

Description

Technical Field

[0001] The present invention relates to a refrigeration cycle apparatus intended for uses such as refrigeration, air conditioning, and hot-water supply.

Background Art

[0002] Hitherto known waste-heat-utilization systems included in refrigeration cycle apparatuses such as refrigerators and air-conditioning apparatuses include, as disclosed by Patent Literature 1, a system that includes a refrigerator connected to a showcase or the like installed in a store, and a hot-water-supplying apparatus that supplies hot water to the store by utilizing waste heat generated from the refrigerator. In this waste-heat-utilization system, waste heat is recovered from a high-temperature, high-pressure discharge gas refrigerant that has been discharged from a compressor of the refrigerator but is yet to be taken into a condenser.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2009-293839 (Abstract and Fig. 2)

Summary of Invention

Technical Problem

[0004] A condenser included in a typical refrigeration cycle apparatus includes a header that distributes a refrigerant to be taken into a condenser body. If the refrigerant to be taken into the header is in a gas phase, the header can distribute the refrigerant evenly among individual refrigerant paths provided in the condenser body. However, if the discharge gas refrigerant discharged from the compressor is derived of heat before flowing into the condenser and is condensed into a state of two-phase gas-liquid, the header cannot distribute the refrigerant evenly. Consequently, the performance of the refrigerator may be deteriorated.

[0005] In view of the above, it is an object of the present invention to provide a refrigeration cycle apparatus in which a refrigerant is always distributed evenly among individual refrigerant paths provided in a condenser even if waste heat is recovered from a discharge gas refrigerant, whereby performance deterioration is avoided and high energy-saving performance is thus achieved.

Solution to Problem

[0006] A refrigeration cycle apparatus according to an

embodiment of the present invention includes a refrigeration cycle including a compressor, a multi-path condenser including a condenser body having a plurality of refrigerant paths, a pressure-reducing unit, and an evaporator, the refrigeration cycle allowing a refrigerant to circulate therethrough; a heat exchanger configured to recover heat from the refrigerant discharged from the compressor to heat a heat-exchange object, and an evenly distributing unit configured to evenly distribute the refrigerant among the plurality of refrigerant paths provided in the condenser body. Advantageous Effects of Invention

[0007] According to the embodiment of the present invention, performance deterioration can be avoided, and a high energy-saving effect can be produced.

Brief Description of Drawings

[0008]

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

[Fig. 2] Fig. 2 is a diagram illustrating a distributor of a condenser included in the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a diagram illustrating a configuration in which a first evenly distributing unit is provided to the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a diagram illustrating a configuration in which a sixth evenly distributing unit is provided to the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 5] Fig. 5 is a table summarizing operations of switching valves illustrated in Fig. 4, on the basis of the relationship between the temperature of water flowing into a waste-heat heat exchanger illustrated in Fig. 4 and the condensing temperature.

[Fig. 6] Fig. 6 is a diagram illustrating a configuration of another exemplary distributor of the condenser included in the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 7] Fig. 7 is a diagram illustrating a configuration of a refrigeration cycle apparatus according to Embodiment 2 of the present invention.

Description of Embodiments

Embodiment 1

[0009] Embodiment 1 of the present invention will first be described. According to Embodiment 1, a refrigerant pipe that transports to a condenser a high-temperature, high-pressure discharge gas refrigerant discharged from a compressor included in a refrigeration cycle apparatus is provided at a halfway position thereof with a waste-heat heat exchanger that utilizes heat of the discharge

gas refrigerant. Water for making hot water to be stored in a water storage tank is made to circulate through the waste-heat heat exchanger, where heat is exchanged between the waste-heat gas refrigerant and the water.

[0010] Furthermore, according to Embodiment 1 in which the water warmed by the waste-heat heat exchanger is introduced into the water storage tank and is heated therein, if the temperature of the water in the water storage tank is below a preset temperature, the water in the water storage tank is further heated with an electric heater provided in the water storage tank. Thus, the temperature of the water is raised to the preset level. Hence, the amount of heat generated by the heater can be made far smaller than in a case where no waste heat is utilized, producing a great energy-saving effect. Moreover, the capacity of the electric heater can also be reduced, leading to a possible cost reduction.

[0011] Furthermore, in the above configuration, since the waste-heat heat exchanger cools the discharge gas refrigerant with water, the condensing temperature is lowered. Hence, the compression ratio is lowered. Accordingly, the input to the compressor is reduced. Therefore, an effect of saving energy of the refrigerator itself can be produced. If the condenser is of an air-cooled type, cooling by the waste-heat heat exchanger lowers the condensing temperature. Therefore, the rotation speed of an air-sending device provided for the condenser can be reduced. Consequently, while an energy-saving effect is produced, the noise of operation of the air-sending device can be reduced. Hence, the system according to Embodiment 1 is effective especially if employed for use in a store such as a convenience store located in a dense residential area.

[0012] Now, preferable embodiments of the refrigeration apparatus according to the present invention will be described with reference to the drawings. In Fig. 1 and other drawings to be referred to below, like reference numerals denote like or corresponding elements, which applies to the entire description of this specification. Furthermore, the forms of individual elements described herein are only exemplary, and such elements are not limited thereto.

[0013] Fig. 1 is a diagram illustrating a configuration of a refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[0014] The refrigeration cycle apparatus according to Embodiment 1 includes a refrigerator 100, and a water heater 101 provided as a hot-water-supply system separately from the refrigerator 100 and that supplies hot water to a sink cabinet or any other like equipment.

[0015] The refrigerator 100 illustrated in Fig. 1 includes a compressor 1 and a condenser 2 that are provided therein, and an expansion valve 3 as a pressure-reducing unit and an evaporator 4 that are provided in a showcase 102 installed in a store such as a convenience store. The refrigerator 100 and the showcase 102 are connected to each other by a refrigerant pipe 11, whereby a refrigeration cycle in which a refrigerant circulates

through the compressor 1, the condenser 2, the expansion valve 3, and the evaporator 4 is provided. Furthermore, a waste-heat heat exchanger 5 is provided between the compressor 1 and the condenser 2. A high-temperature, high-pressure discharge gas refrigerant discharged from the compressor 1 flows through the pipe 11 into the waste-heat heat exchanger 5 and then into the condenser 2 provided in the refrigerator 100.

[0016] On the other hand, water as a heat-exchange object is introduced from a water storage tank 6 included in the water heater 101 through a water pipe 12 into the waste-heat heat exchanger 5. The water pipe 12 is provided with a water-circulating pump 7. The water pipe 12 forms a circuit through which the water in the water storage tank 6 is made to flow into the waste-heat heat exchanger 5 and is then returned to the water storage tank 6. The water introduced into the waste-heat heat exchanger 5 exchanges heat with the discharge gas refrigerant introduced into the waste-heat heat exchanger 5 through the refrigerant pipe 11 and is then returned into the water storage tank 6.

[0017] In Embodiment 1, a water supply pipe (not illustrated) is connected to a portion of the water pipe 12 that is on the suction side of the water-circulating pump 7. Water from a faucet is supplied into the water pipe 12 through the water supply pipe. The water storage tank 6 is provided therein with an electric heater 8 that heats the water in the water storage tank 6 (as a matter of convenience, water including heated hot water is hereinafter referred to as water). A control unit 110, to be described below, controls the electric heater 8 to heat the water in the water storage tank 6 if the hot water to be supplied has a temperature lower than or equal to a preset temperature.

[0018] The condenser 2 is a multi-path heat exchanger having a plurality of refrigerant paths. The condenser 2 includes a condenser body 21, and a distributor 22 provided on the refrigerant-inlet side of the condenser body 21. The distributor 22 distributes the refrigerant among the refrigerant paths.

[0019] Fig. 2 is a diagram illustrating the distributor of the condenser included in the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[0020] The distributor 22 is a header and includes a main pipe 22a, an inlet pipe 22b having one end thereof connected to the main pipe 22a, and a plurality of branch pipes 22c each having one end thereof connected to the main pipe 22a and the other end thereof connected to a corresponding one of the refrigerant paths provided in the condenser body 21.

[0021] In the refrigeration cycle apparatus configured as described above, the high-temperature, high-pressure discharge gas refrigerant compressed by the compressor 1 is introduced into the waste-heat heat exchanger 5 through the refrigerant pipe 11, and waste heat thereof is utilized. The discharge gas refrigerant introduced into the waste-heat heat exchanger 5 exchanges heat

with the water that is introduced into the waste-heat heat exchanger 5 from the water storage tank 6 of the water heater 101 by the water-circulating pump 7, whereby the refrigerant is cooled. Meanwhile, the water that has flowed into the waste-heat heat exchanger 5 is heated as a result of heat exchange with the discharge gas refrigerant. The heated water returns to the water storage tank 6 through the water pipe 12.

[0022] The hot water made in Embodiment 1 can be used not only for hot-water supply but also for other purposes such as floor heating and road heating. Hence, the heat-exchange object is not limited to water and may alternatively be any fluid such as brine, an HFC-based refrigerant, an HFO-based refrigerant, an HC-based refrigerant, CO₂, ammonia, or air.

[0023] The refrigeration cycle apparatus further includes a control unit 110 that controls the entirety of the refrigeration cycle apparatus. The control unit 110 is, for example, a microcomputer or any other like device that includes a control-and-arithmetic-processing unit such as a CPU. The control unit 110 further includes a storage unit (not illustrated) in which data in the form of programs indicating processing procedures concerning control operations and other like operations are stored. The control-and-arithmetic-processing unit performs such processing operations based on the program data and implements corresponding control operations.

[0024] In Embodiment 1, waste heat from the discharge gas refrigerant discharged from the compressor 1 is utilized to heat the water in the water storage tank 6. Therefore, the amount of heat exchange in the condenser 2 can be reduced, and the condensing temperature can be lowered, that is, the compression ratio can be lowered, whereby the input to the compressor 1 can be reduced. Thus, according to Embodiment 1, the amount of power consumption is reduced by reducing the operating compression ratio of the refrigerator 100, whereby an energy-saving effect is produced.

[0025] In general, the rotation speed of an air-sending device 9 provided for the condenser 2 is controlled on the basis of the high-side pressure or the condensing temperature. In Embodiment 1, the refrigerant flowing into the condenser 2 is already cooled in the waste-heat heat exchanger 5 by the water from the water storage tank 6 and therefore has a low temperature. Hence, the amount of heat exchange in the condenser 2 is reduced. Consequently, the rotation speed of the air-sending device 9 when waste-heat is utilized in accordance with Embodiment 1 can be controlled to be reduced in correspondence with the reduction in the amount of heat exchange.

[0026] As described above, according to Embodiment 1, the use of the condenser 2, which is of an air-cooled type, can reduce the noise generated while the air-sending device 9 is operated. Hence, if the condenser 2 is employed in a store such as a convenience store located in a dense residential area or any other like area, a system configured with special consideration for environment is

provided.

[0027] In a condenser 2 of a typical refrigerator 100, however, if a refrigerant at the inlet of the condenser 2, that is, a refrigerant flowing into a distributor 22, undergoes waste-heat recovery and is thus condensed into a state of two-phase gas-liquid, the liquid component of the refrigerant cannot be distributed evenly among the refrigerant paths of the condenser body 21, leading to a possible deterioration in the performance of the refrigerator 100. Hence, the refrigeration cycle apparatus according to Embodiment 1 includes an evenly distributing unit that always evenly distributes the refrigerant among the refrigerant paths of the condenser body 21, even if heat is recovered from the discharge gas refrigerant. Thus, performance deterioration is assuredly avoided. Now, eight specific configurations of the evenly distributing unit will be described. Evenly distributing units are roughly categorized into two types: a single-phase gas distribution type in which the refrigerant is evenly distributed by controlling the refrigerant to be in a state of single-phase gas (that is, the refrigerant is prevented from falling into a state of two-phase gas-liquid) at the inlet of the condenser 2 (the outlet of the waste-heat heat exchanger 5); and a two-phase gas-liquid distribution type in which the refrigerant is evenly distributed even if the refrigerant at the inlet of the condenser 2 (the outlet of the waste-heat heat exchanger 5) is in a state of two-phase gas-liquid.

[Single-Phase Gas Distribution Type]

[0028] There are six kinds of evenly distributing units of the single-phase gas distribution type, which will be described sequentially.

(First Evenly Distributing Unit)

[0029] A first evenly distributing unit is a gas-liquid separator 13, which will now be described in detail.

[0030] Fig. 3 is a diagram illustrating a configuration in which the first evenly distributing unit is provided to the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[0031] The gas-liquid separator 13 is provided at the inlet of the condenser 2 and separates a two-phase gas-liquid refrigerant discharged from the waste-heat heat exchanger 5 into a liquid refrigerant and a gas refrigerant. Hence, even if the refrigerant at the inlet of the condenser 2 is two-phase gas-liquid, the two-phase gas-liquid refrigerant is made to flow through the gas-liquid separator 13 before flowing into the distributor 22. Thus, a single-phase gas refrigerant can be made to flow into the distributor 22 of the condenser 2. Hence, as in known cases, a header can be employed as the distributor 22 so that the refrigerant is evenly distributed among the refrigerant paths of the condenser body 21. The liquid refrigerant obtained through the separation by the gas-liquid separator 13 flows through a pipe 13a and is merged with the

liquid refrigerant at the outlet of the condenser 2.

(Second Evenly Distributing Unit)

[0032] A second evenly distributing unit is a unit that controls the capacity of the compressor 1 such that the refrigerant at the outlet of the waste-heat heat exchanger 5 is in a state of single-phase gas. The second evenly distributing unit will now be described in detail.

[0033] If the degree of superheat of the refrigerant at the outlet of the waste-heat heat exchanger 5 is low, the control unit 110 increases the rotation speed of the compressor and thus raises the degree of superheat, thereby controlling the refrigerant at the outlet of the waste-heat heat exchanger 5 to be in a state of single-phase gas. The control unit 110 may control the degree of superheat of the refrigerant at the outlet of the waste-heat heat exchanger 5 by directly detecting the degree of superheat. Note that the input to the compressor 1 is substantially equal to the amount of sensible heat of the discharge gas refrigerant (the amount of heat exchange that is required for changing the discharge gas refrigerant into a saturated gas by cooling). Therefore, the control unit 110 may control the amount of heat exchange in the waste-heat heat exchanger 5 to be lower than or equal to the input to the compressor.

(Third Evenly Distributing Unit)

[0034] A third evenly distributing unit is a waste-heat heat exchanger 5 whose size is adjusted such that the refrigerant in the waste-heat heat exchanger 5 is not condensed while the refrigeration cycle apparatus is in operation. The third evenly distributing unit will now be described in detail.

[0035] The refrigeration cycle apparatus according to Embodiment 1 is operated all year round. Hence, depending on environmental conditions, there are variations in the cooling load of the refrigerator 100 and in the temperature of hot water supplied to the water heater 101. Therefore, under an environmental condition where the refrigerant is most likely to be condensed in the waste-heat heat exchanger 5, for example, in the operation in winter, the size of the waste-heat heat exchanger 5 may be determined such that the refrigerant is not condensed under that condition. Thus, the waste-heat heat exchanger 5 has such a size that the refrigerant is not condensed all year round. In the operation in winter, which is taken herein as an example, since the refrigeration cycle apparatus is operated in an environment at a low outside temperature, the cooling load of the refrigerator 100 is small and the temperature of the water is low. Therefore, in Embodiment 1, the operation in winter is regarded as a condition under which the refrigerant is most likely to be condensed in the waste-heat heat exchanger 5.

[0036] If the size of the waste-heat heat exchanger 5 is adjusted as described above such that the refrigerant is not condensed therein, the refrigerant flowing into the

condenser 2 can always be kept in a state of single-phase gas while the refrigeration cycle apparatus is in operation.

(Fourth Evenly Distributing Unit)

[0037] A fourth evenly distributing unit is a unit that controls the flow rate of the water flowing into the waste-heat heat exchanger 5 such that the refrigerant is not condensed in the waste-heat heat exchanger 5. The fourth evenly distributing unit will now be described in detail.

[0038] If the degree of superheat of the refrigerant at the outlet of the waste-heat heat exchanger 5 is low, the control unit 110 reduces the flow rate of the water by controlling the water-circulating pump 7 and thus reduces the amount of heat exchange in the waste-heat heat exchanger 5, thereby raising the degree of superheat of the refrigerant at the outlet of the waste-heat heat exchanger 5. Since the degree of superheat of the refrigerant at the outlet of the waste-heat heat exchanger 5 is raised, the refrigerant at the outlet of the waste-heat heat exchanger 5 turns into a single-phase gas refrigerant. The control unit 110 may control the degree of superheat of the refrigerant at the outlet of the waste-heat heat exchanger 5 by directly detecting the degree of superheat, as in the case of controlling the capacity of the compressor 1 (by the second evenly distributing unit). Note that the input to the compressor 1 is substantially equal to the amount of sensible heat of the discharge gas refrigerant (the amount of heat exchange that is required for changing the discharge gas refrigerant into a saturated gas by cooling). Therefore, the control unit 110 may control the amount of heat exchange in the waste-heat heat exchanger 5 to be lower than or equal to the input to the compressor 1. To control the flow rate of the water, the capacity of the water-circulating pump 7 may be controlled, as described above. Alternatively, the resistance of the water flow path may be controlled.

(Fifth Evenly Distributing Unit)

[0039] A fifth evenly distributing unit is a heating unit that heats the water flowing into the waste-heat heat exchanger 5 to a temperature higher than or equal to the condensing temperature of the refrigerant in the refrigerator 100 so that the refrigerant is not condensed in the waste-heat heat exchanger 5. The fifth evenly distributing unit will now be described in detail.

[0040] If the temperature of the water flowing into the waste-heat heat exchanger 5 is made higher than or equal to the condensing temperature of the refrigerant, the refrigerant to be cooled is not condensed. To make the temperature of the water higher than or equal to the condensing temperature, the water may be heated in advance by the electric heater 8 provided in the water heater 101 or by a separate heat source.

(Sixth Evenly Distributing Unit)

[0041] A sixth evenly distributing unit allows only a portion of the discharge gas refrigerant to flow into the waste-heat heat exchanger 5 and to exchange heat with water if the temperature of the water flowing into the waste-heat heat exchanger 5 is below the condensing temperature of the refrigerant. In contrast, if the temperature of the water flowing into the waste-heat heat exchanger 5 is higher than or equal to the condensing temperature of the refrigerant, the sixth evenly distributing unit allows all portions of the discharge gas refrigerant to flow into the waste-heat heat exchanger 5 and to exchange heat with the water. The sixth evenly distributing unit will now be described in detail.

[0042] If the temperature of the water is lower than the condensing temperature of the discharge gas refrigerant and heat is exchanged between the water having such a temperature and the discharge gas refrigerant in the waste-heat heat exchanger 5, the temperature of the discharge gas refrigerant drops to a level lower than the condensing temperature and the refrigerant is condensed. Consequently, a two-phase refrigerant may flow into the condenser 2. That is, if all portions of the discharge gas refrigerant is made to flow into the condenser 2 through the waste-heat heat exchanger 5 with the temperature of the water being lower than the condensing temperature of the refrigerant, a two-phase refrigerant may flow into the condenser 2. Hence, only a portion of the discharge gas refrigerant is allowed to flow into the waste-heat heat exchanger 5 and is condensed therein. Then, the refrigerant is merged at the outlet of the condenser 2. Thus, the other portion of the discharge gas refrigerant is not allowed to flow into the waste-heat heat exchanger 5 but directly flows into the condenser 2. Since the refrigerant flowing into the condenser 2 is a gas refrigerant, the refrigerant can be evenly distributed by the distributor 22.

[0043] On the other hand, if the temperature of the water is higher than or equal to the condensing temperature of the refrigerant and heat is exchanged with the water having a temperature higher than or equal to the condensing temperature of the refrigerant, the temperature of the refrigerant does not become lower than the condensing temperature of the refrigerant and the refrigerant is therefore not condensed. Hence, if the temperature of the water is higher than or equal to the condensing temperature of the refrigerant, all portions of the discharge gas refrigerant is allowed to flow into the waste-heat heat exchanger 5, to exchange heat with the water therein, and then to flow into the condenser 2. A specific configuration will now be described.

[0044] Fig. 4 is a diagram illustrating a configuration in which the sixth evenly distributing unit is provided to the refrigeration cycle apparatus according to Embodiment 1 of the present invention. Fig. 5 is a table summarizing operations of switching valves illustrated in Fig. 4, on the basis of the relationship between the temperature of the

water flowing into a waste-heat heat exchanger illustrated in Fig. 4 and the condensing temperature.

[0045] In the configuration illustrated in Fig. 1, all of the discharge gas refrigerant discharged from the compressor 1 flows through the waste-heat heat exchanger 5 without fail. In the configuration illustrated in Fig. 4, a portion or all of the discharge gas refrigerant is selectively allowed to flow through the waste-heat heat exchanger 5.

[0046] The sixth evenly distributing unit includes a bypass 30 that connects the inlet and the outlet of the condenser 2 to each other. The bypass 30 is provided with the waste-heat heat exchanger 5. The sixth evenly distributing unit includes another bypass 31 that connects the outlet of the waste-heat heat exchanger 5 and the inlet of the condenser 2 to each other. The sixth evenly distributing unit further includes a switching valve 30a that opens and closes the bypass 30, a switching valve 31a that opens and closes the bypass 31, and a switching valve 32 provided to the main circuit between the compressor 1 and the condenser 2 and on the downstream side of a point from which the bypass 30 branches off.

[0047] If the temperature of the water flowing into the waste-heat heat exchanger 5 is lower than the condensing temperature of the refrigerant, the switching valve 30a and the switching valve 32 are opened while the switching valve 31a is closed as summarized in Fig. 5. Hence, a path that allows the refrigerant discharged from the compressor 1 to directly flow toward the condenser 2 and a path that allows the refrigerant discharged from the compressor 1 to flow through the waste-heat heat exchanger 5 and then toward the outlet of the condenser 2 along the bypass 30 are provided. Thus, a portion of the discharge gas refrigerant discharged from the compressor 1 flows into the waste-heat heat exchanger 5, heats the water with heat of condensation (waste heat generated from the discharge gas refrigerant), and is discharged from the waste-heat heat exchanger 5. Meanwhile, the rest of the discharge gas refrigerant remains in the state of single-phase gas and flows into the condenser 2. Hence, the refrigerant flowing into the condenser 2 is evenly distributed by the distributor 22 and flows through the refrigerant paths provided in the condenser body 21. The refrigerant having flowed through the refrigerant paths provided in the condenser body 21 is merged with the refrigerant that has flowed through the waste-heat heat exchanger 5.

[0048] In the case where a portion of the discharge gas refrigerant is allowed to flow into the waste-heat heat exchanger 5 and to heat the water with the heat of condensation thereof, if the flow rate of the bypass 30 is adjusted and the refrigerant is assuredly subcooled in the waste-heat heat exchanger 5, the refrigerant obtained after the merger at the outlet of the condenser 2 is also assuredly subcooled. If the liquid refrigerant cannot be subcooled, the refrigerant turns into a state of two-phase gas-liquid at the inlet of the expansion valve 3, leading to problems such as the following: the flow rate is reduced and the refrigeration capacity is therefore low-

ered, hunting occurs and the operation becomes unstable, and noise increases. Therefore, the refrigerant at the outlet of the condenser 2 needs to be assuredly sub-cooled. To control the flow rate in the bypass 30, a flow control valve may be provided to the bypass 30, and the opening degree of the flow control valve may be controlled by the control unit 110.

[0049] If the temperature of the water is higher than or equal to the condensing temperature of the refrigerant, the switching valve 30a and the switching valve 32 are closed while the switching valve 31 a is opened as summarized in Fig. 5. In this case, the path provided in Embodiment 1 is provided. Hence, all of the discharge gas refrigerant discharged from the compressor 1 flows into the waste-heat heat exchanger 5 and heats the water with waste heat generated from the discharge gas refrigerant. Although the water is heated by undergoing heat exchange with the discharge gas refrigerant, the refrigerant is not condensed because the temperature of the water is higher than or equal to the condensing temperature. Hence, single-phase gas refrigerant flows into the condenser 2, and the distributor 22 of the condenser 2 can evenly distribute the refrigerant among the refrigerant paths provided in the condenser body 21.

[Two-Phase Gas-Liquid Distribution Type]

[0050] There are three kinds of evenly distributing units of the two-phase gas-liquid distribution type, which will be described sequentially.

(Seventh Evenly Distributing Unit)

[0051] A seventh evenly distributing unit includes an inlet pipe 22b whose diameter is set such that, if the refrigerant discharged from the waste-heat heat exchanger 5 is in a state of two-phase gas-liquid, the refrigerant is distributed in a flow pattern of an annular flow or an annular dispersed flow. The seventh evenly distributing unit will now be described in detail.

[0052] Even if the refrigerant on the upstream side of the inlet of the condenser 2 is in a state of two-phase gas-liquid, the liquid refrigerant can be distributed evenly by setting the flow pattern of the refrigerant in the inlet pipe 22b of the distributor 22 to an annular flow or an annular dispersed flow. The flow pattern is basically determined by the quality of the refrigerant and the flow speed of the refrigerant at the inlet of the distributor 22. Hence, the amount of heat exchange in the waste-heat heat exchanger 5 and the diameter of the pipe at the inlet of the distributor 22 are adjusted to provide such a quality and such a flow speed of the refrigerant that the refrigerant flowing through the inlet pipe 22b forms a flow pattern of an annular flow or an annular dispersed flow. In general, if the flow speed of the refrigerant is increased (if the diameter of the inlet pipe 22b of the distributor 22 is reduced), an annular flow or an annular dispersed flow is obtained. Furthermore, which of the annular flow and

the annular dispersed flow is obtained is determined by the quality. Specifically, as the quality is increased, that is, as the amount of heat exchange by the waste-heat heat exchanger 5 is reduced, the flow pattern changes from an annular flow to an annular dispersed flow.

[0053] If the refrigerant flowing through the inlet pipe 22b can be assuredly made to form an annular dispersed flow, which is a homogeneous flow, by the setting of the diameter of the inlet pipe 22b, the distributor 22 may be a header as illustrated in Fig. 2. However, if there is a chance that the refrigerant flowing through the inlet pipe 22b may form an annular flow, a distributor illustrated in Fig. 6 is preferably employed as the distributor 22.

[0054] Fig. 6 a diagram illustrating a configuration of another exemplary distributor of the condenser included in the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[0055] The distributor 22 illustrated in Fig. 2 includes the plurality of branch pipes 22c connected to the side face of the main pipe 22a. The distributor 22 illustrated in Fig. 6 includes an inlet pipe 22b having one end thereof connected to a refrigerant-inlet-side end of a main pipe 22a, and a plurality of branch pipes 22c each having one end thereof connected to the refrigerant-outlet side of the main pipe 22a and the other end thereof connected to a corresponding one of the plurality of refrigerant paths provided in the condenser body 21. The distributor 22 has a refrigerant inlet (distribution port) leading to the branch pipes 22c. The refrigerant inlet is provided at a liquid-film-generated part 23 of the main pipe 22a. The diameter of the inlet pipe 22b is set such that the refrigerant flowing through the inlet pipe 22b forms a flow pattern of at least an annular flow.

[0056] If there is a possibility that the refrigerant flowing through the inlet pipe 22b forms an annular flow, the assuredness of achieving even distribution can be increased by employing the distributor 22 illustrated in Fig. 6. Furthermore, to reduce the unevenness in the distribution due to gravity, it is more effective to orient the distributor 22 such that the branch pipes 22c of the distributor 22 illustrated in Fig. 6 extend vertically.

(Eighth Evenly Distributing Unit)

[0057] In an eighth evenly distributing unit, the distributor 22 of the condenser 2 has two branch pipes 22c, whereby only two distribution lines leading to the condenser body 21 are provided. The eighth evenly distributing unit will now be described in detail.

[0058] As the number of refrigerant branches leading to the condenser 2 increases, the difficulty in achieving even distribution increases. Hence, the number of refrigerant paths provided in the condenser 2 is set to two, that is, only two distribution lines leading to the condenser body 21 are provided. Thus, compared to a case where a more number of branches are provided, the refrigerant can be distributed more evenly to the individual refrigerant paths. In such a case where only two distribution lines

are provided, setting the flow pattern of the refrigerant to an annular flow or an annular dispersed flow or employing an orientation that is not influenced by gravity is more effective for even distribution.

(Advantageous Effects Common to Seventh and Eighth Evenly Distributing Units)

[0059] In the known configuration where the refrigerant at the inlet of the condenser 2 cannot be distributed evenly if the refrigerant is in a state of two-phase gas-liquid, the amount of heat exchange by the waste-heat heat exchanger 5 needs to be limited so that the refrigerant at the inlet of the condenser 2 does not fall into a state of two-phase gas-liquid. However, with the seventh or eighth evenly distributing unit, even if the refrigerant at the inlet of the condenser 2 turns into a state of two-phase gas-liquid, the refrigerant can be distributed evenly by the condenser 2 as described above. Hence, the limitation on the amount of heat exchange in the waste-heat heat exchanger 5 is not necessary, and the amount of heat exchange can be increased significantly by increasing the area of the waste-heat heat exchanger 5. Consequently, the amount of waste heat recovered from the discharge gas refrigerant by the waste-heat heat exchanger 5 can be increased, and the time required for boiling the water can be reduced significantly, allowing the use of a large amount of hot water.

[0060] As described above, Embodiment 1 employs an evenly distributing unit that evens out the refrigerant distribution among the refrigerant paths of the condenser 2 even if waste heat is recovered from the discharge gas refrigerant that is discharged from the compressor 1. Therefore, the deterioration in the performance of the refrigerator 100 can be assuredly avoided. Furthermore, since the waste heat recovered from the discharge gas refrigerant can be efficiently utilized, high energy-saving performance can be provided all year round.

Embodiment 2

[0061] Fig. 7 is a diagram illustrating a configuration of a refrigeration cycle apparatus according to Embodiment 2 of the present invention. Embodiment 2 will now be described, focusing on differences from Embodiment 1.

[0062] While Embodiment 1 concerns a configuration in which the distributor 22 is provided on the downstream side of the waste-heat heat exchanger 5, Embodiment 2 concerns a configuration in which the distributor 22 is provided on the upstream side of the waste-heat heat exchanger 5, that is, between the waste-heat heat exchanger 5 and the compressor 1. In Embodiment 2, the distributor 22 corresponds to the evenly distributing unit and distributes the refrigerant on the upstream side of the waste-heat heat exchanger 5. The distributor 22 is the header illustrated in Fig. 2.

[0063] In the above configuration, the refrigerant flowing into the distributor 22 turns into a state of single-phase

gas without fail. Hence, there is no chance that the refrigerant that is in a state of two-phase gas-liquid is distributed, and the refrigerant can assuredly be distributed evenly by the header used as the distributor 22.

[0064] Furthermore, to increase the efficiency in the recovery of waste heat, the waste-heat heat exchanger 5 allows all portions of the refrigerant distributed by the distributor 22 to flow through the waste-heat heat exchanger 5 and to exchange heat with a heat-exchange object so that waste heat can be recovered from each of all portions of the refrigerant distributed by the distributor 22. For example, the waste-heat heat exchanger 5 is provided in the form of a shell-and-tube heat exchanger that includes a shell-type flow path through which water as a heat-exchange object flows, and pipes inserted into the shell-type flow path and through which distributed portions of the refrigerant flow, respectively. Alternatively, the waste-heat heat exchanger 5 may be configured such that pipes through which distributed portions of the refrigerant flow, respectively, and pipes through each of which water flows are in contact with each other for heat exchange. In such a configuration, highly efficient heat exchange can be achieved with a compact waste-heat heat exchanger 5 even if the waste-heat heat exchanger 5 is configured such that water exchanges heat with all of the distributed portions of the refrigerant.

[0065] As described above, Embodiment 2 produces not only the advantageous effect produced in Embodiment 1 but also the advantageous effects produced in the case of single-phase distribution (assuredly even) and in the case of two-phase distribution (no limitations on the amount of waste heat exchanged).

[0066] In the refrigerator 100 according to Embodiment 1 or Embodiment 2, the discharge gas refrigerant discharged from the compressor 1 needs to have a high temperature. Refrigerants such as an HFC-based refrigerant, an HFO-based refrigerant, an HC-based refrigerant, and natural refrigerants such as CO₂ and ammonia can all have high temperatures and are therefore suitable for waste-heat utilization.

Industrial Applicability

[0067] The present invention is especially effective when employed in stores (convenience stores or supermarkets) in which refrigeration apparatuses, hot-water-supplying apparatuses, and hot-water-utilization apparatuses are installed. Particularly, since there are so many convenience stores, the effect of CO₂ reduction through energy conservation realized by employing the present invention in such stores is tremendous. Therefore, the present invention is extremely valuable in making environmental improvements.

Reference Signs List

[0068]

1 compressor 2 condenser 3 expansion valve 4 evaporator 5 waste-heat heat exchanger (heat exchanger) 6 water storage tank 7 water-circulating pump 8 electric heater 9 air-sending device 11 refrigerant pipe 12 water pipe 13 gas-liquid separator 13a pipe 21 condenser body 22 distributor 22a main pipe 22b inlet pipe 22c branch pipe 23 liquid-film-generated part 30 bypass (first bypass) 30a switching valve 31 bypass (second bypass) 31 a switching valve 32 switching valve 60 plate-stacking heat exchanger 70 shell-and-tube heat exchanger 100 refrigerator 101 water heater 102 showcase 110 control unit

Claims

1. A refrigeration cycle apparatus comprising:

a refrigeration cycle including a compressor, a multi-path condenser including a condenser body having a plurality of refrigerant paths, a pressure-reducing unit, and an evaporator, the refrigeration cycle allowing a refrigerant to circulate therethrough;

a heat exchanger configured to recover heat from the refrigerant discharged from the compressor to heat a heat-exchange object, and an evenly distributing unit configured to evenly distribute the refrigerant among the plurality of refrigerant paths provided in the condenser body.

2. The refrigeration cycle apparatus of claim 1, wherein the condenser includes a header provided on a refrigerant-inlet side of the condenser body, and the evenly distributing unit is a gas-liquid separator provided between the header and the heat exchanger.

3. The refrigeration cycle apparatus of claim 1, wherein the evenly distributing unit is configured such that the refrigerant is not condensed in the heat exchanger.

4. The refrigeration cycle apparatus of claim 3, wherein the evenly distributing unit is configured to control a capacity of the compressor such that the refrigerant at an outlet of the heat exchanger is in a state of single-phase gas.

5. The refrigeration cycle apparatus of claim 3, wherein the evenly distributing unit is the heat exchanger whose size is adjusted such that the refrigerant flowed into the heat exchanger is not condensed while the refrigeration cycle apparatus is in operation.

6. The refrigeration cycle apparatus of claim 3, wherein the evenly distributing unit is configured to control a flow rate of the heat-exchange object such that the refrigerant is not condensed in the heat exchanger.

7. The refrigeration cycle apparatus of claim 3, wherein the evenly distributing unit is a heating unit configured to heat the heat-exchange object flowing through the heat exchanger to a temperature higher than or equal to a condensing temperature of the condenser.

8. The refrigeration cycle apparatus of claim 1, wherein the evenly distributing unit includes

a first bypass that bypasses the condenser and is provided with the heat exchanger, and a second bypass that connects a refrigerant outlet of the heat exchanger provided at the first bypass and a refrigerant inlet of the condenser provided to the refrigeration cycle to each other,

the evenly distributing unit is configured to, when the heat-exchange object has a temperature lower than the condensing temperature of the refrigerant, allow a portion of the refrigerant discharged from the compressor and flowing toward the condenser to flow through the heat exchanger via the first bypass, and when the heat-exchange object has a temperature higher than or equal to the condensing temperature of the refrigerant, allow the refrigerant discharged from the compressor to flow through the heat exchanger via the first bypass, and to flow into the condenser via the second bypass.

9. The refrigeration cycle apparatus of claim 8, wherein the first bypass is provided with a flow control valve configured to control a flow rate of the refrigerant that bypasses the condenser.

10. The refrigeration cycle apparatus of claim 9, wherein the flow control valve is controlled such that the refrigerant is subcooled in the heat exchanger.

11. The refrigeration cycle apparatus of claim 1, wherein the evenly distributing unit is provided between the heat exchanger and the compressor and configured to distribute the refrigerant in a state of single-phase gas that is discharged from the compressor.

12. The refrigeration cycle apparatus of claim 11, wherein the evenly distributing unit comprises a distributor including a main pipe, an inlet pipe having one end connected to the main pipe and an other end connected to the compressor, and a plurality of

branch pipes each having one end connected to the main pipe and an other end connected to the heat exchanger and to a corresponding one of the plurality of refrigerant paths provided in the condenser body, and
the heat exchanger is configured such that the portions of the refrigerant distributed by the distributor flow through the heat exchanger and exchange heat with the heat-exchange object.

13. The refrigeration cycle apparatus of claim 11 or 12, wherein the heat exchanger comprises a shell-and-tube heat exchanger.
14. The refrigeration cycle apparatus of claim 11 or 12, wherein the heat exchanger is configured such that pipes through which the portions of the refrigerant distributed by the evenly distributing unit flow and a pipe through which the heat-exchange object flows are in contact with each other for heat exchange.
15. The refrigeration cycle apparatus of claim 1, wherein, the evenly distributing unit is configured to, when the refrigerant discharged from the heat exchanger is in a state of two-phase gas-liquid, distribute the refrigerant such that a flow pattern of an annular flow or an annular dispersed flow is formed.
16. The refrigeration cycle apparatus of claim 15, wherein the evenly distributing unit includes a main pipe, an inlet pipe having one end connected to the main pipe, and a plurality of branch pipes each having one end connected to the main pipe and an other end connected to a corresponding one of the plurality of refrigerant paths provided in the condenser body, and the inlet pipe has such a diameter that the refrigerant flowing through the inlet pipe forms a flow pattern of an annular flow or an annular dispersed flow.
17. The refrigeration cycle apparatus of claim 15, wherein the evenly distributing unit comprises a distributor that includes a main pipe, an inlet pipe having one end connected to an end of the main pipe that is on a refrigerant-inlet side, and a plurality of branch pipes each having one end connected to an end of the main pipe that is on a refrigerant-outlet side and an other end connected to a corresponding one of the plurality of refrigerant paths provided in the condenser body, and
the inlet pipe has such a diameter that the refrigerant flowing through the inlet pipe forms a flow pattern of an annular flow.
18. The refrigeration cycle apparatus of claim 1 or 2, wherein the plurality of refrigerant paths include two refrigerant paths, and the evenly distributing unit divides the refrigerant discharged from the compres-

sor into two portions.

19. The refrigeration cycle apparatus of any one of claims 1 to 18, wherein the refrigerant is any of an HFC-based refrigerant, an HFO-based refrigerant, an HC-based refrigerant, CO₂, and ammonia.
20. The refrigeration cycle apparatus of any one of claims 1 to 19, wherein the heat exchange object is any of water, brine, an HFC-based refrigerant, an HFO-based refrigerant, an HC-based refrigerant, CO₂, ammonia, and air.

FIG. 1

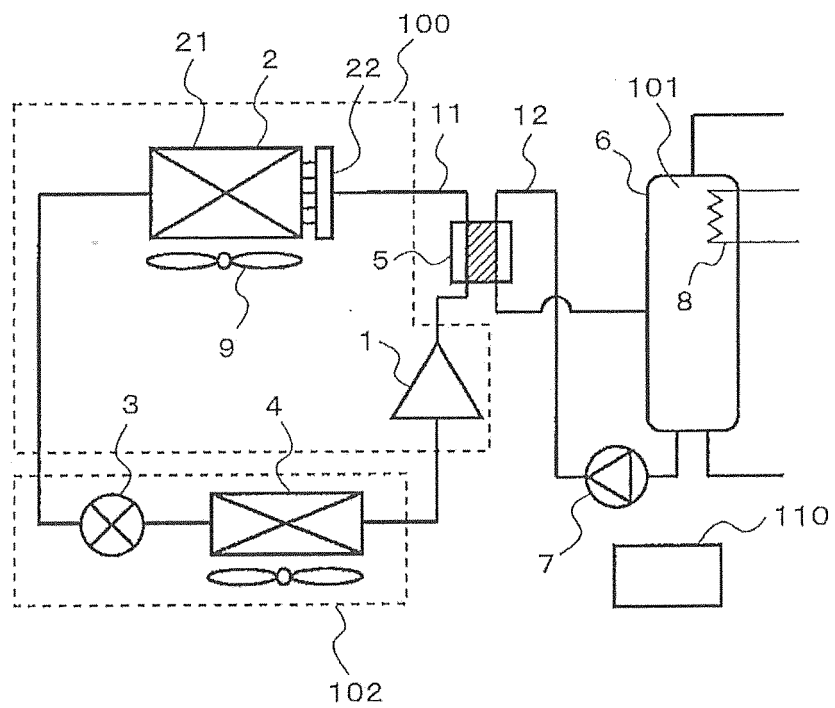


FIG. 2

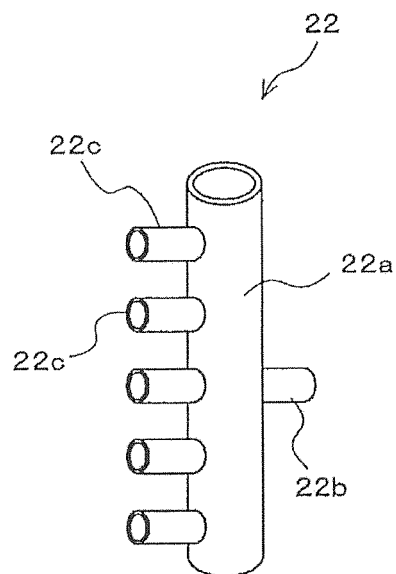


FIG. 3

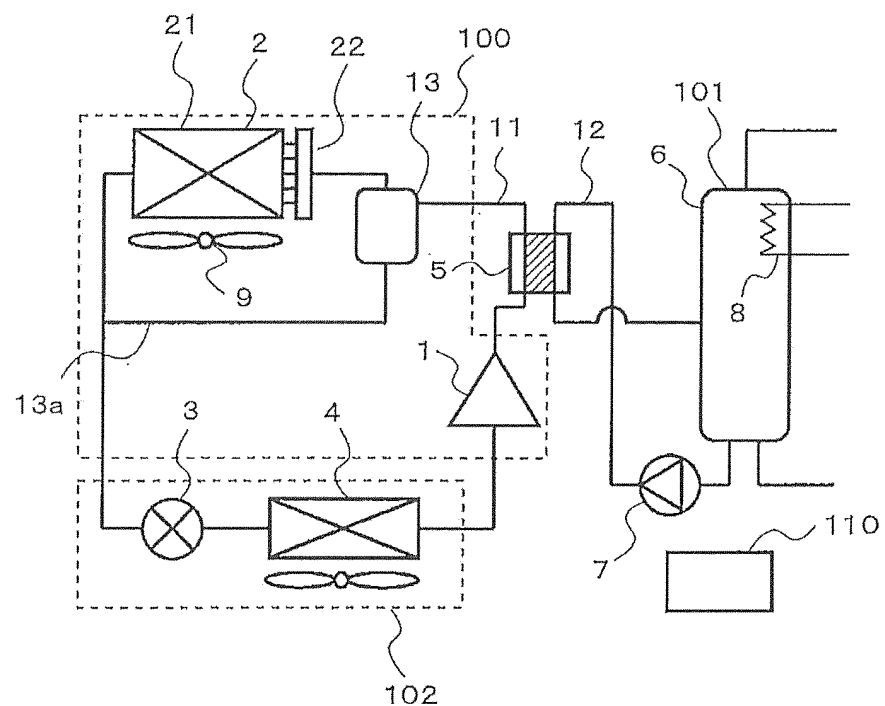


FIG. 4

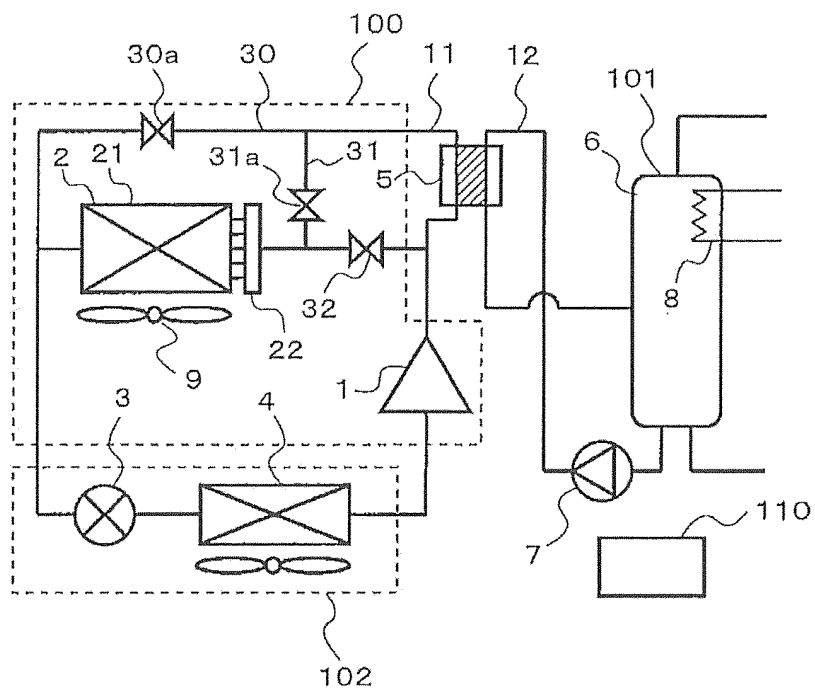


FIG. 5

WATER TEMPERATURE < CONDENSING TEMPERATURE	SWITCHING VALVE 30a	OPEN
	SWITCHING VALVE 31a	CLOSED
	SWITCHING VALVE 32	OPEN
CONDENSING TEMPERATURE $\leq$ WATER TEMPERATURE	SWITCHING VALVE 30a	CLOSED
	SWITCHING VALVE 31a	OPEN
	SWITCHING VALVE 32	CLOSED

FIG. 6

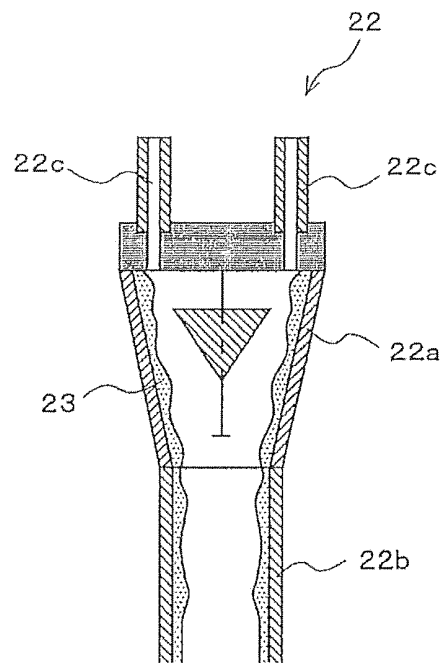
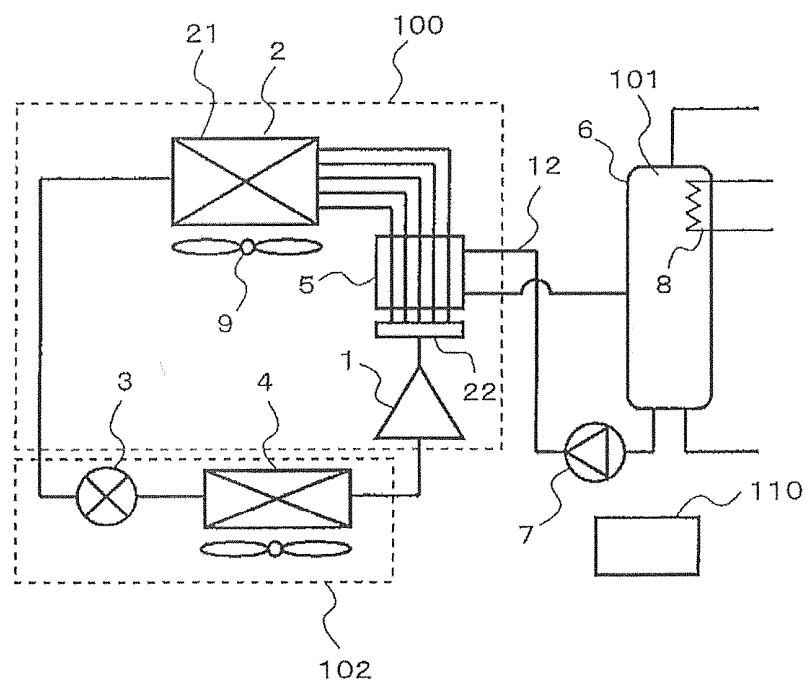


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/075066

A. CLASSIFICATION OF SUBJECT MATTER

F25B41/00(2006.01)i, F25B1/00(2006.01)i, F25B6/02(2006.01)i, F25B6/04(2006.01)i, F25B39/00(2006.01)i, F25B39/04(2006.01)i, F28F9/02(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)

F25B41/00, F25B1/00, F25B6/02, F25B6/04, F25B39/00, F25B39/04, F28F9/02

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 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2009-300021 A (Mitsubishi Electric Corp.), 24 December 2009 (24.12.2009), paragraphs [0013], [0015], [0016], [0033] to [0036]; fig. 1, 2, 4 (Family: none)	1-2 3-10, 15-20
Y	JP 2013-185741 A (Rinnai Corp.), 19 September 2013 (19.09.2013), claim 2; paragraphs [0006], [0011] to [0021]; fig. 1, 2 (Family: none)	3-7, 15-20
Y	JP 2008-121982 A (Matsushita Electric Industrial Co., Ltd.), 29 May 2008 (29.05.2008), paragraphs [0001], [0012], [0018]; fig. 1, 4 (Family: none)	8-10, 15-20

☒ 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
22 December 2014 (22.12.14)

Date of mailing of the international search report
06 January 2015 (06.01.15)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/075066

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 2008-232508 A (Mitsubishi Electric Corp.), 02 October 2008 (02.10.2008), paragraph [0010]; fig. 1 & EP 1972871 A2	8-10, 18-20
X Y	JP 2011-247457 A (Hitachi Appliances, Inc.), 08 December 2011 (08.12.2011), paragraphs [0017] to [0032], [0054]; fig. 1, 2 (Family: none)	11-14 18-20
Y	JP 11-101530 A (Mitsubishi Electric Corp.), 13 April 1999 (13.04.1999), paragraph [0017]; fig. 1, 13 (Family: none)	15-20

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REFERENCES CITED IN THE DESCRIPTION

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