in the first evaporator 104. In addition, the heated liquid heat medium flows in the order from the second evaporator 106 to the first evaporator 104 so that the liquid heat medium can be gradually cooled. In this manner, the refrigerant whose evaporating temperature is higher than that in the first evaporator 104 can be sucked into the compressor 101. Thus, the COP of the refrigeration cycle is enhanced, and the operation efficiency can be increased.

[0027] In a conventional refrigerating and air-conditioning apparatus, water-side channels of two water heat exchangers are serially connected to each other and a refrigerant channel of each of the water heat exchangers includes one compressor so as to increase the operation efficiency (see, for example, Japanese Patent No. 4651627). On the other hand, Embodiment 1 is advantageous in that a refrigerant circuit including one compressor can constitute an economically efficient refrigeration cycle.

Embodiment 2

(Configuration)

[0028] A refrigeration cycle apparatus according to Embodiment 2 of the present invention is different from that of Embodiment 1 in that a first evaporator 104 and a second evaporator 106 have different capacities. Specifically, as illustrated in Fig. 22, the capacity of the second evaporator 106 is larger than that of the first evaporator 104.

(Operation)

[0029] The capacity difference between the first evaporator 104 and the second evaporator 106 enhances the COP of the refrigeration cycle. The principle thereof is as follows.

[0030] High-temperature high-pressure refrigerant that has flowed from a condenser 102 is divided into a portion flowing toward a first expansion valve 103 and a portion flowing toward an ejector 105. The performance of the first evaporator 104 degrades by a degree corresponding to a decrease in the capacity of the first evaporator 104, and thus, the amount of refrigerant flowing toward the first expansion valve 103 decreases. On the other hand, the performance of the second evaporator 106 increases by a degree corresponding to an increase in the capacity of the second evaporator 106, and thus, the amount of refrigerant flowing toward the ejector 105 increases.

[0031] The degree of pressure rise obtained by power recovery in the ejector 105 is defined by the following

equation, and the degree of the pressure rise increases as the amount of refrigerant flowing into the ejector 105 increases.

[Equation 1]

$$\Delta P = \eta \cdot \frac{G_n (h_g - h_e)}{G_e / \rho_e} \quad \dots (1)$$

where G_n is the flow rate of refrigerant flowing into the ejector 105, h_g is an enthalpy of the refrigerant inflow portion 204 of the ejector 105, h_e is an enthalpy obtained when the cross section expands from the inlet to the outlet of the nozzle 201 illustrated in Fig. 2, G_e is the flow rate of refrigerant sucked by the ejector 105, and ρ_e is the density of the refrigerant suction portion 205 of the ejector 105.

(Advantages)

[0032] The increase in the capacity of the second evaporator 106 increases the driven flow of the ejector 105, and the amount of collected power in the ejector 105 increases. Accordingly, the evaporating temperature of the second evaporator 106 increases, and the suction temperature of the compressor 101 increases. Consequently, the COP of the refrigeration cycle increases, thereby enhancing the operation efficiency.

[0033] Fig. 7 shows COP characteristics of a refrigeration cycle in a case where the sum of the capacity of the first evaporator 104 and the capacity of the second evaporator 106 is fixed and the proportion of the first evaporator 104 is varied. With the COP at 50% on the abscissa, the capacity of the first evaporator 104 is equal to that of the second evaporator 106. As shown in Fig. 7, the COP is increased by reducing the capacity of the first evaporator 104 and increasing the capacity of the second evaporator 106, independently of the ejector efficiency. Specifically, the COP is effectively increased when the capacity of the first evaporator 104 is in the range from 30% to 50%, especially when the first evaporator 104 is around 40% of the entire capacity.

[0034] When the capacity of the first evaporator 104 is excessively reduced, the performance of the second evaporator 106 increases, and thus, the evaporating temperature of refrigerant flowing in the first evaporator 104 decreases. Consequently, the suction pressure of the compressor 101 decreases but, as a result, the COP decreases. When the capacity of the first evaporator 104 is increased, the flow rate G_n of refrigerant flowing into the ejector 105 decreases and the G_e increases. Thus, the degree of pressure rise decreases. Consequently, the COP is not increased. An excessively large difference between the capacity of the first evaporator 104 and the capacity of the second evaporator 106 is not appropriate.

Embodiment 3

(Configuration of First Example)

[0035] In a refrigeration cycle apparatus according to a first example of Embodiment 3 of the present invention, the first evaporator 104 and the second evaporator 106 of Embodiment 1 or 2 are vertically stacked.

[0036] Fig. 8 illustrates an example of installation of the first evaporator 104, the second evaporator 106, and the ejector 105 in the first example. As illustrated in Fig. 8, the first evaporator 104 is positioned higher than the second evaporator 106. The ejector 105 is disposed such that a refrigerant inflow portion 204 is positioned higher 104 and 106 than a diffuser (a refrigerant outflow portion) 203. A refrigerant outlet 802 of the first evaporator 104 is connected to a refrigerant suction portion 205 of the ejector 105 by a pipe 805. A diffuser (a refrigerant outflow portion) 203 of the ejector 105 is connected to the second evaporator 106 by a pipe 806.

[0037] On the other hand, a liquid heat medium inlet 811 of the first evaporator 104 is connected to a liquid heat medium outlet 814 of the second evaporator 106 by a pipe 815.

(Operation)

[0038] Single-phase liquid or two-phase gas-liquid refrigerant that has flowed into the first evaporator 104 flows from a lower portion to an upper portion of the first evaporator 104 while being heated and vaporized with a liquid heat medium flowing in a liquid heat medium circulation circuit. The refrigerant that has flowed from the refrigerant outlet 802 of the first evaporator 104 is sucked into the refrigerant suction portion 205 of the ejector 105 through the pipe 805. In the ejector 105, the refrigerant that has flowed from the refrigerant inflow portion 204 and refrigerant sucked from the first evaporator 104 into the refrigerant suction portion 205 sequentially flow in a mixer 202 of the ejector 105, the diffuser (the refrigerant outflow portion) 203, and the pipe 806 in this order, and then flows into the refrigerant inlet 803 of the second evaporator 106. The two-phase gas-liquid refrigerant that has flowed into the second evaporator 106 flows toward an upper portion of the second evaporator 106 while being heated and vaporized with the liquid heat medium flowing in the liquid heat medium circulation circuit, and then flows out from the refrigerant outlet 804.

[0039] The liquid heat medium of the liquid heat medium circulation circuit flows from the liquid heat medium inlet 813 into the second evaporator 106. Then, the liquid heat medium is cooled with relatively high-temperature refrigerant whose pressure has been increased in the ejector 105, and flows out from the liquid heat medium outlet 814. Then, the liquid heat medium flows from the liquid heat medium inlet 811 of the first evaporator 104 into the first evaporator 104 through the pipe 815. Thereafter, the liquid heat medium is cooled with relatively low-

temperature refrigerant immediately before the pressure rise in the ejector 105, and flows out from the liquid heat medium outlet 812. Here, the refrigerant and the liquid heat medium flow in opposite directions, that is, a counterflow is formed.

(Advantages)

[0040] As described above, in the configuration in which the first evaporator 104 is disposed at an upper level, the second evaporator 106 is disposed at a lower level, and the diffuser (the refrigerant outflow portion) 203 of the ejector 105 is disposed below the refrigerant inflow portion 204 and the refrigerant suction portion 205 of the ejector 105, the pipe 805 and the pipe 806 are shortened. Thus, a pressure loss in connection piping is reduced so that the efficiency of the refrigeration cycle can be increased. In addition, the ejector 105, the first evaporator 104, and the second evaporator 106 can be made compact, thereby reducing the space and cost.

[0041] In addition, as illustrated in Fig. 9, similar advantages can also be obtained in a configuration in which the inlet and outlets of refrigerant and the liquid heat medium in the first evaporator 104 and the second evaporator 106 may be diagonally disposed. In this case, weldability of connection by pipes can be further enhanced.

[0042] In the configurations of Figs. 8 and 9, the refrigerant and the liquid heat medium flow in opposite directions. Alternatively, as illustrated in Fig. 10, the refrigerant and the liquid heat medium may flow in parallel. In such a case, substantially the same advantages can be obtained. This configuration can be obtained only by changing the connection of pipes of the liquid heat medium as illustrated in Fig. 10 without a change in connection of the ejector 105.

(Configuration of Second Example)

[0043] In a refrigeration cycle apparatus according to a second example of Embodiment 3 of the present invention, the first evaporator 104 and the second evaporator 106 are disposed in a horizontal line, that is, arranged side by side, and the refrigerant inflow portion 204 of the ejector 105 is positioned higher than the diffuser (the refrigerant outflow portion) 203 of the ejector 105. The other parts of the configuration and operation are the same as those in Embodiment 1 and the first example of Embodiment 3.

[0044] Fig. 11 illustrates an example of installation of the first evaporator 104, the second evaporator 106, and the ejector 105 in the second example. As illustrated in Fig. 11, the first evaporator 104 and the second evaporator 106 are arranged side by side. The ejector 105 is disposed such that the refrigerant inflow portion 204 is positioned higher than the diffuser (the refrigerant outflow portion) 203. The refrigerant outlet 802 of the first evaporator 104 is connected to the refrigerant suction portion 205 of the ejector 105 by the pipe 805. The diffuser (the

refrigerant outflow portion) 203 of the ejector 105 is connected to the second evaporator 106 by the pipe 806. The liquid heat medium outlet 812 of the first evaporator 104 is connected to the liquid heat medium inlet 813 of the second evaporator 106 by the pipe 815.

(Advantages)

[0045] In the second example of Embodiment 3, the first evaporator 104 and the second evaporator 106 are arranged side by side, and the diffuser (the refrigerant outflow portion) 203 of the ejector 105 is located below the refrigerant inflow portion 204 and the refrigerant suction portion 205 of the ejector 105. Thus, the pipe 805 and the pipe 806 are shortened. The connection method is effective when the configuration is restricted by the height of installation. In a manner similar to those illustrated in Figs. 8 through 10, a pressure loss in connection piping is reduced, and the efficiency of the refrigeration cycle is enhanced.

(Summary of Advantages)

[0046]

(1) The configuration in which the refrigerant inflow portion 204 of the driven flow in the ejector 105 is positioned higher than the refrigerant outflow portion 203 of the ejector 105 can shorten the connection pipe between the ejector 105 and the second evaporator 106. The shortening of the pipe can reduce a pressure loss from the refrigerant outflow portion 203 of the ejector 105 to the second evaporator 106, and the evaporating temperature of the second evaporator 106 increases. Thus, the suction pressure of the compressor 101 increases, thereby increasing the efficiency of the refrigeration cycle.

(2) The configuration in which the suction portion of the ejector 105 is linearly connected to the outlet of the first evaporator 104 can reduce a pressure loss from the outlet of the first evaporator 104 to the refrigerant suction portion 205 of the ejector 105. Thus, the pressure at the refrigerant outflow portion 203 of the ejector 105 increases, and the suction pressure of the compressor 101 increases. Thus, the efficiency of the refrigeration cycle is enhanced.

(3) The distance between each evaporator and the ejector 105 is minimized so that materials for pipes can be reduced and cost reduction can be achieved.

Embodiment 4

(Configuration)

[0047] Fig. 12 illustrates a configuration of a refrigeration cycle apparatus according to Embodiment 4 of the present invention. The refrigeration cycle apparatus illustrated in Fig. 12 is configured as an outdoor unit 100

including a first high and low pressure heat exchanger 1101 and a second high and low pressure heat exchanger 1102 that exchange heat between refrigerants in addition to a compressor 101, a condenser 102, a first expansion valve 103, a first evaporator 104, an ejector 105, and a second evaporator 106.

[0048] The compressor 101, the condenser 102, a high-pressure side of the first high and low pressure heat exchanger 1101, a high-pressure side of the second high and low pressure heat exchanger 1102, the first expansion valve 103, the first evaporator 104, a low-pressure side of the second high and low pressure heat exchanger 1102, and a refrigerant suction portion 205 of the ejector 105 are connected in series to each other, thereby forming a first refrigerant circuit. The first refrigerant circuit of Embodiment 4 is obtained by adding a high-pressure side channel of the first high and low pressure heat exchanger 1101 and a high-pressure side channel of the second high and low pressure heat exchanger 1102 between the condenser 102 and the first expansion valve 103 of the first refrigerant circuit of one of Embodiments 1 to 3 and adding a low-pressure side channel of the second high and low pressure heat exchanger 1102 between the first evaporator 104 and the refrigerant suction portion 205 of the ejector 105.

[0049] A pipe branching off from a refrigerant pipe between the condenser 102 and the first high and low pressure heat exchanger 1101 is connected to a refrigerant inflow portion 204 of the ejector 105 and forms a second refrigerant circuit. A diffuser (a refrigerant outflow portion) 203 of the ejector 105, the second evaporator 106, a low-pressure side of the first high and low pressure heat exchanger 1101, and a refrigerant suction portion of the compressor 101 are connected to each other by refrigerant pipes, thereby forming a third refrigerant circuit. The third refrigerant circuit of Embodiment 4 is obtained by adding a low-pressure side channel of the first high and low pressure heat exchanger 1101 between the second evaporator 106 and the compressor 101 of the third refrigerant circuit of one of Embodiments 1 to 3.

[0050] These elements and pipes connecting the elements are housed in a casing.

[0051] Fig. 13 illustrates an example of the high and low pressure heat exchanger used in Embodiment 4. As illustrated in Fig. 13(a), the high and low pressure heat exchangers 1101 and 1102 are composed of double pipes, low-pressure low-temperature refrigerant flows in an inner space 1201 of the inner pipe, and high-temperature high-pressure refrigerant flows in a ring space 1202 of an outer pipe located on an outer side of the inner pipe such that these refrigerants exchange heat. The high and low pressure heat exchanger illustrated in Fig. 13(b) is composed of double pipes of the outer pipe 2101 and the inner pipe 2102. The inner pipe 2102 is provided with a plurality of fins 2102a that are arranged around the axis such that heat exchange performance between the refrigerant flowing in the inner space 2104 of the inner pipe 2102 and the refrigerant flowing in the ring space 2103

of the outer pipe 2101 is enhanced. In addition, the inner pipe may be provided with a plurality of spiral pipes.

(Operation)

[0052] Fig. 14 is a mollier chart showing an operating state of the refrigeration cycle apparatus illustrated in Fig. 12. The state of refrigerant at the outlet of the condenser 102 is the same as that in Embodiment 1. Refrigerant that has flowed from the condenser 102 toward the first expansion valve 103 is cooled to be in a state b' through heat exchange with low-temperature low-pressure refrigerant that has flowed from the second evaporator 106 in the first high and low pressure heat exchanger 1101. In addition, this refrigerant becomes a state b" through heat exchange with low-temperature low-pressure refrigerant that has flowed from the first evaporator 104 in the second high and low pressure heat exchanger 1102, and flows into the first expansion valve 103. The refrigerant subjected to pressure reduction in the first expansion valve 103 becomes a state c, and passes through the first evaporator 104 to be in a state d'. This refrigerant is heated with high-temperature high-pressure refrigerant in the second high and low pressure heat exchanger 1102 to be in a state d and is sucked into the ejector 105. Then, the refrigerant passes through the ejector 105 and the second evaporator 106 to be in a state h, and then is heated by the first high and low pressure heat exchanger 1101 to be in a state h' and is sucked into the compressor 101.

(Advantages)

[0053] The refrigeration cycle apparatus of Embodiment 4 uses the high and low pressure heat exchangers 1101 and 1102 in order to change refrigerant that flows out of the first and second evaporators 104 and 106 into two-phase refrigerant. Specifically, as illustrated in Fig. 15, as compared to a configuration (a) including no high and low pressure heat exchangers, a configuration (b) including high and low pressure heat exchangers enables the refrigerant flowing out from the outlets of the first and second evaporators 104 and 106 to be in the two-phase state so that the refrigerant is in a superheat state in the high and low pressure heat exchangers. Thus, the heat transfer coefficient of the first and second evaporators 104 and 106 can be increased, resulting in increases in the pressure of the refrigerant suction portion 205 of the ejector 105 and the suction pressure of the compressor 101. In addition, the temperature of refrigerant sucked into the compressor 101 increases, thereby enhancing the efficiency of the refrigeration cycle.

[0054] As shown in Fig. 16, in regard to the relationship between the length and the COP ratio in heat exchange portions of the high and low pressure heat exchangers 1101 and 1102, the COP ratio gradually increases to a certain length, and thus, an appropriate length is preferably selected.

Embodiment 5

(Configuration)

[0055] Fig. 17 illustrates a configuration of a refrigeration cycle apparatus according to Embodiment 5 of the present invention. The refrigeration cycle apparatus illustrated in Fig. 17 is configured as an outdoor unit 100 including a gas-liquid separator 1701 in addition to a compressor 101, a condenser 102, a first expansion valve 103, a first evaporator 104, an ejector 105, and a second evaporator 106. The compressor 101, the condenser 102, the first expansion valve 103, the first evaporator 104, and the ejector 105 are connected to each other by refrigerant pipes, thereby forming a first refrigerant circuit. The refrigeration cycle apparatus also includes a second refrigerant circuit that branches off from a refrigerant pipe between the condenser 102 and the first expansion valve 103 and is connected to the refrigerant inflow portion 204 of the ejector 105. In addition, a refrigerant outflow portion 203 of the ejector 105, a gas-liquid separator 1701, the second evaporator 106, a refrigerant suction portion of the compressor 101 are connected to each other by refrigerant pipes, thereby forming a third refrigerant circuit. The third refrigerant circuit of Embodiment 5 is obtained by inserting the gas-liquid separator 1701 between the ejector 105 of the third refrigerant circuit and the second evaporator 106 of one of Embodiments 1 to 3.

[0056] In addition, the refrigeration cycle apparatus also includes a bypass circuit 1702 that connects a gas refrigerant outlet of the gas-liquid separator 1701 and an outlet of the second evaporator 106 through first flow control means 1703. The bypass circuit 1702 may be a capillary tube.

[0057] These elements and pipes connecting the elements are housed in a casing.

(Gas-liquid Separator)

[0058] The gas-liquid separator 1701 is composed of a refrigerant inlet, an outlet of gas refrigerant, and an outlet of liquid refrigerant. Fig. 18 illustrates an example of the gas-liquid separator 1701. The gas-liquid separator 1701 includes a container 301 having a cylindrical side wall 301 a, a top wall 301 b, and a bottom wall 301 c, an inlet pipe 302 penetrating through the top wall 301 b, an upper outlet pipe 303 arranged on the side of the inlet pipe 302 and attached to the top wall 301 b, and a lower outlet pipe 304 attached to the bottom wall 301 c of the container 301.

[0059] Refrigerant liquid 306 that has blown from a lateral hole in the inlet pipe 302 hits and is attached to the side wall 301 a of the container 301 to be refrigerant liquid 307b. The refrigerant liquid 307b is separated from refrigerant steam 308 and is dropped by gravity along the side wall 301 a, and accumulates as refrigerant liquid 307e on the bottom of the container 301. On the other

hand, the refrigerant steam 308 flows out of the container 301 through the upper outlet pipe 303. The refrigerant liquid 307a that is not blown from the lateral hole in the inlet pipe 302 and flows to a lower portion accumulates on the bottom surface of the inlet pipe 302, and flows out downward as refrigerant liquid 307c through the lower hole. Then, the refrigerant liquid 307c merges with the refrigerant liquid 307e that has accumulated on the bottom of the container 301 together with the refrigerant liquid 307b, and flows out of the container 301 through the lower outlet pipe 304.

(Operation)

[0060] Fig. 19 is a mollier chart showing an operating state of the refrigeration cycle apparatus illustrated in Fig. 17. Here, the difference from Embodiments 1 to 3 will be described. Refrigerant in the state g that has flowed out of the ejector 105 is separated into liquid refrigerant (state g') and gas refrigerant (state g'') in the gas-liquid separator 1701. The liquid refrigerant is heated by liquid heat medium in the second evaporator 106. On the other hand, the gas refrigerant is subjected to flow control in the first flow control means 1703, and then merges with refrigerant that has flowed out of the second evaporator 106 to be in a state h, and is sucked into the compressor 101.

(Advantages)

[0061] In the refrigeration cycle apparatus configured as described above, liquid refrigerant separated in the gas-liquid separator 1701 is caused to flow into the second evaporator 106 so that the refrigerant speed in the second evaporator 106 decreases and a pressure loss in the second evaporator 106 decreases. The decrease in pressure loss in the second evaporator 106 increases the evaporating temperature of the second evaporator 106 so that the suction pressure of the compressor 101 increases, thereby obtaining efficient operation of the refrigeration cycle.

Embodiment 6

(Configuration)

[0062] Fig. 20 illustrates a configuration of a refrigeration cycle apparatus according to Embodiment 6 of the present invention. The refrigeration cycle apparatus of Embodiment 6 is configured as an outdoor unit 100 including an internal heat exchanger 2001 and second flow control means 2002 in addition to a compressor 101, a condenser 102, a first expansion valve 103, a first evaporator 104, an ejector 105, and a second evaporator 106.

[0063] The compressor 101, the condenser 102, a high-pressure side of the internal heat exchanger 2001, the first expansion valve 103, the first evaporator 104, and a refrigerant suction portion 205 of the ejector 105 are sequentially connected to each other, thereby form-

ing a first refrigerant circuit (obtained by adding a high-pressure side channel of the internal heat exchanger 2001 between the condenser 102 and the first expansion valve 103 of the first refrigerant circuit of Embodiments 1 to 3).

[0064] A pipe branching off from a refrigerant pipe between the condenser 102 and the internal heat exchanger 2001 is connected to the refrigerant inflow portion 204 of the ejector 105, thereby forming a second refrigerant circuit. In addition, a diffuser (a refrigerant outflow portion) 203 of the ejector 105, the second evaporator 106, a refrigerant suction portion of the compressor 101 are connected to each other by refrigerant pipes, thereby forming a third refrigerant circuit.

[0065] The refrigeration cycle apparatus further includes an injection circuit 2003 branching off from between an outlet side of the condenser 102 and an inlet side of the internal heat exchanger 2001 and is connected to an intermediate pressure port of the compressor 101 through the second flow control means 2002 and the low-pressure side channel of the internal heat exchanger 2001.

[0066] These elements and pipes connecting the elements are housed in a casing.

[0067] The internal heat exchanger 2001 may have the same configuration as that of the high and low pressure heat exchanger described above, and/or may use the water heat exchanger described above as an internal heat exchanger.

(Operation)

[0068] Fig. 21 is a mollier chart showing an operating state of the refrigeration cycle apparatus illustrated in Fig. 20. Here, only portions different from those of the operation illustrated in Fig. 1 will be described. The refrigerant in the high-temperature high-pressure state b that has flowed out from the condenser 102 is divided into refrigerant flowing toward the internal heat exchanger 2001 and refrigerant flowing toward the ejector 105. The refrigerant flowing toward the internal heat exchanger 2001 is then divided into refrigerant flowing toward the internal heat exchanger 2001 and refrigerant flowing toward the second flow control means 2002. The refrigerant in the state i subjected to flow control and pressure reduction in the second flow control means 2002 is heated through heat exchange with the high-temperature high-pressure refrigerant in the internal heat exchanger 2001 to be in a state j, and flows into portions around an intermediate pressure of the compressor 101. The refrigerant that has flowed into an intermediate pressure of the compressor 101 is mixed with refrigerant that has flowed from a suction portion of the compressor 101 and is compressed to be in a state k, and then is compressed again. On the other hand, refrigerant in the state b that has flowed into a high-pressure side of the internal heat exchanger 2001 is cooled through heat exchange with low-temperature refrigerant flowing in the low-pressure side of the internal

heat exchanger 2001 to be in a state c', and flows into the first expansion valve 103. Subsequent operation is the same as that in Fig. 5, and description thereof will not be repeated.

(Advantages)

[0069] Refrigerant that branches from the refrigerant pipe between the outlet side of the condenser 102 and the inlet side of the internal heat exchanger 2001 and has become a low temperature in the second flow control means 2002 exchanges heat with high-temperature refrigerant in the internal heat exchanger 2001. The refrigerant subjected to the heat exchange is caused to flow (injected) into the intermediate pressure port of the compressor 101, thereby temporarily cooling refrigerant compressed in the compressor 101 and compressing the refrigerant again. In this manner, the discharge temperature of the compressor 101 is lower than that in the case of using no injection, and superheat of the motor of the compressor 101 can be reduced, thereby increasing the reliability. In addition, advantageously, low-temperature water that cannot be operated in order to protect the motor against superheat can be produced.

Reference Signs List

[0070] 100 outdoor unit, 101 compressor, 102 condenser, 103 first expansion valve, 104 first evaporator, 105 ejector, 106 second evaporator, 107 water supply, 108 indoor unit, 109 indoor heat exchanger, 201 nozzle of ejector, 202, mixer of ejector, 203 diffuser (refrigerant outflow portion) of ejector, 204 refrigerant inlet of ejector, 205 refrigerant suction portion of ejector, 1101 first high and low pressure heat exchanger, 1102 second high and low pressure heat exchanger, 1701 gas-liquid separator, 1702 bypass circuit, 1703 first flow control means, 2001 internal heat exchanger, 2002 second flow control means, 2003 injection circuit.

Claims

1. A refrigeration cycle apparatus comprising:

- a first refrigerant circuit connecting a refrigerant discharging portion of a compressor, a condenser, a first expansion valve, a first evaporator, and a refrigerant suction portion of an ejector;
- a second refrigerant circuit branching off from connection piping between an outlet side of the condenser and the first expansion valve, and connecting to a refrigerant inflow portion of the ejector; and
- a third refrigerant circuit connecting a refrigerant outflow portion of the ejector, a second evaporator, and a refrigerant suction portion of the compressor,

- the first evaporator being a water heat exchanger to exchange heat between refrigerant flowing in the first refrigerant circuit and a liquid heat medium different from the refrigerant, the second evaporator being a water heat exchanger to exchange heat between refrigerant flowing in the second refrigerant circuit and the liquid heat medium, the liquid heat medium being supplied from outside, flowing in the second evaporator and the first evaporator in this order, and then flowing out to the outside.
2. The refrigeration cycle apparatus of claim 1, wherein the second evaporator has a capacity larger than that of the first evaporator.
 3. The refrigeration cycle apparatus of claim 2, wherein the capacity of the first evaporator is greater than or equal to 30% of a sum of the capacity of the first evaporator and the capacity of the second evaporator.
 4. The refrigeration cycle apparatus of any one of claims 1 to 3, wherein the first evaporator is disposed higher than the second evaporator, and the ejector is disposed such that the refrigerant inflow portion of the ejector is positioned higher than the refrigerant outflow portion of the ejector.
 5. The refrigeration cycle apparatus of any one of claims 1 to 3, wherein the first evaporator and the second evaporator are disposed side by side in a horizontal direction, and the ejector is disposed such that the refrigerant inflow portion of the ejector is positioned higher than the refrigerant outflow portion of the ejector.
 6. The refrigeration cycle apparatus of claim 4 or 5, wherein a refrigerant outlet of the first evaporator is connected to the refrigerant suction portion of the ejector by horizontal piping.
 7. The refrigeration cycle apparatus of any one of claims 1 to 6, further comprising a first high and low pressure heat exchanger and a second high and low pressure heat exchanger to exchange heat between high-pressure side refrigerant and low-pressure side refrigerant, wherein a high-pressure side channel of the first high and low pressure heat exchanger and a high-pressure side channel of the second high and low pressure heat exchanger are connected in series between a refrigerant outlet side of the condenser and a refrigerant inlet side of the first expansion valve in the first refrigerant circuit,
 - a low-pressure side channel of the second high and low pressure heat exchanger is connected between a refrigerant outlet side of the first evaporator and the refrigerant suction portion of the ejector, and a low-pressure side channel of the first high and low pressure heat exchanger is connected between a refrigerant outlet side of the second evaporator and the refrigerant suction portion of the compressor.
 8. The refrigeration cycle apparatus of any one of claims 1 to 6, further comprising: a gas-liquid separator to separate refrigerant into a gaseous-phase portion of refrigerant and a liquid-phase portion of refrigerant; and a bypass circuit to cause the gaseous-phase portion of refrigerant separated in the gas-liquid separator to bypass the second evaporator and flow into the refrigerant suction portion of the compressor, wherein the gas-liquid separator is connected between the refrigerant outflow portion of the ejector and a refrigerant inlet side of the second evaporator in the third refrigerant circuit, the liquid-phase portion of refrigerant flows into the refrigerant suction portion of the compressor via the second evaporator, and the gaseous-phase portion of refrigerant flows into the refrigerant suction portion of the compressor through the bypass circuit.
 9. The refrigeration cycle apparatus of any one of claims 1 to 6, further comprising an internal heat exchanger to exchange heat between high-pressure side refrigerant and low-pressure side refrigerant, wherein a high-pressure side channel of the internal heat exchanger is connected between a refrigerant outlet side of the condenser and a refrigerant inlet side of the first expansion valve in the first refrigerant circuit, and the refrigeration cycle apparatus includes an injection circuit that branches off from between the refrigerant outlet side of the condenser and a refrigerant inlet side of the internal heat exchanger and is connected to an intermediate pressure port of the compressor via second flow control means and a low-pressure side channel of the internal heat exchanger.
 10. The refrigeration cycle apparatus of any one of claims 1 to 9, wherein the first evaporator and the second evaporator are configured such that the refrigerant and the liquid heat medium flow in opposite directions with respect to each other.

FIG. 1

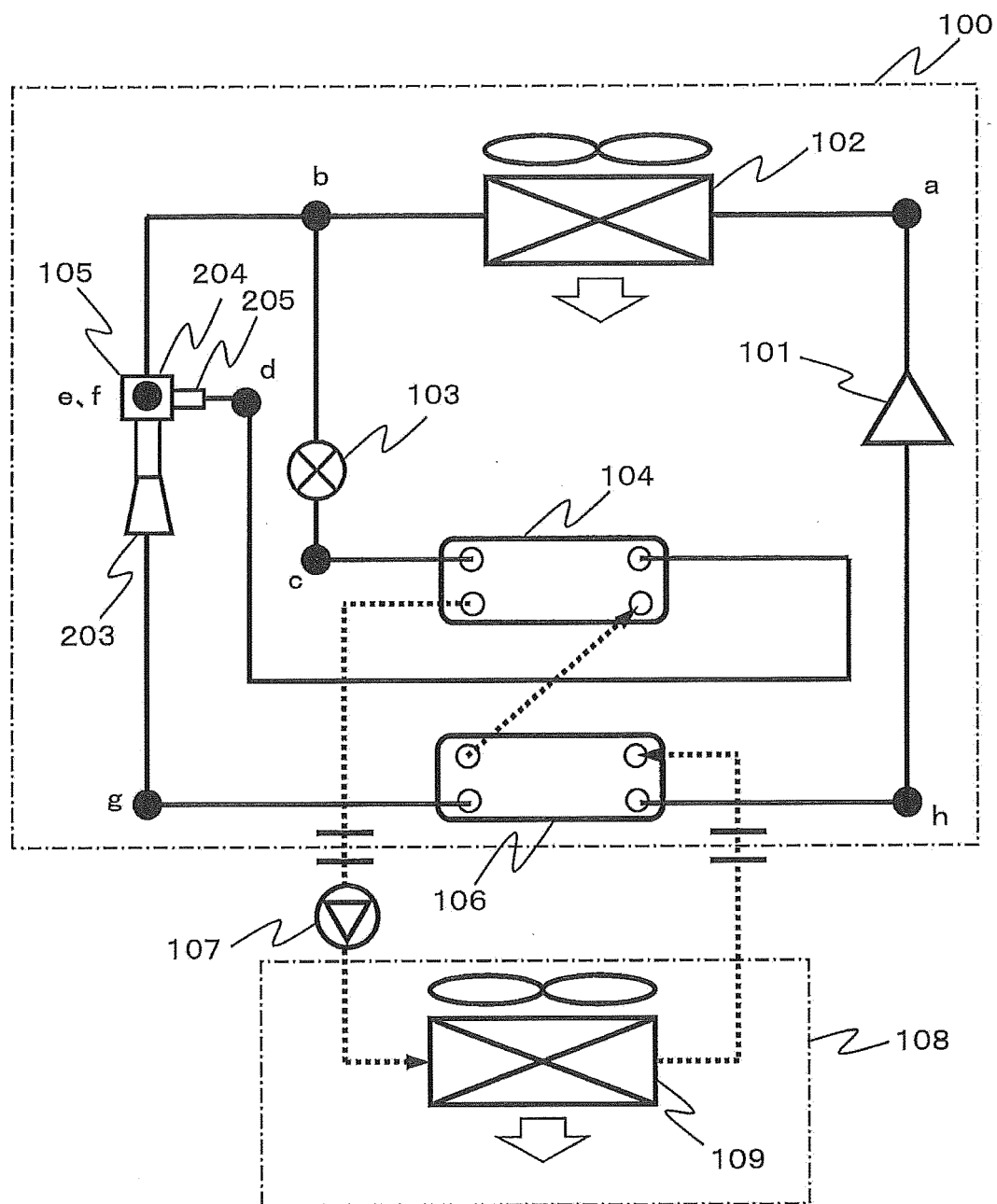


FIG. 2

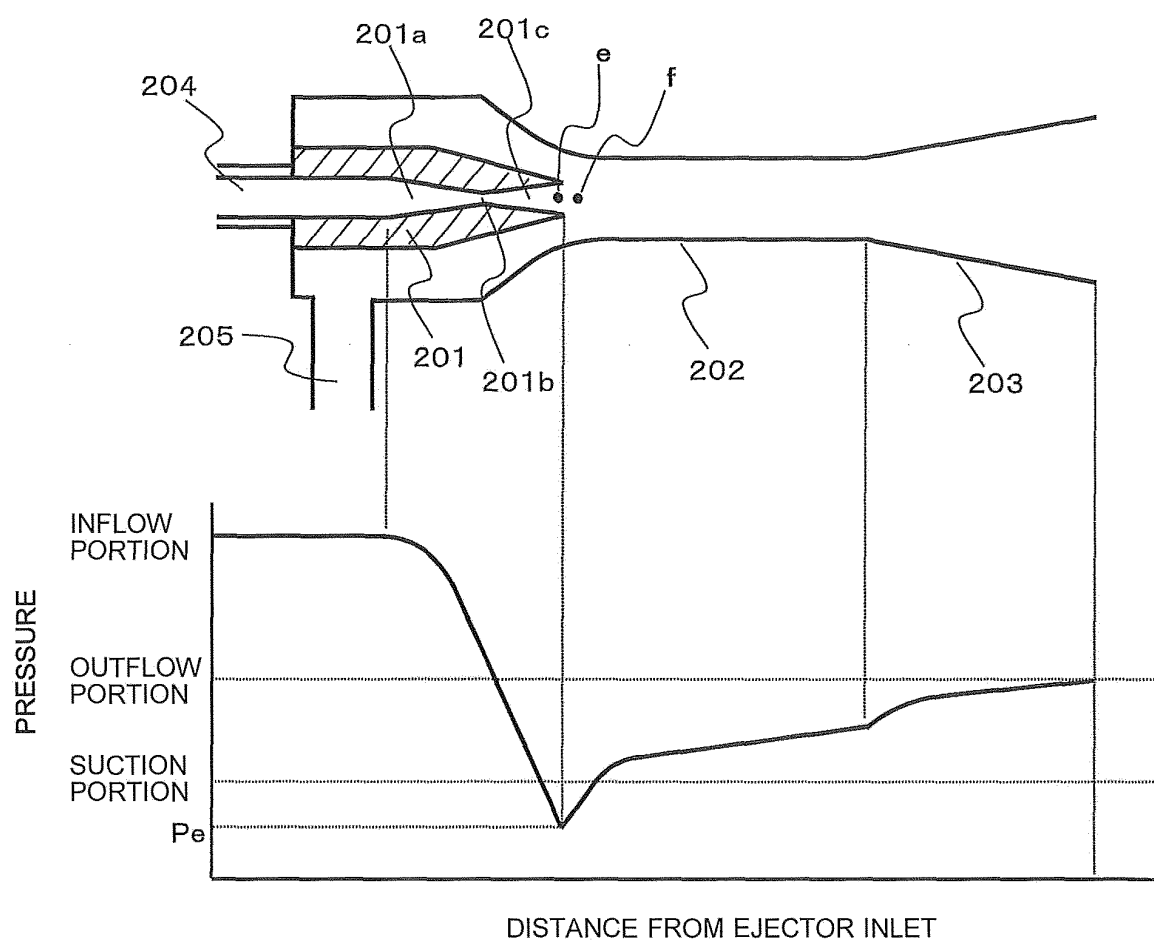


FIG. 3

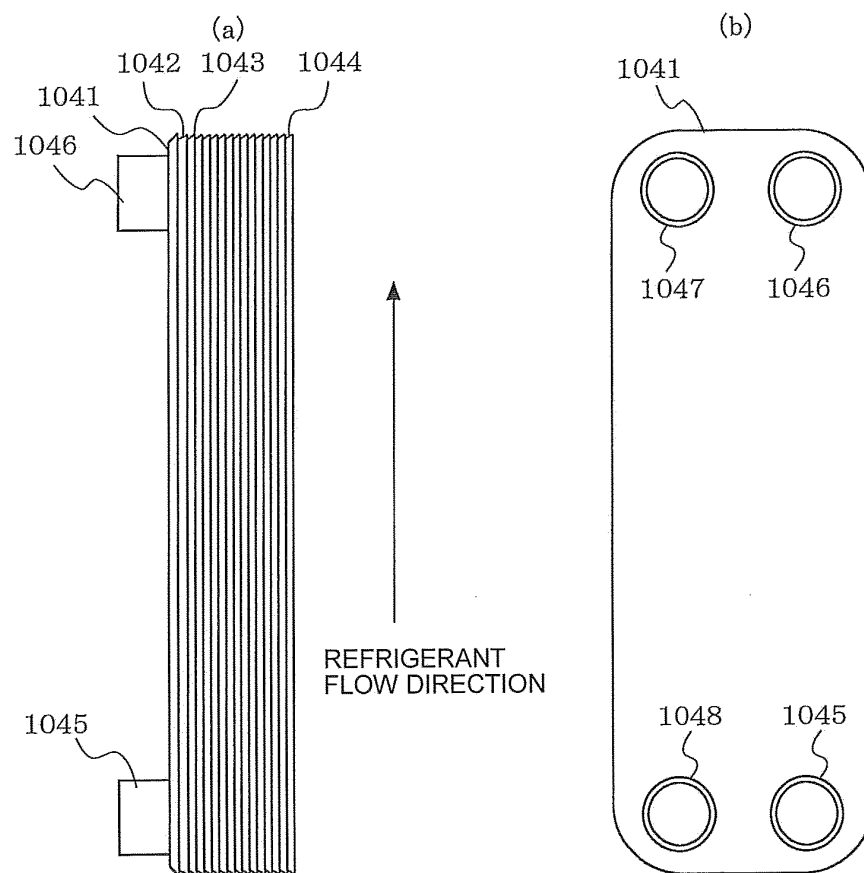


FIG. 4

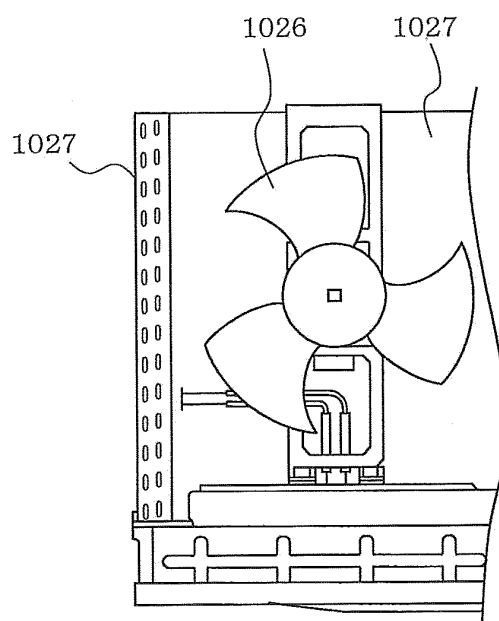


FIG. 5

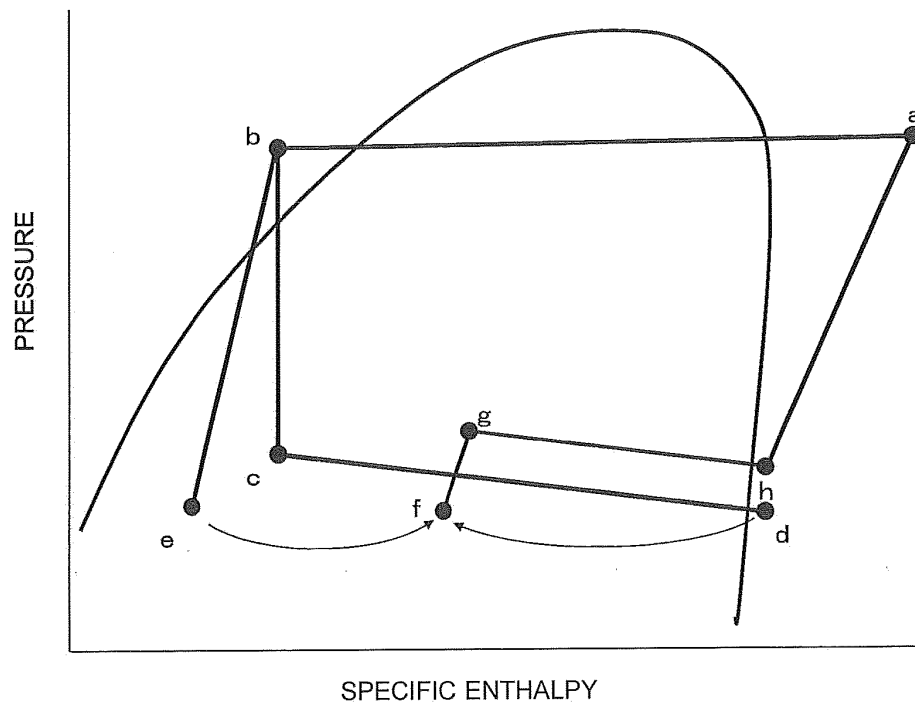


FIG. 6

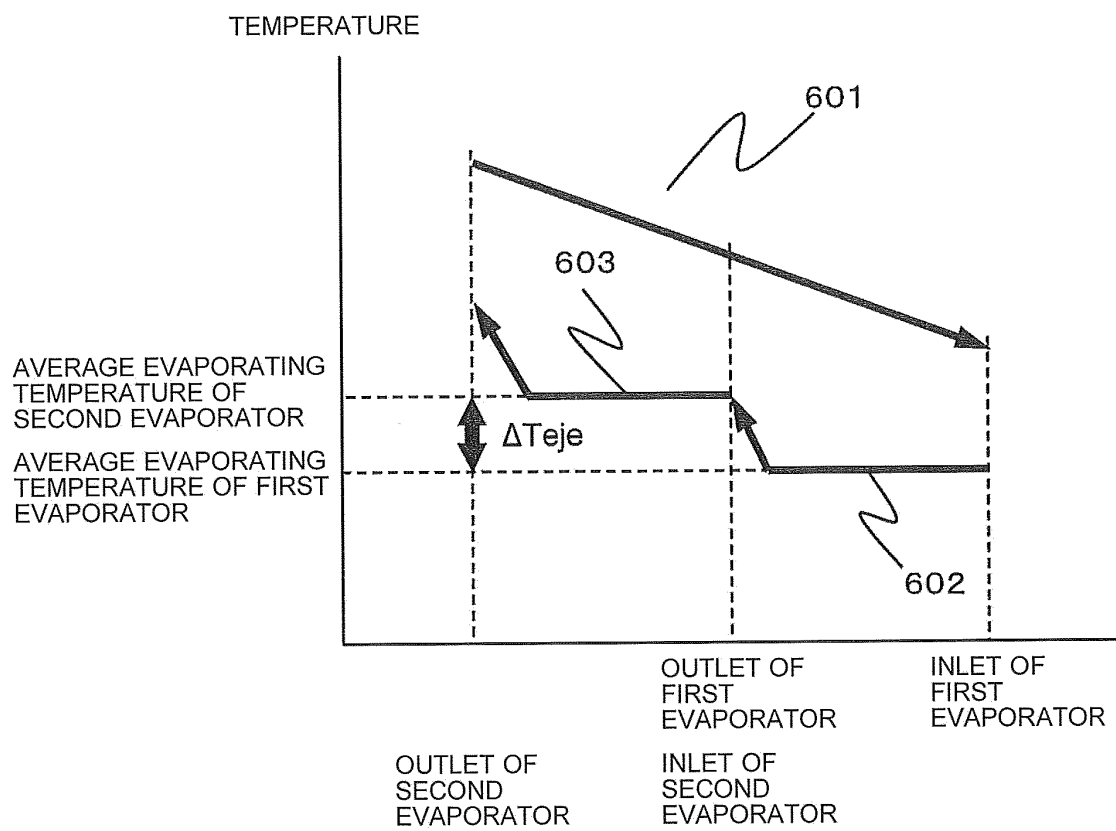


FIG. 7

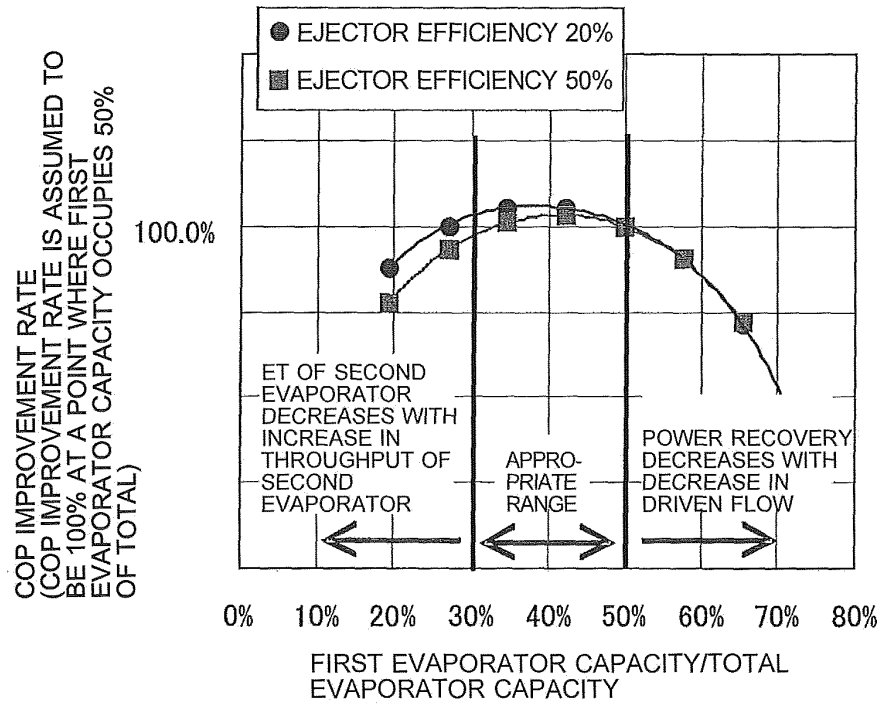


FIG. 8

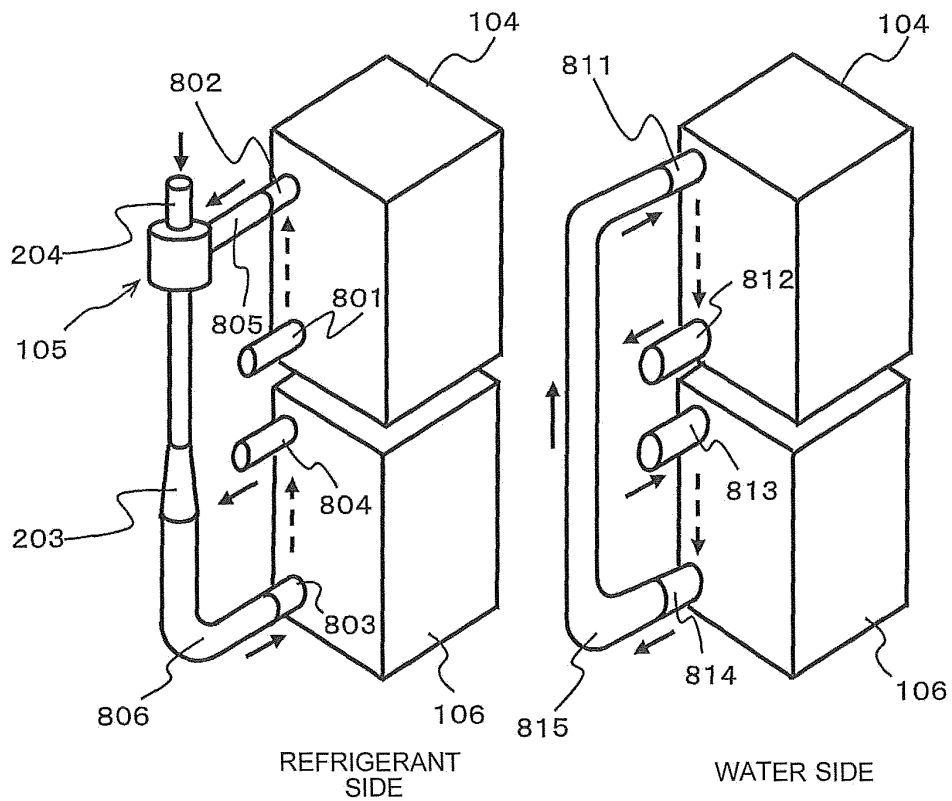


FIG. 9

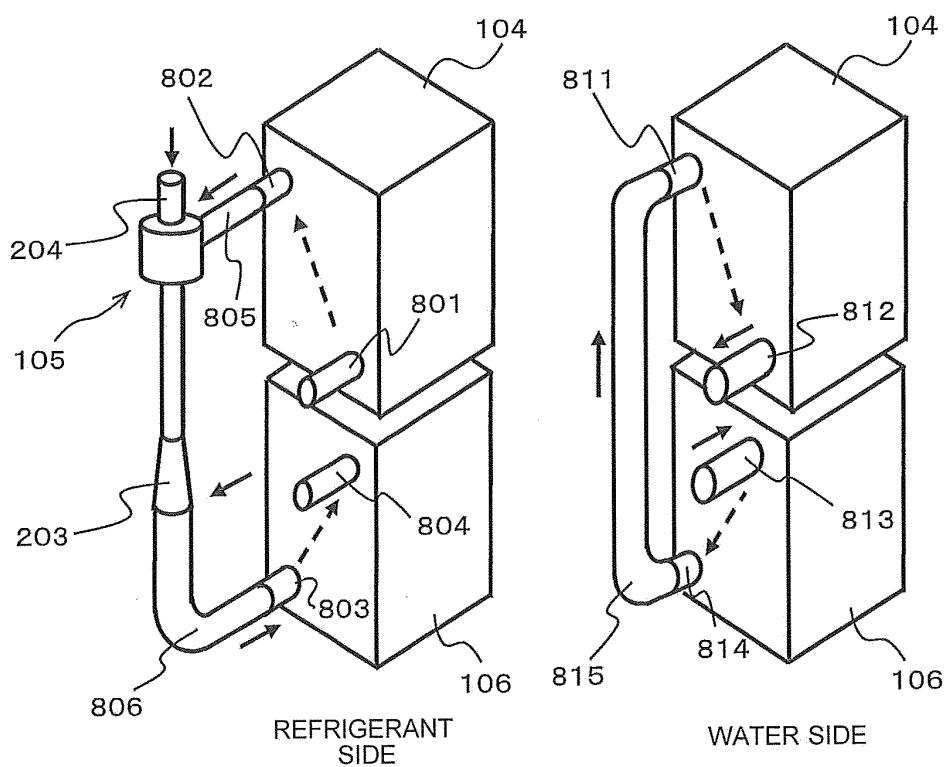


FIG. 10

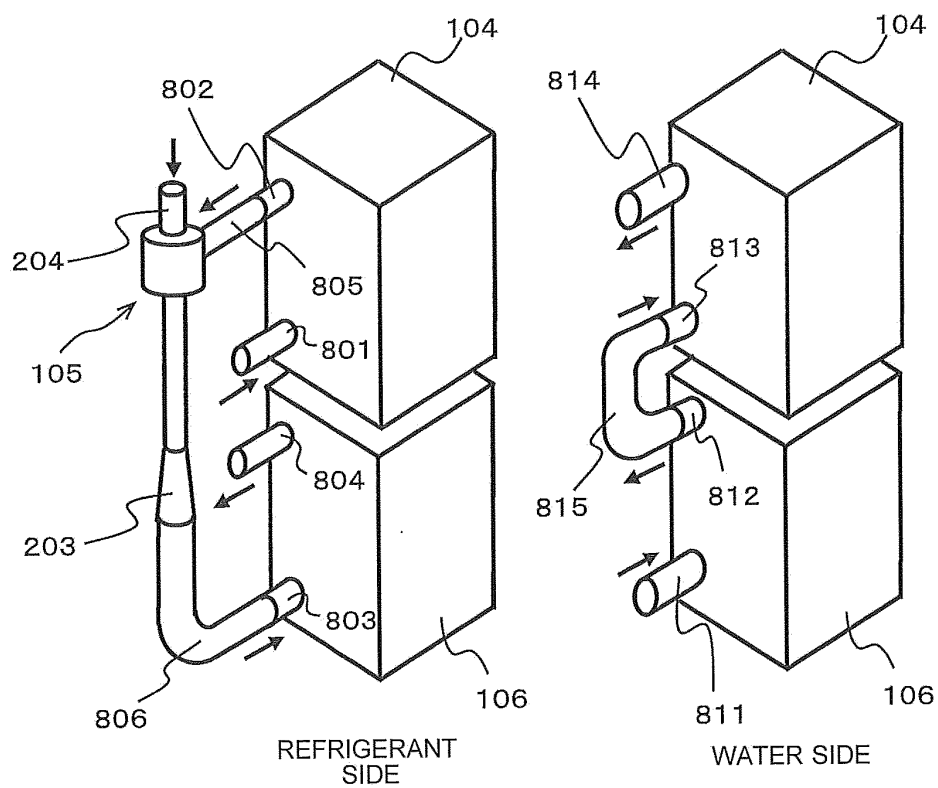


FIG. 11

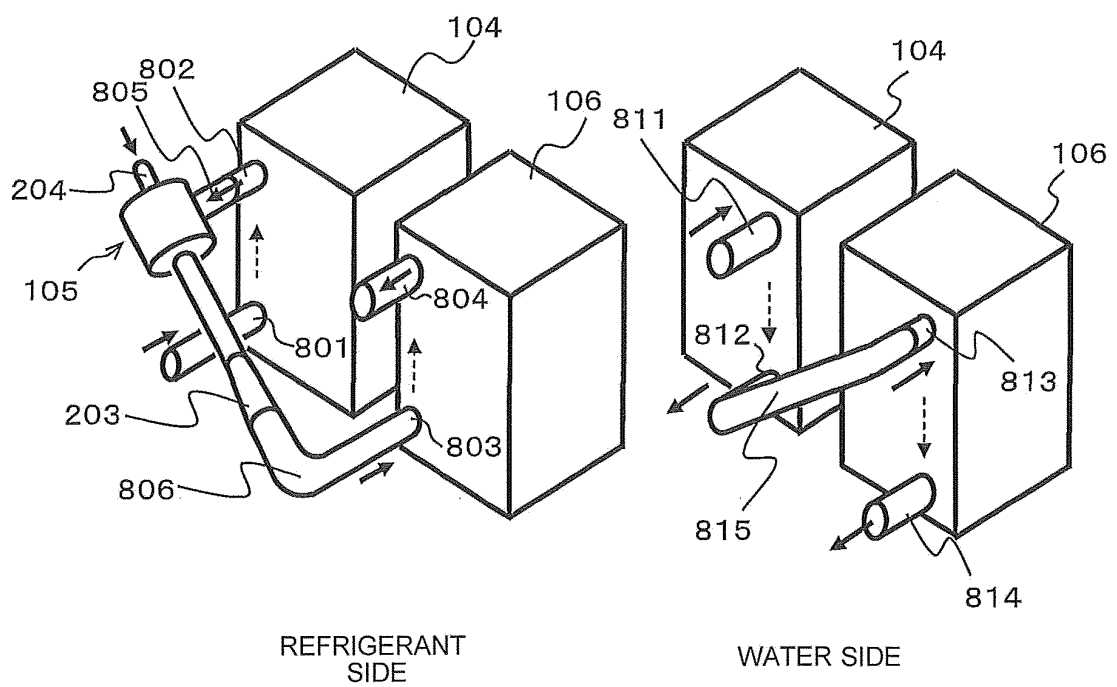


FIG. 12

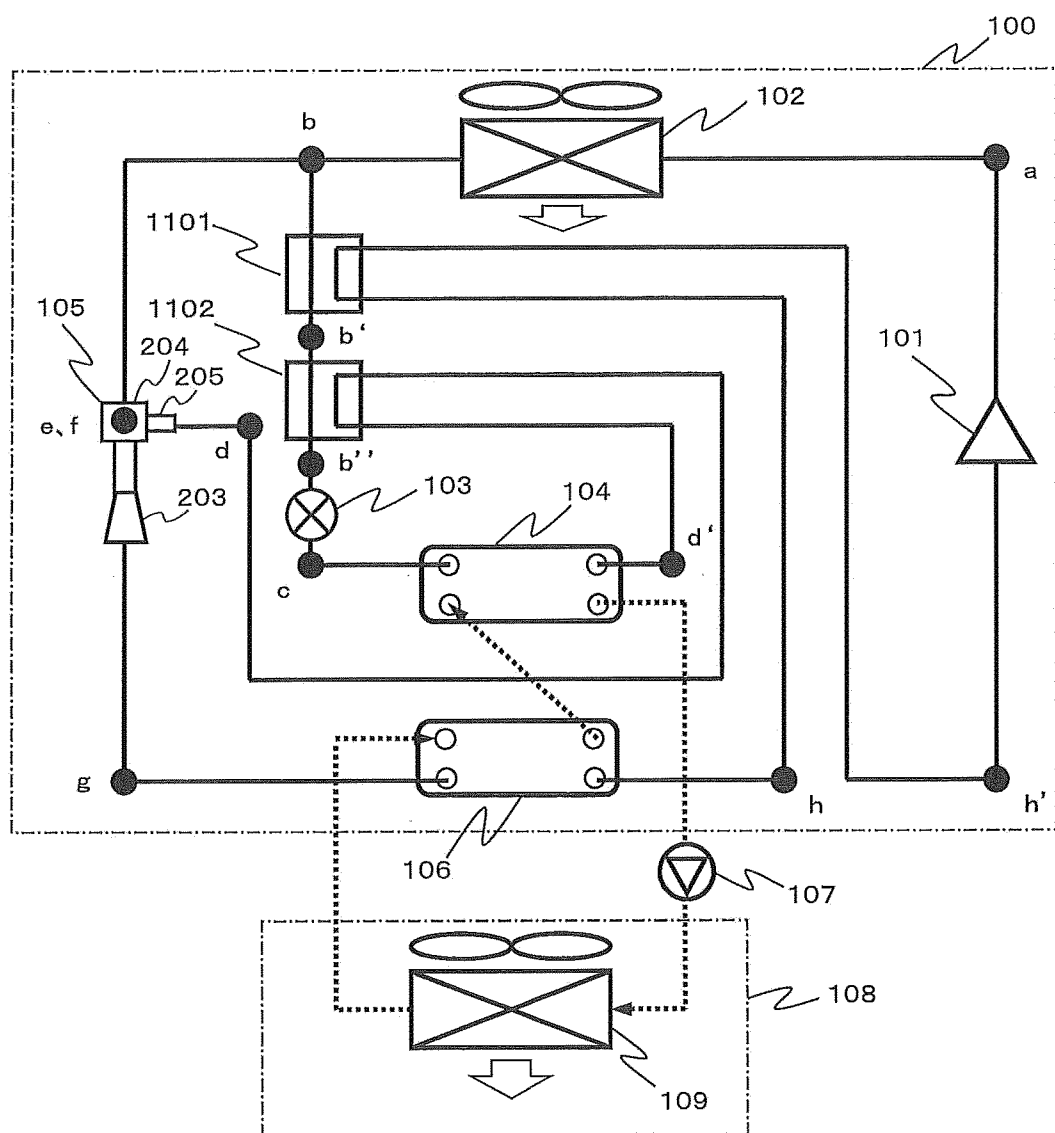


FIG. 13

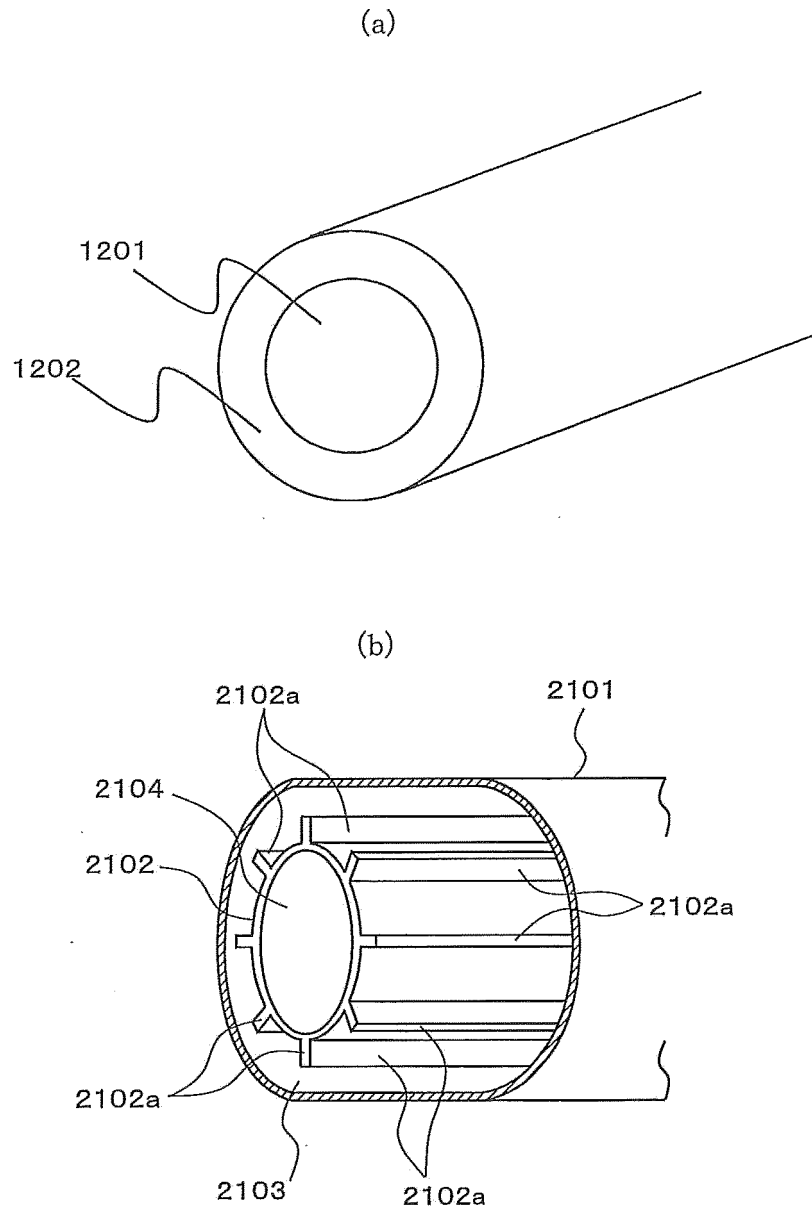


FIG. 14

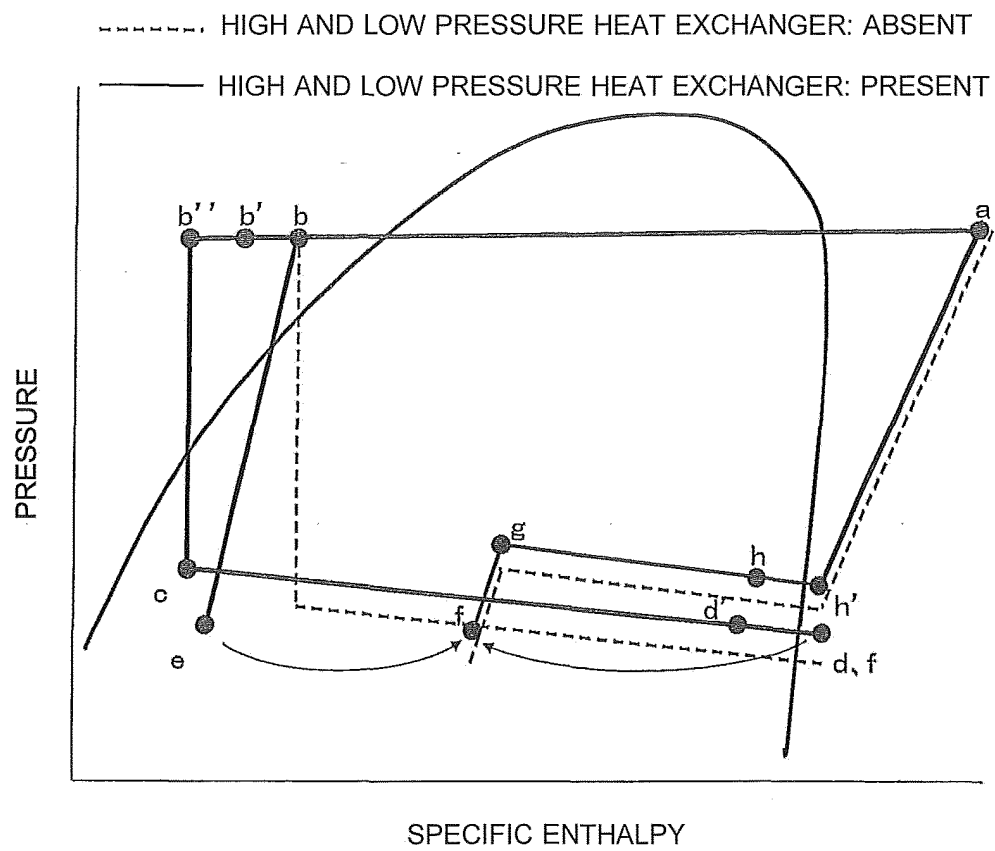


FIG. 15

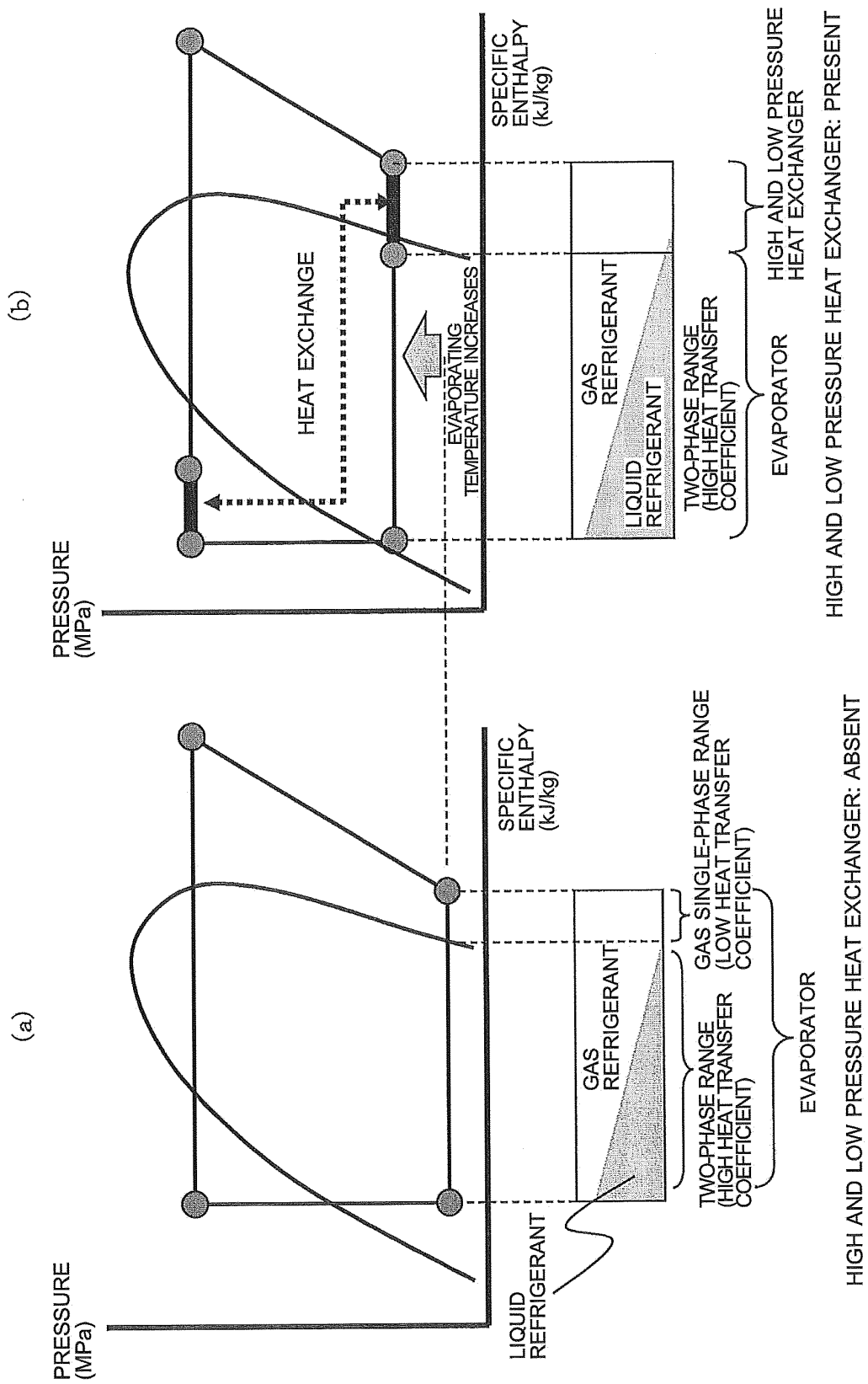


FIG. 16

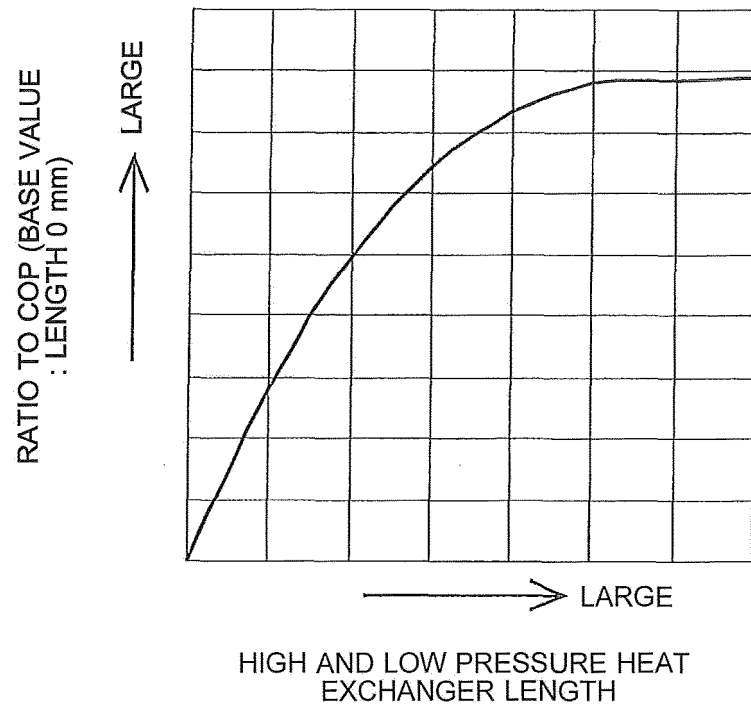


FIG. 17

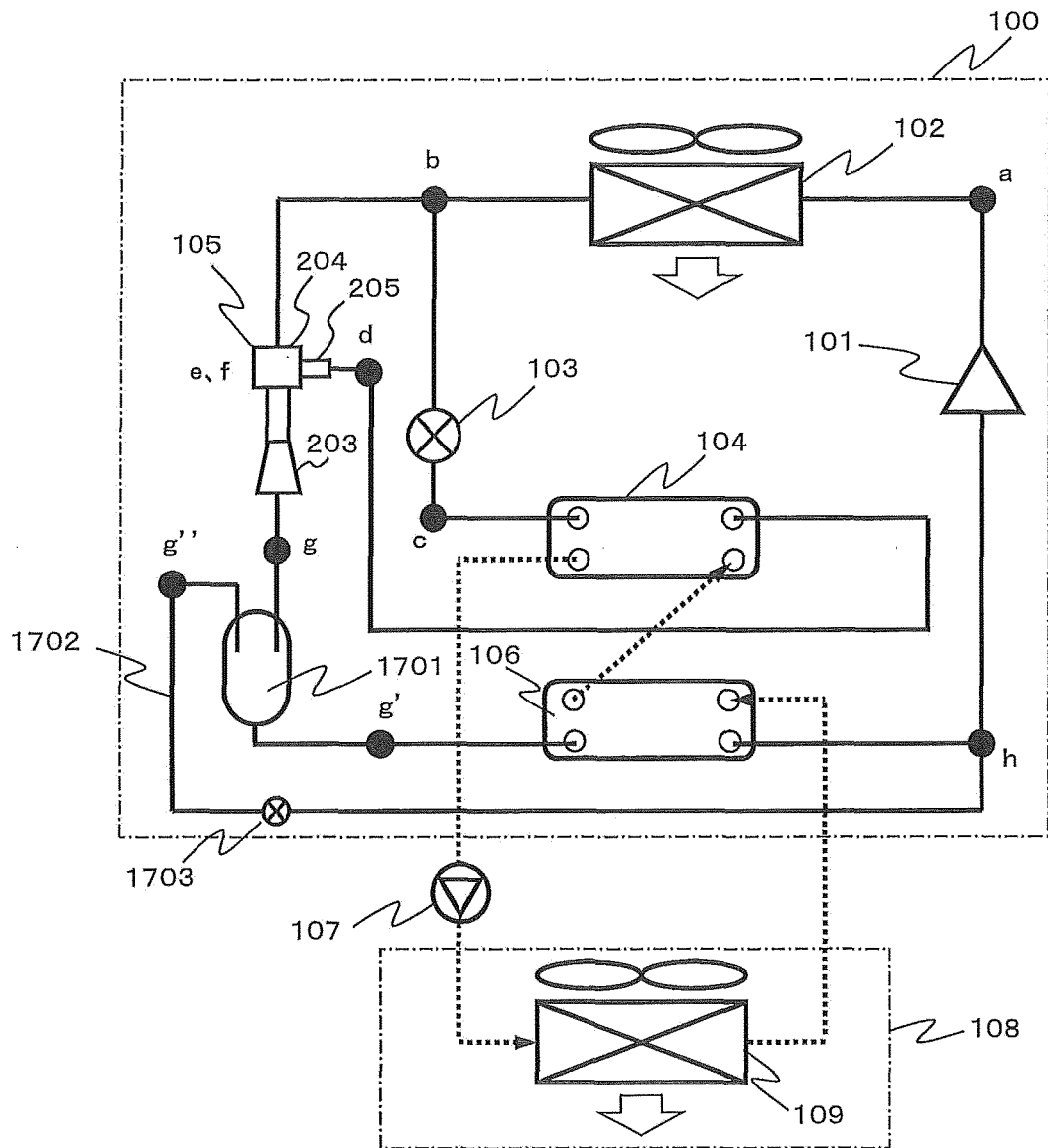


FIG. 18

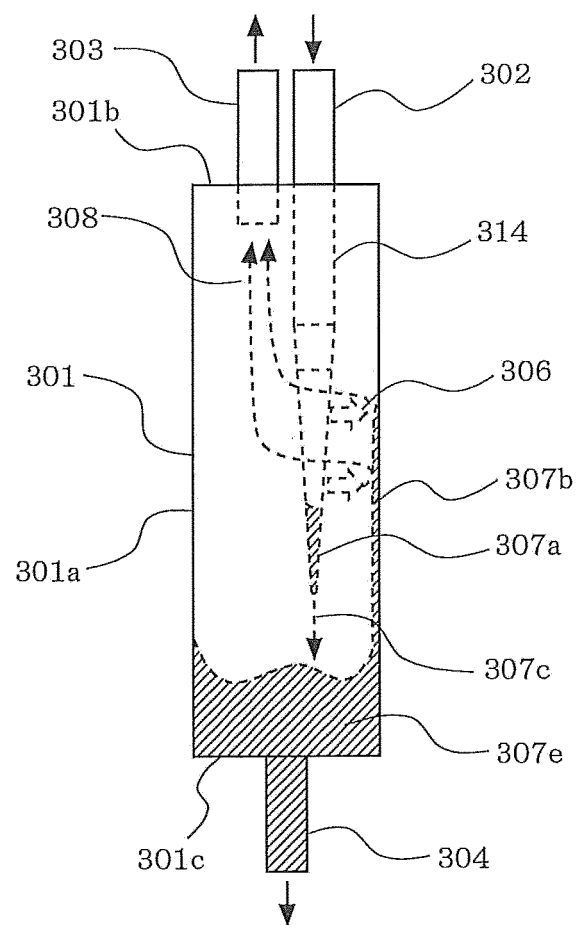


FIG. 19

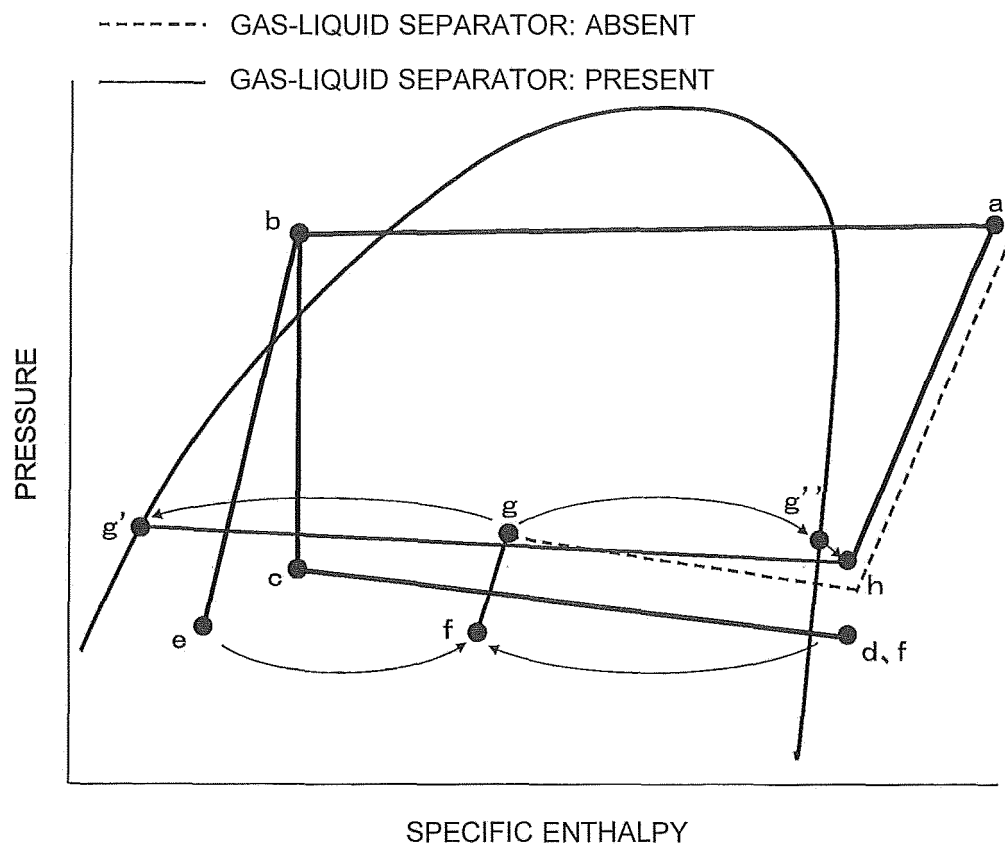


FIG. 20

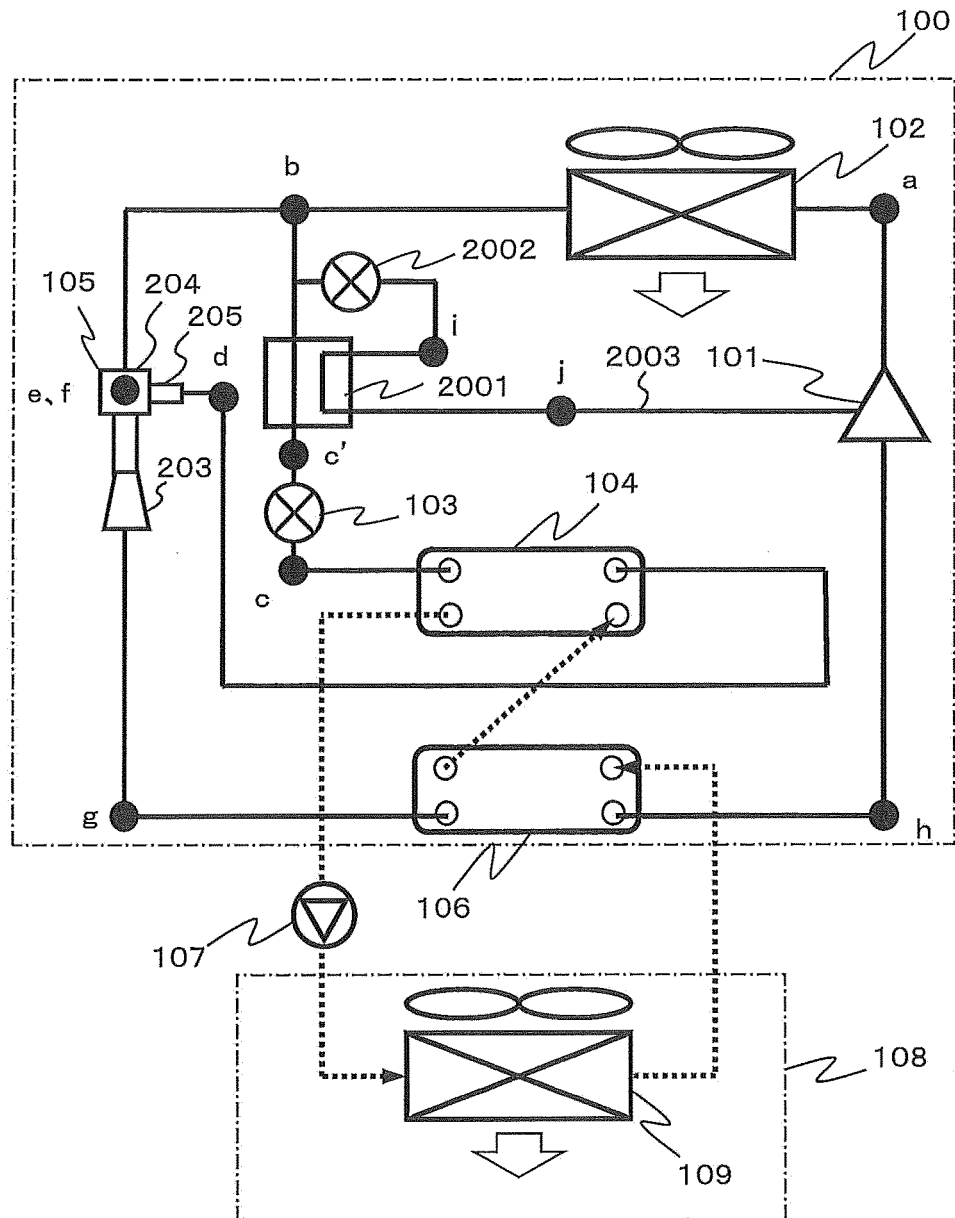


FIG. 21

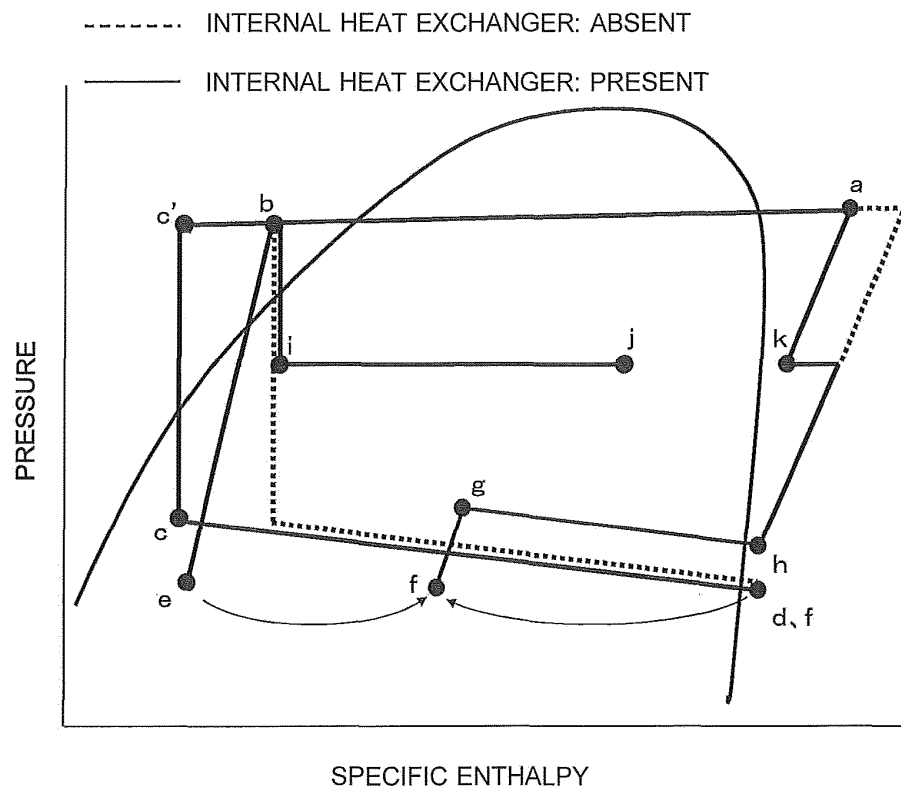
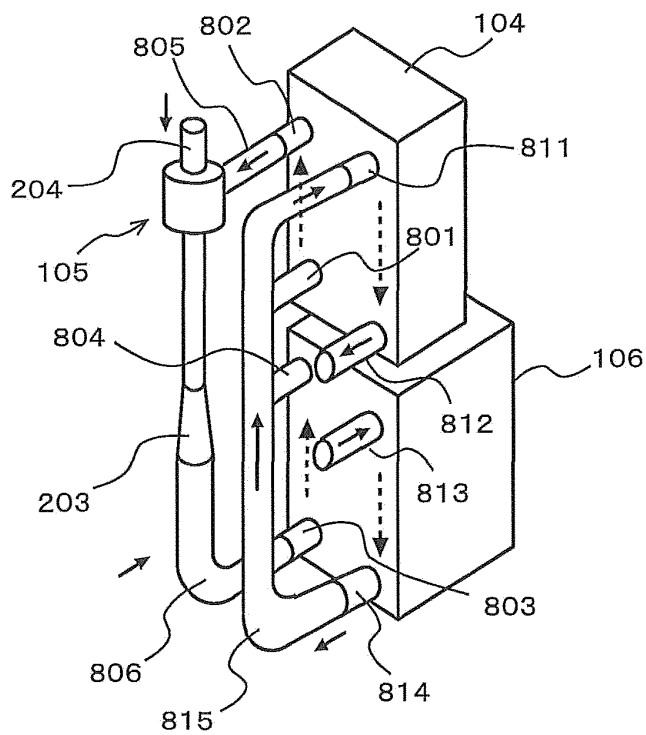


FIG. 22



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/074012

A. CLASSIFICATION OF SUBJECT MATTER

F25B5/04(2006.01)i, F25B1/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B5/04, F25B1/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013

Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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.
Y	JP 2007-51833 A (Denso Corp.), 01 March 2007 (01.03.2007), paragraphs [0058] to [0113]; fig. 1 to 5 & US 2007/0039337 A1 & DE 102006038464 A & CN 1916535 A & CN 101311646 A	1-10
Y	JP 2009-133624 A (Mitsubishi Electric Corp.), 18 June 2009 (18.06.2009), paragraphs [0013] to [0040]; fig. 1 to 4 (Family: none)	1-10
Y	JP 2007-57177 A (Denso Corp.), 08 March 2007 (08.03.2007), paragraphs [0066] to [0070]; fig. 1, 2 (Family: none)	4-10

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

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Date of the actual completion of the international search

02 December, 2013 (02.12.13)

Date of mailing of the international search report

10 December, 2013 (10.12.13)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/074012

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 2008-267721 A (Mitsubishi Electric Corp.), 06 November 2008 (06.11.2008), paragraphs [0010] to [0017]; fig. 1, 2 (Family: none)	4, 6-10
Y	JP 2009-275969 A (Daikin Industries, Ltd.), 26 November 2009 (26.11.2009), paragraphs [0002] to [0007]; fig. 6 to 7 (Family: none)	5-10
Y	JP 2007-212121 A (Denso Corp.), 23 August 2007 (23.08.2007), paragraphs [0048] to [0102], [0175] to [0185]; fig. 1 to 4, 22, 23 & US 2007/0163293 A1 & US 2010/0139315 A1 & DE 102007001878 A & CN 101078570 A	7, 10
Y	JP 2007-147198 A (Denso Corp.), 14 June 2007 (14.06.2007), paragraphs [0053] to [0054]; fig. 1 (Family: none)	8, 10
Y	WO 2011/048662 A1 (Mitsubishi Electric Corp.), 28 April 2011 (28.04.2011), paragraphs [0008] to [0011]; fig. 1, 2 & US 2012/0180510 A1 & EP 2492612 A1 & CN 102575882 A	9-10
A	JP 2009-138952 A (Denso Corp.), 25 June 2009 (25.06.2009), paragraphs [0054] to [0057]; fig. 1, 2 (Family: none)	1-10

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 2012002425 A [0015]
- JP 4651627 B [0027]