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(54) **REFRIGERATION APPARATUS**

KÜHLVORRICHTUNG

APPAREIL DE RÉFRIGÉRATION

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a refrigeration apparatus, and more particularly, to a refrigeration apparatus capable of performing exhaust heat recovery by hot water supply.

Description of the Related Art

[0002] Conventionally, for example, many freezing or cold storage showcases have been installed in large stores such as supermarkets, and many refrigeration apparatuses that operate these showcases by using refrigerators have been used.

[0003] For example, there is disclosed, as such a refrigeration apparatus, a conventional technique in which a water pipe is connected to an intercooler and a gas cooler in parallel, the intercooler exchanges heat between a coolant supplied to the intercooler and a refrigerant discharged from a low-stage compression mechanism, and the gas cooler exchanges heat between the coolant supplied to the gas cooler and the refrigerant discharged from a high-stage compression mechanism (e.g., refer to Japanese Patent No. 497197).

[0004] Document EP 2407734 A1 discloses a refrigeration apparatus according to the preamble of claim 1. From this document, a heat pump system is known that includes a heat pump circuit with a low stage side compressor and a high stage side compressor, an air-warming circuit, a hot-water supply circuit with a hot water supply pump, an intermediate-pressure water heat exchanger and a high-pressure water heat exchanger with a first, a second and a third high-pressure water heat exchanger for exchanging heat between the hot water circulating in the hot-water supply circuit via the first and second high-pressure water heat exchanger and the air-warming circuit via the intermediate-pressure water heat exchanger and the second high-pressure water heat exchanger. The heat pump circuit may further comprise a second intermediate-pressure water heat exchanger through which hot water supplied by the hot water supply pump flows via a hot water supply mixing valve to the first high-pressure water heat exchanger.

[0005] However, in the above conventional technique, in order to increase a hot water supply temperature, it is necessary to reduce the flow rate of water flowing through the water pipe of the intercooler and the gas cooler. Thus, the reduction in the water flow rate reduces the heat-exchange performance, insufficient heat dissipation of the refrigerant occurs in the intercooler and the gas cooler, and the refrigerant temperature at the outlet side of the gas cooler rises, which disadvantageously results in a shortage of the refrigeration capacity of the refrigeration apparatus.

[0006] The present invention has been made in view of the above point, and an object thereof is to provide a refrigeration apparatus capable of efficiently cooling a cooling apparatus without a shortage of the refrigeration capacity even when a hot water supply temperature is increased.

SUMMARY OF THE INVENTION

[0007] In order to achieve the above object, the present invention provides a refrigeration apparatus according to claim 1. This apparatus is configured to cool a refrigerant by heat exchange between the refrigerant and water, the refrigeration apparatus including: a low-stage compression mechanism; a high-stage compression mechanism; an expansion mechanism; an intercooler configured to cool the refrigerant discharged from the low-stage compression mechanism; a main gas cooler configured to cool the refrigerant discharged from the high-stage compression mechanism; an auxiliary gas cooler configured to cool the refrigerant that has passed through the main gas cooler; a water pipe constituting a flow passage of water for cooling the refrigerant, the water pipe including: a first water pipe; a first branch point where the first water pipe branches midway; a first merging point; a second water pipe connecting the first branch point and the first merging point through the auxiliary gas cooler; a third water pipe connecting the first branch point and the first merging point through the intercooler without merging with the second water pipe; a fourth water pipe connecting the first merging point and the main gas cooler; and a hot water supply pipe connecting the main gas cooler and a hot water supply destination; and a water feeding mechanism disposed in a midway part of the water pipe.

[0008] With this configuration, it is possible to reduce the outlet refrigerant temperature of the auxiliary gas cooler and the outlet refrigerant temperature of the intercooler to the vicinity of the incoming water temperature by allowing water to enter the auxiliary gas cooler and the intercooler in parallel.

[0009] According to the present invention, it is possible to reduce the outlet refrigerant temperature of the auxiliary gas cooler and the outlet refrigerant temperature of the intercooler to the vicinity of the incoming water temperature by allowing water to enter the auxiliary gas cooler and the intercooler in parallel. As a result, the main gas cooler and the auxiliary gas cooler make it possible to sufficiently cool the refrigerant even with a low water flow rate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a refrigerant circuit diagram of a refrigeration apparatus in a first embodiment of the present invention;

Fig. 2 is a block diagram showing a control configuration of the first embodiment;

Fig. 3 is a flowchart showing operation of the first embodiment; and

Fig. 4 is a refrigerant circuit diagram of a refrigeration apparatus of a second embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] A first invention provides a refrigeration apparatus configured to cool a refrigerant by heat exchange between the refrigerant and water, the refrigeration apparatus including: a low-stage compression mechanism; a high-stage compression mechanism; an expansion mechanism; an intercooler configured to cool the refrigerant discharged from the low-stage compression mechanism; a main gas cooler configured to cool the refrigerant discharged from the high-stage compression mechanism; an auxiliary gas cooler configured to cool the refrigerant that has passed through the main gas cooler; a water pipe constituting a flow passage of water for cooling the refrigerant, the water pipe including: a first water pipe; a first branch point where the first water pipe branches midway; a first merging point; a second water pipe connecting the first branch point and the first merging point through the auxiliary gas cooler; a third water pipe connecting the first branch point and the first merging point through the intercooler without merging with the second water pipe; a fourth water pipe connecting the first merging point and the main gas cooler; and a hot water supply pipe connecting the main gas cooler and a hot water supply destination; and a water feeding mechanism disposed in a midway part of the water pipe.

[0012] With this configuration, it is possible to reduce the outlet refrigerant temperature of the auxiliary gas cooler and the outlet refrigerant temperature of the intercooler to the vicinity of the incoming water temperature by allowing water to enter the auxiliary gas cooler and the intercooler in parallel. The main gas cooler and the auxiliary gas cooler make it possible to sufficiently cool the refrigerant even with a low water flow rate.

[0013] Furthermore, the refrigeration apparatus further includes: a control unit configured to control the water feeding mechanism; and an outlet-side water temperature sensor disposed on the hot water supply pipe, the outlet-side water temperature sensor being configured to detect an outlet-side water temperature of the main gas cooler, the water feeding mechanism controls a flow rate of the water pipe, and the control unit controls the water feeding mechanism on the basis of a detection value of the outlet-side water temperature sensor.

[0014] With this configuration, since the water feeding mechanism can regulate the flow rate of water flowing through the water pipe, it is possible to ensure a sufficient refrigeration capacity while performing hot water supply at a predetermined temperature.

[0015] Moreover, the refrigeration apparatus further includes: an inlet-side water temperature sensor disposed on the first water pipe, the inlet-side water temperature sensor being configured to detect a temperature of water entering the auxiliary gas cooler and the intercooler; a refrigerant temperature sensor configured to measure a temperature of the refrigerant that has passed through the auxiliary gas cooler; a drain pipe connected to the fourth water pipe; and a first flow regulating mechanism configured to regulate a flow rate of water flowing to the main gas cooler and the drain pipe, and the control unit controls the first flow regulating mechanism.

[0016] With this configuration, since unnecessary water can be discharged by using the first flow regulating mechanism, it is possible to ensure a sufficient flow rate of water flowing into the auxiliary gas cooler and the intercooler while reducing the flow rate of water flowing into the main gas cooler. This makes it possible to perform hot water supply with water heated up to the temperature of the refrigerant discharged from the high-stage compression mechanism while ensuring a sufficient refrigeration capacity.

[0017] In a second invention, the water feeding mechanism is disposed on the fourth water pipe between the first merging point and the first flow regulating mechanism.

[0018] With this configuration, since the water feeding mechanism is disposed on the fourth water pipe, exhaust heat from the water feeding mechanism can be used for hot water supply, and hot water supply can be more efficiently performed. Furthermore, water fed to the auxiliary gas cooler and the intercooler is not heated by the water feeding mechanism, and the temperature of water entering the auxiliary gas cooler and the intercooler can thus be reduced. This increases the efficiency of the compression mechanism, which makes it possible to increase the refrigeration capacity.

[0019] In a third invention, the refrigeration apparatus further includes: an external heat radiator connected to the drain pipe; a second merging point disposed on the first water pipe; and a fifth water pipe connecting the external heat radiator and the second merging point.

[0020] With this configuration, water flowing through the drain pipe can be cooled in the external heat radiator, and the cooled water is fed to the auxiliary gas cooler and the intercooler through the water pipe, which makes it possible to reuse water without discarding it and operate the refrigeration apparatus with a reduced amount of water.

[0021] In a fourth invention, the refrigeration apparatus further includes: an internal heat exchanger disposed between the auxiliary gas cooler and the expansion mechanism; a refrigerant branch point disposed downstream of the internal heat exchanger; a refrigerant merging point disposed at a suction side of the high-stage compression mechanism; a refrigerant return pipe connecting the refrigerant branch point and the refrigerant merging point through the internal heat exchanger; and a second expansion mechanism disposed upstream of the internal heat exchanger on the refrigerant return pipe.

[0022] With this configuration, the temperature of the refrigerant fed to the evaporator can be reduced by the internal heat exchanger exchanging heat between the refrigerant fed from the auxiliary gas cooler and the refrigerant expanded by the second expansion mechanism through the refrigerant return pipe, thereby making it possible to increase the refrigeration capacity. Furthermore, in the present invention, the outlet refrigerant temperature of the intercooler is reduced to the vicinity of the incoming water temperature by parallel water entry, which reduces the suction refrigerant pressure of the high-stage compression mechanism, that is, the refrigerant pressure inside the refrigerant return pipe after the refrigerant passes through the second expansion mechanism, thereby making it possible to further reduce the temperature of the refrigerant cooled by the internal heat exchanger. Thus, it is possible to further increase the refrigeration capacity.

[0023] Hereinbelow, embodiments of the present invention will be described with reference to the drawings.

[0024] Fig. 1 is a refrigerant circuit diagram showing a refrigeration apparatus according to a first embodiment of the present invention.

[0025] As shown in Fig. 1, a refrigeration apparatus 1 is connected to a cooling apparatus that is cooled with a refrigerant fed from the refrigeration apparatus 1, and the cooling apparatus is, for example, a showcase that is installed in a facility such as a convenience store or a supermarket and cools chilled/frozen products displayed in the showcase.

[0026] In the present embodiment, the refrigeration apparatus 1 uses, as the refrigerant, carbon dioxide which brings a refrigerant pressure at the high-pressure side (high-pressure side pressure) equal to or higher than a critical pressure (supercritical). The carbon dioxide refrigerant is a natural refrigerant that is environmentally friendly and takes flammability and toxicity into consideration.

[0027] The refrigeration apparatus 1 includes a compressor 10. In the present embodiment, the compressor 10 includes two stages of compression mechanisms: a low-stage compression mechanism 11 and a high-stage compression mechanism 12.

[0028] Note that although, in the present embodiment, the compressor 10 includes the two stages of compression mechanisms: the low-stage compression mechanism 11 and the high-stage compression mechanism 12, an equal function can be obtained also by using two compressors as a low-stage compressor and a high-stage compressor.

[0029] The low-stage compression mechanism 11 is provided with a low-stage suction port 13 and a low-stage discharge port 14, and the high-stage compression mechanism 12 is provided with a high-stage suction port 15 and a high-stage discharge port 16.

[0030] A low-pressure refrigerant pipe 17, which is connected to an evaporator 40 of the cooling apparatus, is connected to the low-stage suction port 13, and a low-pressure refrigerant fed from the evaporator 40 of the cooling apparatus through the low-pressure refrigerant pipe 17 is fed to the low-stage compression mechanism 11 through the low-stage suction port 13.

[0031] The low-stage compression mechanism 11 compresses the low-temperature and low-pressure refrigerant sucked through the low-stage suction port 13 to increase the pressure thereof up to an intermediate pressure and discharges the refrigerant through the low-stage discharge port 14. The intermediate-pressure refrigerant compressed by the low-stage compression mechanism 11 passes through an intermediate-pressure discharge pipe 18, an intercooler 30, and an intermediate-pressure suction pipe 19, is sucked through the high-stage suction port 15, compressed by the high-stage compression mechanism 12 up to a high pressure, and discharged through the high-stage discharge port 16.

[0032] The intermediate-pressure discharge pipe 18, which is connected to the low-stage compression mechanism 11, is connected to an inlet side 30a of one flow passage of the intercooler 30.

[0033] The intermediate-pressure suction pipe 19 is connected to an outlet side 30b of the one flow passage of the intercooler 30, and the intermediate-pressure suction pipe 19 is connected to the high-stage suction port 15 of the high-stage compression mechanism 12.

[0034] A high-pressure discharge pipe 20 is connected to the high-stage discharge port 16 of the high-stage compression mechanism 12, and the high-pressure discharge pipe 20 is connected to an inlet side 31a of one flow passage of a main gas cooler 31.

[0035] An outlet side 31b of the one flow passage of the main gas cooler 31 is connected to an inlet side 32a of one flow passage of an auxiliary gas cooler 32 through a refrigerant pipe 21. An outlet side 32b of the one flow passage of the auxiliary gas cooler 32 is connected to an expansion mechanism 41 of the cooling apparatus through a refrigerant pipe 22. The evaporator 40 is connected to the expansion mechanism 41, and the low-stage compression mechanism 11 is connected to the evaporator 40.

[0036] A water pipe 50 is connected to the other flow passage of the auxiliary gas cooler 32, the other flow passage of the main gas cooler 31, and the other flow passage of the intercooler 30.

[0037] The water pipe 50 includes a first water pipe 51, a first branch point 52 where the first water pipe 51 branches midway, a first merging point 53, a second water pipe 54 which connects the first branch point 52 and the first merging point 53 through an inlet side 32c and an outlet side 32d of the auxiliary gas cooler 32, a third water pipe 55 which connects the first branch point 52 and the first merging point 53 through an inlet side 30c and an outlet side 30d of the intercooler 30 without merging with the second water pipe 54, a fourth water pipe 56 which connects the first merging point 53 and an inlet side 31c of the main gas cooler 31, and a hot water supply pipe 57 which connects an outlet side 31d of the main gas cooler 31 and a hot water supply destination.

[0038] As described above, in the present embodiment, the water pipe 50 is configured in such a manner that the second water pipe 54 and the third water pipe 55 are respectively connected to the auxiliary gas cooler 32 and the intercooler 30 in parallel, and the second water pipe 54 connected to the auxiliary gas cooler 32 and the third water pipe 55 connected to the intercooler 30 are connected in series to the main gas cooler 31 through the fourth water pipe 56.

[0039] The first water pipe 51 of the water pipe 50 is provided with, for example, a water feeding mechanism 60, such as a water feeding pump.

[0040] A first flow regulating valve 61 as the first flow regulating mechanism is disposed in a midway part of the fourth water pipe 56 into which the outlet side of the auxiliary gas cooler 32 and the outlet side of the intercooler 30 are connected and merged. A drain pipe 58 is connected to the first flow regulating valve 61 at a position that is not connected to the water pipe 50.

[0041] Note that although, in the present embodiment, a three-way valve is used as the first flow regulating valve 61, an equal function can be obtained also by using two two-way valves as the first flow regulating valve 61.

[0042] The refrigerant pipe 22 is provided with a refrigerant temperature sensor 71 which detects a refrigerant temperature at the outlet side of the auxiliary gas cooler 32. The first water pipe 51 is provided with an inlet-side water temperature sensor 72 which detects the temperature of water entering the auxiliary gas cooler 32 and the intercooler 30, and the hot water supply pipe 57 at the outlet side of the main gas cooler 31 is provided with an outlet-side water temperature sensor 73.

[0043] Fig. 2 is a block diagram showing a control configuration of the present embodiment.

[0044] As shown in Fig. 2, in the present embodiment, the refrigeration apparatus 1 includes a control unit 70 which performs centralized control of the refrigeration apparatus 1. The control unit 70 controls driving of the compressor 10 and controls the opening degree of the expansion mechanism 41. The control unit 70 is configured to control driving of the water feeding mechanism 60 and the first flow regulating valve 61 on the basis of detection values of the refrigerant temperature sensor 71, the inlet-side water temperature sensor 72, and the outlet-side water temperature sensor 73.

[0045] Next, operation of the first embodiment will be described.

[0046] First, the compressor 10 is operated to suck, through the low-stage suction port 13 of the low-stage compression mechanism 11, the refrigerant fed from the evaporator 40 of the cooling apparatus, and the sucked refrigerant is compressed to the intermediate pressure by the low-stage compression mechanism 11 and discharged through the low-stage discharge port 14.

[0047] The refrigerant discharged through the low-stage discharge port 14 of the low-stage compression mechanism 11 flows into the intercooler 30 through the intermediate-pressure discharge pipe 18. The refrigerant is cooled by exchanging heat with water in the intercooler 30 and fed to the high-stage suction port 15 of the high-stage compression mechanism 12.

[0048] The refrigerant fed from the intercooler 30 is compressed by the high-stage compression mechanism 12, discharged through the high-stage discharge port 16, and fed to the main gas cooler 31.

[0049] The refrigerant fed from the high-stage compression mechanism 12 exchanges heat with water in the main gas cooler 31, then exchanges heat in the auxiliary gas cooler 32, and is fed to the evaporator 40 through the expansion mechanism 41.

[0050] In the present embodiment, the water pipe 50 is connected to the auxiliary gas cooler 32 and the intercooler 30 in parallel and then connected in series to the main gas cooler 31.

[0051] Thus, water flowing through the water pipe 50 simultaneously flows to the auxiliary gas cooler 32 and the intercooler 30 and then flows to the main gas cooler 31.

[0052] Thus, it is possible to reduce the outlet refrigerant temperature of the auxiliary gas cooler 32 and the outlet refrigerant temperature of the intercooler 30 to the vicinity of the incoming water temperature by allowing water to enter the auxiliary gas cooler 32 and the intercooler 30 in parallel.

[0053] The main gas cooler 31 and the auxiliary gas cooler 32 make it possible to sufficiently cool the refrigerant even with a low water flow rate.

[0054] Furthermore, since the water feeding mechanism 60 can regulate the flow rate of water flowing through the water pipe 50, it is possible to ensure a sufficient refrigeration capacity while performing hot water supply at a predetermined temperature.

[0055] Water in an amount unnecessary for hot water supply at the predetermined temperature can be discharged before flowing into the main gas cooler 31 by using the first flow regulating valve 61. Thus, it is possible to ensure a sufficient flow rate of water flowing into the auxiliary gas cooler 32 and the intercooler 30 while reducing the flow rate of water flowing into the main gas cooler 31. This makes it possible to perform hot water supply with water heated up to the temperature of the refrigerant discharged from the high-stage compression mechanism 12 while ensuring a sufficient refrigeration capacity.

[0056] Next, control operation of the first embodiment will be described.

[0057] Fig. 3 is a flowchart showing the operation of the first embodiment.

[0058] As shown in Fig. 3, when flow rate control of water supply (hot water supply) is performed, the control unit 70 first sets the flow rate to an initial flow rate and starts operation (ST1).

[0059] Then, the control unit 70 acquires a target hot water supply temperature set value Tg, a current outlet-side water temperature Tout detected by the outlet-side water temperature sensor 73, an inlet-side water temperature Tin detected by the inlet-side water temperature sensor 72, and a refrigerant outlet temperature Tref detected by the refrigerant temperature sensor 71 (ST2).

[0060] The control unit 70 determines whether the refrigerant outlet temperature Tref is higher than the inlet-side water temperature Tin + tin1 (ST3).

[0061] When it is determined that the refrigerant outlet temperature Tref is higher than the inlet-side water temperature Tin + tin1 (ST3: YES), the control unit 70 performs control to increase the flow rate by using the water feeding mechanism 60 (ST4).

[0062] Then, until a flow rate control end signal is input (ST5: NO), the above control is continued.

[0063] On the other hand, when it is determined that the refrigerant outlet temperature Tref is lower than the inlet-side water temperature Tin + tin1 (ST3: NO), the control unit 70 determines whether the refrigerant outlet temperature Tref is lower than the inlet-side water temperature Tin + tin2 (ST6).

[0064] When it is determined that the refrigerant outlet temperature Tref is lower than the inlet-side water temperature Tin + tin2 (ST6: YES), the control unit 70 performs control to reduce the flow rate by using the water feeding mechanism 60 (ST7). Then, until the flow rate control end signal is input (ST5: NO), the above control is continued.

[0065] When it is determined that the refrigerant outlet temperature Tref is higher than the inlet-side water temperature Tin + tin2 (ST6: NO), the control unit 70 determines whether the outlet-side water temperature Tout is higher than the target hot water supply temperature set value Tg + tg (ST8).

[0066] When it is determined that the outlet-side water temperature Tout is higher than the target hot water supply temperature set value Tg + tg (ST8: YES), the control unit 70 performs control to increase the flow rate at the hot water supply side of the first flow regulating valve 61 (ST9). Then, until the flow rate control end signal is input (ST5: NO), the above control is continued.

[0067] When it is determined that the outlet-side water temperature Tout is lower than the target hot water supply temperature set value Tg + tg (ST8: NO), the control unit 70 determines whether the outlet-side water temperature Tout is lower than the target hot water supply temperature set value Tg - tg (ST10).

[0068] When it is determined that the outlet-side water temperature Tout is lower than the target hot water supply temperature set value Tg - tg (ST10: YES), the control unit 70 performs control to reduce the flow rate at the hot water supply side of the first flow regulating valve 61 (ST11).

[0069] When it is determined that the outlet-side water temperature Tout is higher than the target hot water supply temperature set value Tg - tg (ST10: NO), the above control is continued until the flow rate control end signal is input (ST5: NO).

[0070] Then, when the flow rate control end signal is input (ST5: YES), the flow rate control is finished.

[0071] As described above, according to the first embodiment, the refrigeration apparatus 1 includes the intercooler 30 which cools the refrigerant discharged from the low-stage compression mechanism 11, the main gas cooler 31 which cools the refrigerant discharged from the high-stage compression mechanism 12, and the auxiliary gas cooler 32 which cools the refrigerant that has passed through the main gas cooler 31. The water pipe 50 includes the first water pipe 51, the first branch point 52 where the first water pipe 51 branches midway, the first merging point 53, the second water pipe 54 which connects the first branch point 52 and the first merging point 53 through the auxiliary gas cooler 32, the third water pipe 55 which connects the first branch point 52 and the first merging point 53 through the intercooler 30 without merging with the second water pipe 54, the fourth water pipe 56 which connects the first merging point 53 and the main gas cooler 31, and the hot water supply pipe 57 which connects the main gas cooler 31 and the hot water supply destination. The refrigeration apparatus 1 includes the water feeding mechanism 60 which is disposed in the midway part of the water pipe 50.

[0072] With this configuration, it is possible to reduce the outlet refrigerant temperature of the auxiliary gas cooler 32 and the outlet refrigerant temperature of the intercooler 30 to the vicinity of the incoming water temperature by allowing water to enter the auxiliary gas cooler 32 and the intercooler 30 in parallel. Furthermore, the main gas cooler 31 and the auxiliary gas cooler 32 make it possible to sufficiently cool the refrigerant even with a low water flow rate.

[0073] In the present embodiment, the refrigeration apparatus 1 further includes the control unit 70 which controls the water feeding mechanism 60, and the outlet-side water temperature sensor 73 which detects the outlet-side water temperature of the hot water supply pipe 57 of the main gas cooler 31. The water feeding mechanism 60 controls the flow rate of the water pipe 50. The control unit 70 controls the water feeding mechanism 60 on the basis of a detection value of the outlet-side water temperature sensor 73.

[0074] With this configuration, the water feeding mechanism 60 can regulate the flow rate of water flowing through the water pipe 50, and it is possible to ensure a sufficient refrigeration capacity while performing hot water supply at the predetermined temperature.

[0075] In the present embodiment, the refrigeration apparatus 1 further includes the inlet-side water temperature sensor 72 which is disposed on the first water pipe 51 and detects the temperature of water entering the auxiliary gas cooler 32 and the intercooler 30, the refrigerant temperature sensor 71 which measures the temperature of the refrigerant that has passed through the auxiliary gas cooler 32, the drain pipe 85 which is connected to the fourth water pipe 56, and the first flow regulating valve 61 which regulates the flow rate of water flowing to the main gas cooler 31 and the drain pipe 58. The control unit 70 controls the first flow regulating valve 61.

[0076] With this configuration, water in an amount unnecessary for hot water supply at the predetermined temperature can be discharged by using the first flow regulating valve 61. Thus, it is possible to ensure a sufficient flow rate of water flowing into the auxiliary gas cooler 32 and the intercooler 30 while reducing the flow rate of water flowing into the main gas cooler 31. This makes it possible to perform hot water supply with water heated up to the temperature of the refrigerant discharged from the high-stage compression mechanism 12 while ensuring a sufficient refrigeration capacity.

[0077] Next, a second embodiment of the present invention will be described.

[0078] Fig. 4 is a refrigerant circuit diagram of a refrigeration apparatus according to the second embodiment of the present invention.

[0079] As shown in Fig. 4, in the present embodiment, a water feeding mechanism 60 is disposed on a fourth water pipe 56 between a first merging point 53 and a first flow regulating valve 61.

[0080] Furthermore, an external heat radiator 80 is connected to a drain pipe 58, and the external heat radiator 80 merges with a second merging point 82 on a first water pipe 51 through a fifth water pipe 81.

[0081] Furthermore, an internal heat exchanger 83 is disposed between an auxiliary gas cooler 32 and an expansion mechanism 41. A refrigerant branch point 84 is disposed downstream of the internal heat exchanger 83, and a refrigerant merging point 85 is disposed at an inlet side of a high-stage compression mechanism 12. Refrigerant return pipes 86a, 86b which connect the refrigerant branch point 84, the internal heat exchanger 83, and the refrigerant merging point 85 are provided, and a second expansion mechanism 87 is disposed upstream of the internal heat exchanger 83 on the refrigerant return pipe 86a.

[0082] The other configurations are similar to those of the first embodiment. Thus, identical parts are designated by the same reference signs to omit redundant description.

[0083] Furthermore, since control of the water feeding mechanism 60 and the first flow regulating valve 61 is also similar to that of the first embodiment, description thereof will be omitted.

[0084] In the present embodiment, the water feeding mechanism 60 is disposed on the fourth water pipe 56. Thus, exhaust heat from the water feeding mechanism 60 can be used for hot water supply, and hot water supply can be more efficiently performed.

[0085] Furthermore, water fed to the auxiliary gas cooler 32 and the intercooler 30 is not heated by the water feeding mechanism 60, and the temperature of water entering the auxiliary gas cooler 32 and the intercooler 30 can thus be reduced. This increases the efficiency of the compression mechanism, which makes it possible to increase the refrigeration capacity. Furthermore, since the temperature of water entering the main gas cooler 31 can be increased using part of the amount of heat dissipated from the water feeding mechanism 60, it is possible to efficiently increase the water temperature up to a predetermined hot water supply temperature.

[0086] Furthermore, in the present embodiment, water flowing from the fourth water pipe 56 to the drain pipe 58 through the first flow regulating valve 61 is fed to the external heat radiator 80 and cooled in the external heat radiator 80.

[0087] The cooled water is fed to the auxiliary gas cooler 32 and the intercooler 30 through the fifth water pipe 81, the first water pipe 51, the second water pipe 54, and the third water pipe 55. This makes it possible to reuse water without discarding it and operate the refrigeration apparatus 1 with a reduced amount of water.

[0088] Furthermore, the temperature of the refrigerant fed to the evaporator 40 can be reduced by the internal heat exchanger 83 exchanging heat between the refrigerant fed from the auxiliary gas cooler 32 and the refrigerant expanded by the second expansion mechanism 87 through the refrigerant return pipe 86a, thereby making it possible to increase the refrigeration capacity.

[0089] Furthermore, in the present embodiment, the outlet refrigerant temperature of the intercooler 30 is reduced to the vicinity of the incoming water temperature by parallel water entry, which reduces the suction refrigerant pressure of the high-stage compression mechanism 12, that is, the refrigerant pressure inside the refrigerant return pipes 86a, 86b after the refrigerant passes through the second expansion mechanism 87, thereby making it possible to further reduce the temperature of the refrigerant cooled by the internal heat exchanger 83. Thus, it is possible to further increase the refrigeration capacity.

[0090] As described above, in the present embodiment, the water feeding mechanism 60 is disposed on the fourth water pipe 56 between the first merging point 53 and the first flow regulating valve 61.

[0091] With this configuration, since the water feeding mechanism 60 is disposed on the fourth water pipe 56, exhaust heat from the water feeding mechanism 60 can be used for hot water supply, and hot water supply can be more efficiently performed.

[0092] Furthermore, water fed to the auxiliary gas cooler 32 and the intercooler 30 is not heated by the water feeding mechanism 60, and the temperature of water entering the auxiliary gas cooler 32 and the intercooler 30 can thus be reduced. This increases the efficiency of the compressor 10, which makes it possible to increase the refrigeration capacity.

[0093] In the present embodiment, the refrigeration apparatus 1 further includes the external heat radiator 80 which is connected to the drain pipe 58, the second merging point 82 which is disposed on the first water pipe 51, and the fifth water pipe 81 which connects the external heat radiator 80 and the second merging point 82.

[0094] With this configuration, the external heat radiator 80 enables water cooled by the external heat radiator 80 to be fed to the auxiliary gas cooler 32 and the intercooler 30, which makes it possible to reuse water without discarding it and operate the refrigeration apparatus 1 with a reduced amount of water.

[0095] Furthermore, in the present embodiment, the refrigeration apparatus 1 further includes the internal heat exchanger 83 which is disposed between the auxiliary gas cooler 32 and the expansion mechanism 41, the refrigerant branch point 84 which is disposed downstream of the internal heat exchanger 83, the refrigerant merging point 85 which is disposed at the suction side of the high-stage compression mechanism 12, the refrigerant return pipes 86a, 86b which connect the refrigerant branch point 84 and the refrigerant merging point 85 through the internal heat exchanger 83, and the second expansion mechanism 87 which is disposed upstream of the internal heat exchanger 83 on the refrigerant return pipe 86a.

[0096] With this configuration, the temperature of the refrigerant fed to the evaporator 40 can be reduced by heat exchange in the internal heat exchanger 83, thereby making it possible to increase the refrigeration capacity. Furthermore, the outlet refrigerant temperature of the intercooler 30 is reduced to the vicinity of the incoming water temperature by parallel water entry, which reduces the suction refrigerant pressure of the high-stage compression mechanism 12, that is, the refrigerant pressure inside the refrigerant return pipes 86a, 86b after the refrigerant passes through the second expansion mechanism 87, thereby making it possible to reduce the temperature of the refrigerant cooled by the internal heat exchanger 83. Thus, it is possible to further increase the refrigeration capacity.

[0097] AS described above, the refrigeration apparatus according to the present invention is suitably usable as a refrigeration apparatus capable of maintaining a sufficient refrigeration capacity even when the hot water supply temperature is increased. Furthermore, the refrigeration apparatus according to the present invention is also suitably usable for hot water supply using hot water generated by heat exchange between a refrigerant and water, hot water supply used for, for example, hot water heating, and a hot water heating apparatus.

Reference Signs List

[0098]

1	refrigeration apparatus
10	compressor
11	low-stage compression mechanism
12	high-stage compression mechanism
13	low-stage suction port
14	low-stage discharge port
15	high-stage suction port
16	high-stage discharge port
17	low-pressure refrigerant pipe
18	intermediate-pressure discharge pipe
19	intermediate-pressure suction pipe
20	high-pressure discharge pipe
21	refrigerant pipe
22	refrigerant pipe
30	intercooler
31	main gas cooler
32	auxiliary gas cooler
40	evaporator
41	expansion mechanism
50	water pipe
51	first water pipe
52	first branch point
53	first merging point
54	second water pipe
55	third water pipe
56	fourth water pipe
57	hot water supply pipe
58	drain pipe
60	water feeding mechanism
61	first flow regulating valve
70	control unit
71	refrigerant temperature sensor
72	inlet-side water temperature sensor
73	outlet-side water temperature sensor
80	external heat radiator
81	fifth water pipe
82	second merging point
83	internal heat exchanger
84	refrigerant branch point
85	refrigerant merging point
86a, 86b	refrigerant return pipe
87	second expansion mechanism

Claims

1. A refrigeration apparatus configured to cool a refrigerant by heat exchange between the refrigerant and water, the refrigeration apparatus comprising:

    a low-stage compression mechanism (11);
    a high-stage compression mechanism (12);
    an expansion mechanism (41);
    an intercooler (30) configured to cool the refrigerant discharged from the low-stage compression mechanism;
    a main gas cooler (31) configured to cool the refrigerant discharged from the high-stage compression mechanism;
    an auxiliary gas cooler (32) configured to cool the refrigerant that has passed through the main gas cooler;
    a water pipe (50) constituting a flow passage of water for cooling the refrigerant,
    the water pipe including:

        a first water pipe (51);
        a first branch point (52) where the first water

pipe branches midway;
a first merging point (53);
a second water pipe (54) connecting the first branch point and the first merging point through the auxiliary gas cooler;
a third water pipe (55) connecting the first branch point and the first merging point through the intercooler without merging with the second water pipe;
a fourth water pipe (56) connecting the first merging point and the main gas cooler; and
a hot water supply pipe (57) connecting the main gas cooler and a hot water supply destination; and

a water feeding mechanism (60) disposed in a midway part of the water pipe,
a control unit (70) configured to control the water feeding mechanism; and
an outlet-side water temperature sensor (73) disposed on the hot water supply pipe, the outlet-side water temperature sensor being configured to detect an outlet-side water temperature of the main gas cooler, wherein
the water feeding mechanism controls a flow rate of the water pipe, and
the control unit controls the water feeding mechanism on the basis of a detection value of the outlet-side water temperature sensor,
an inlet-side water temperature sensor (72) disposed on the first water pipe, the inlet-side water temperature sensor being configured to detect a temperature of water entering the auxiliary gas cooler and the intercooler;
characterized by further comprising:

a refrigerant temperature sensor (71) configured to measure a temperature of the refrigerant that has passed through the auxiliary gas cooler (32);
a drain pipe (58) connected to the fourth water pipe (56); and
a first flow regulating mechanism (61) configured to regulate a flow rate of water flowing to the main gas cooler (31) and the drain pipe (58), wherein
the control unit (70) is configured to control the first flow regulating mechanism (61).

2. The refrigeration apparatus according to claim 1, wherein the water feeding mechanism is disposed on the fourth water pipe between the first merging point and the first flow regulating mechanism.

3. The refrigeration apparatus according to claim 1, further comprising:

an external heat radiator (80) connected to the drain pipe;
a second merging point (82) disposed on the first water pipe; and
a fifth water pipe (81) connecting the external heat radiator and the second merging point.

4. The refrigeration apparatus according to claim 3, further comprising:

an internal heat exchanger (83) disposed between the auxiliary gas cooler and the expansion mechanism;
a refrigerant branch point (84) disposed downstream of the internal heat exchanger;
a refrigerant merging point (85) disposed at a suction side of the high-stage compression mechanism;
a refrigerant return pipe (86a, 86b) connecting the refrigerant branch point and the refrigerant merging point through the internal heat exchanger; and
a second expansion mechanism (87) disposed upstream of the internal heat exchanger on the refrigerant return pipe.

Patentansprüche

1. Kühlvorrichtung, die zum Kühlen eines Kältemittels durch Wärmeaustausch zwischen dem Kältemittel und Wasser konfiguriert ist, wobei die Kühlvorrichtung umfasst:

eine Niedrigstufen-Kompressionseinrichtung (11);
eine Hochstufen-Kompressionseinrichtung (12);
eine Expansionseinrichtung (41);
einen Zwischenkühler (30), der dazu konfiguriert ist, das von der Niedrigstufen-Kompressionseinrichtung abgegebene Kältemittel zu kühlen;
einen Hauptgaskühler (31), der dazu konfiguriert ist, das von der Hochstufen-Kompressionseinrichtung abgegebene Kältemittel zu kühlen;
einen Hilfsgaskühler (32), der dazu konfiguriert ist, das Kältemittel zu kühlen, das den Hauptgaskühler durchlaufen hat;
eine Wasserleitung (50), die einen Durchflusskanal für Wasser zum Kühlen des Kältemittels bildet,
wobei die Wasserleitung aufweist:

eine erste Wasserleitung (51);
einen ersten Verzweigungspunkt (52), an dem sich die erste Wasserleitung in der Mitte verzweigt;
einen ersten Vereinigungspunkt (53);

eine zweite Wasserleitung (54), die den ersten Verzweigungspunkt und den ersten Vereinigungspunkt über den Hilfsgaskühler verbindet;
eine dritte Wasserleitung (55), die den ersten Verzweigungspunkt und den ersten Vereinigungspunkt über den Zwischenkühler verbindet, ohne sich mit der zweiten Wasserleitung zu vereinigen;
eine vierte Wasserleitung (56), die den ersten Vereinigungspunkt und den Hauptgaskühler verbindet; und
eine Heißwasser-Versorgungsleitung (57), die den Hauptgaskühler und ein Heißwasserversorgungsziel verbindet; und

eine Wassereinspeiseeinrichtung (60), die in einem Mittelteil der Wasserleitung angeordnet ist,
eine Steuereinheit (70), die dazu konfiguriert ist, die Wassereinspeiseeinrichtung zu steuern; und
einen ausgangsseitigen Wassertemperatursensor (73), der an der Heißwasser-Versorgungsleitung angeordnet ist, wobei der ausgangsseitige Wassertemperatursensor dazu konfiguriert ist, eine ausgangsseitige Wassertemperatur des Hauptgaskühlers zu erfassen, wobei
die Wassereinspeiseeinrichtung eine Durchflussrate der Wasserleitung steuert, und
die Steuereinrichtung die Wassereinspeiseeinrichtung auf der Grundlage eines Erfassungswertes des ausgangsseitigen Wassertemperatursensors steuert,
einen eingangsseitigen Wassertemperatursensor (72), der an dem ersten Wasserrohr angeordnet ist, wobei der eingangsseitige Wassertemperatursensor dazu konfiguriert ist, eine Temperatur des in den Hilfsgaskühler und den Zwischenkühler eintretenden Wassers zu erfassen;
dadurch gekennzeichnet, dass sie ferner umfasst:

einen Kältemitteltemperatursensor (71), der dazu konfiguriert ist, eine Temperatur des Kältemittels zu messen, das den Hilfsgaskühler (32) durchlaufen hat;
ein Ablaufrohr (58), das mit dem vierten Wasserrohr (56) verbunden ist; und
eine erste Durchflussregelungseinrichtung (61), die dazu konfiguriert ist, eine Durchflussrate von Wasser, das zu dem Hauptgaskühler (31) und dem Ablaufrohr (58) fließt, zu regeln, wobei
die Steuereinheit (70) dazu konfiguriert ist, die erste Durchflussregelungseinrichtung (61) zu steuern.

2. Kühlvorrichtung nach Anspruch 1, wobei die Wassereinspeiseeinrichtung an der vierten Wasserleitung zwischen dem ersten Vereinigungspunkt und der ersten Durchflussregelungseinrichtung angeordnet ist.

3. Kühlvorrichtung nach Anspruch 1, ferner umfassend:

einen externen Kühlkörper (80), der mit dem Ablaufrohr verbunden ist;
einen zweiten Vereinigungspunkt (82), der an der ersten Wasserleitung angeordnet ist; und
eine fünfte Wasserleitung (81), die den externen Kühlkörper und den zweiten Vereinigungspunkt verbindet.

4. Kühlvorrichtung nach Anspruch 3, ferner umfassend:

einen internen Wärmetauscher (83), der zwischen dem Hilfsgaskühler und der Entspannungseinrichtung angeordnet ist;
einen Kältemittelverzweigungspunkt (84), der stromabwärts des internen Wärmetauschers angeordnet ist;
einen Kältemittelvereinigungspunkt (85), der an einer Saugseite der Hochstufen-Kompressionseinrichtung angeordnet ist;
eine Kältemittelrückführleitung (86a, 86b), die den Kältemittelverzweigungspunkt und den Kältemittelvereinigungspunkt über den internen Wärmetauscher verbindet; und
eine zweite Expansionseinrichtung (87), die stromaufwärts des internen Wärmetauschers an der Kältemittelrückführleitung angeordnet ist.

Revendications

1. Appareil de réfrigération conçu pour refroidir un fluide frigorigène par échange de chaleur entre le fluide frigorigène et de l'eau, l'appareil de réfrigération comprenant :

un mécanisme de compression (11) d'étage inférieur;
un mécanisme de compression (12) d'étage supérieur ;
un mécanisme de détente (41) ;
un refroidisseur intermédiaire (30) conçu pour refroidir le fluide frigorigène évacué du mécanisme de compression d'étage inférieur ;
un refroidisseur de gaz principal (31) conçu pour refroidir le fluide frigorigène évacué du méca-

nisme de compression d'étage supérieur;
un refroidisseur de gaz auxiliaire (32) conçu pour refroidir le fluide frigorigène qui a traversé le refroidisseur de gaz principal ;
une conduite d'eau (50) constituant un passage d'écoulement d'eau pour le refroidissement du fluide frigorigène,
la conduite d'eau comprenant :

une première conduite d'eau (51) ;
un premier point de ramification (52) dont la première conduite d'eau se ramifie à mi-chemin ;
un premier point de convergence (53) ;
une deuxième conduite d'eau (54) reliant le premier point de ramification et le premier point de convergence à travers le refroidisseur de gaz auxiliaire ;
une troisième conduite d'eau (55) reliant le premier point de ramification et le premier point de convergence à travers le refroidisseur intermédiaire sans converger avec la deuxième conduite d'eau ;
une quatrième conduite d'eau (56) reliant le premier point de convergence et le refroidisseur de gaz principal ; et
une conduite d'alimentation en eau chaude (57) reliant le refroidisseur de gaz principal et une destination d'alimentation en eau chaude ; et
un mécanisme d'alimentation en eau (60) disposé dans une partie médiane de la conduite d'eau,
une unité de commande (70) configurée pour commander le mécanisme d'alimentation en eau ; et
un capteur de température d'eau côté sortie (73) disposé sur la conduite d'alimentation en eau chaude, le capteur de température d'eau côté sortie étant conçu pour détecter une température d'eau côté sortie du refroidisseur de gaz principal,
le mécanisme d'alimentation en eau commandant un débit de la conduite d'eau et
l'unité de commande commandant le mécanisme d'alimentation en eau sur la base d'une valeur de détection du capteur de température d'eau côté sortie,
un capteur de température d'eau côté entrée (72) disposé sur la première conduite d'eau, le capteur de température d'eau côté entrée étant conçu pour détecter une température d'eau entrant dans le refroidisseur de gaz auxiliaire et le refroidisseur intermédiaire ;
caractérisé en ce qu'il comprend en outre :

un capteur de température de fluide frigorigène (71) conçu pour mesurer une température du fluide frigorigène qui a traversé le refroidisseur de gaz auxiliaire (32) ;
une conduite de drainage (58) reliée à la quatrième conduite d'eau (56) ; et
un premier mécanisme de régulation d'écoulement (61) conçu pour réguler un débit d'eau s'écoulant vers le refroidisseur de gaz principal (31) et la conduite de drainage (58),
l'unité de commande (70) étant configurée pour commander le premier mécanisme de régulation d'écoulement (61).

2. Appareil de réfrigération selon la revendication 1, le mécanisme d'alimentation en eau étant disposé sur la quatrième conduite d'eau entre le premier point de convergence et le premier mécanisme de régulation d'écoulement.

3. Appareil de réfrigération selon la revendication 1, comprenant en outre :

un radiateur chauffant externe (80) relié à la conduite de drainage ;
un deuxième point de convergence (82) disposé sur la première conduite d'eau ; et
une cinquième conduite d'eau (81) reliant le radiateur chauffant externe et le deuxième point de convergence.

4. Appareil de réfrigération selon la revendication 3, comprenant en outre :

un échangeur de chaleur interne (83) disposé entre le refroidisseur de gaz auxiliaire et le mécanisme de détente ;
un point de ramification de fluide frigorigène (84) disposé en aval de l'échangeur de chaleur interne ;
un point de convergence de fluide frigorigène (85) disposé au niveau d'un côté aspiration du mécanisme de compression d'étage supérieur;
une conduite de retour de fluide frigorigène (86a, 86b) reliant le point de ramification de fluide frigorigène et
le point de convergence de fluide frigorigène à l'échangeur de chaleur interne ; et
un deuxième mécanisme de détente (87) disposé en amont de l'échangeur de chaleur interne sur la conduite de retour de fluide frigorigène.

FIG.1

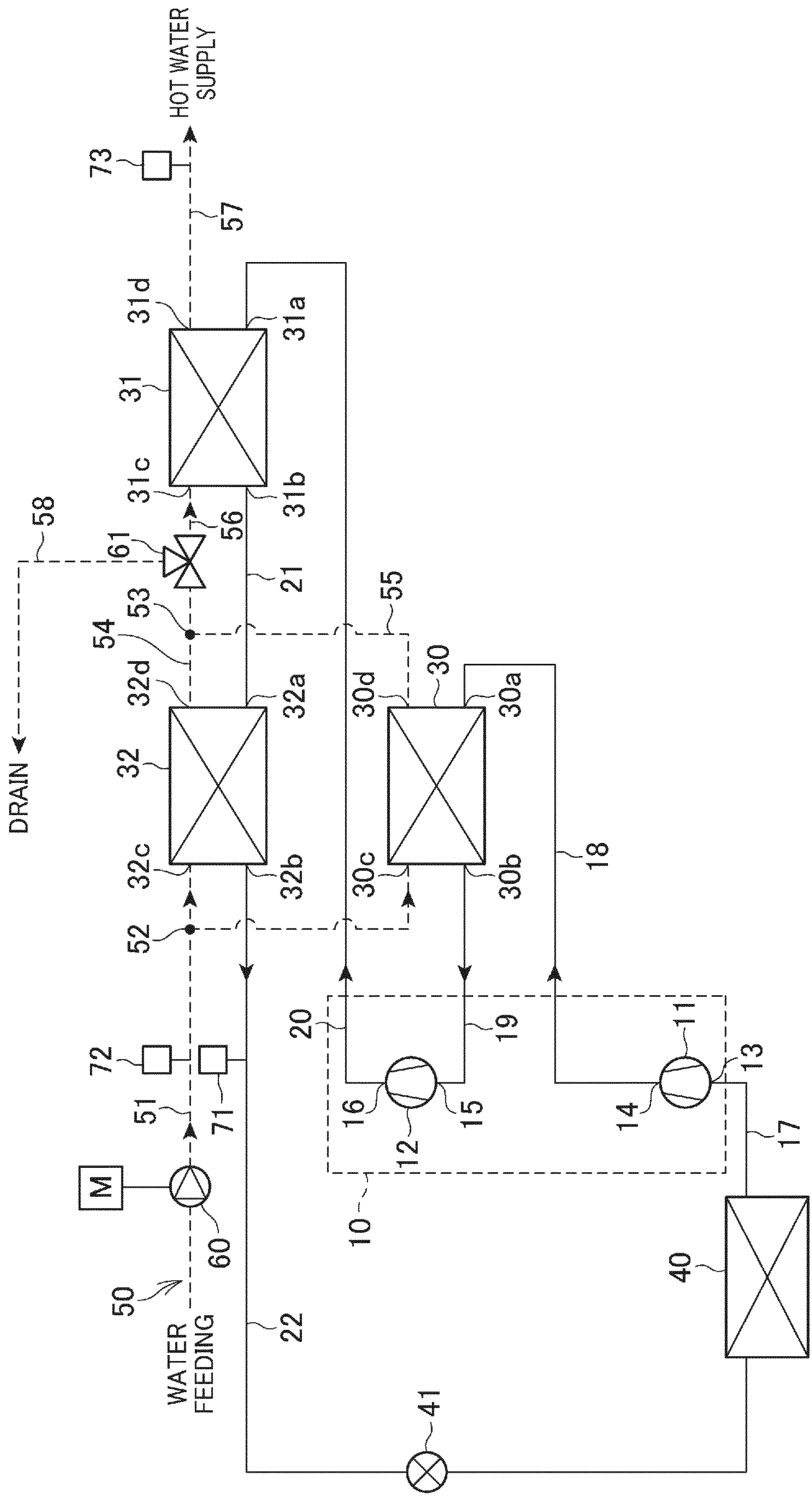

HOT WATER SUPPLY
DRAIN
WATER FEEDING
M
73
57
31d
31a
31
31c
31b
58
61
56
21
53
54
55
32d
32a
30d
30
30a
32
32c
32b
30c
30b
18
52
72
71
20
19
11
13
16
12
15
14
17
51
60
10
50
40
22
41

FIG.2

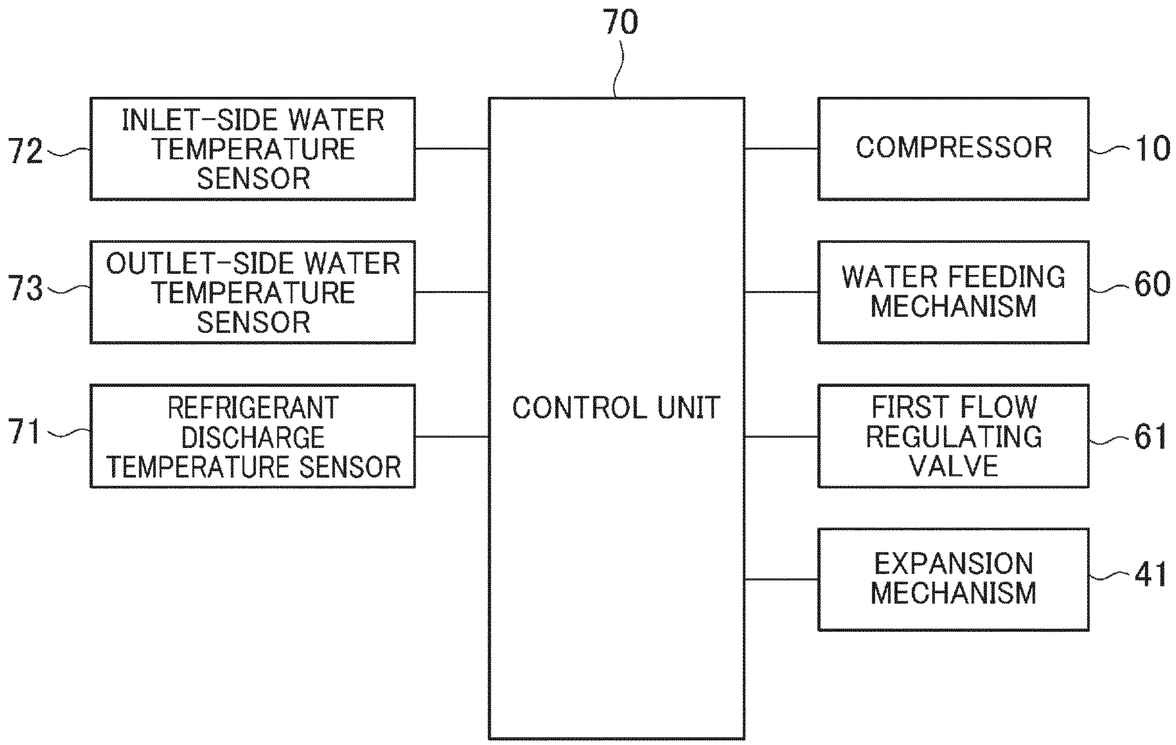
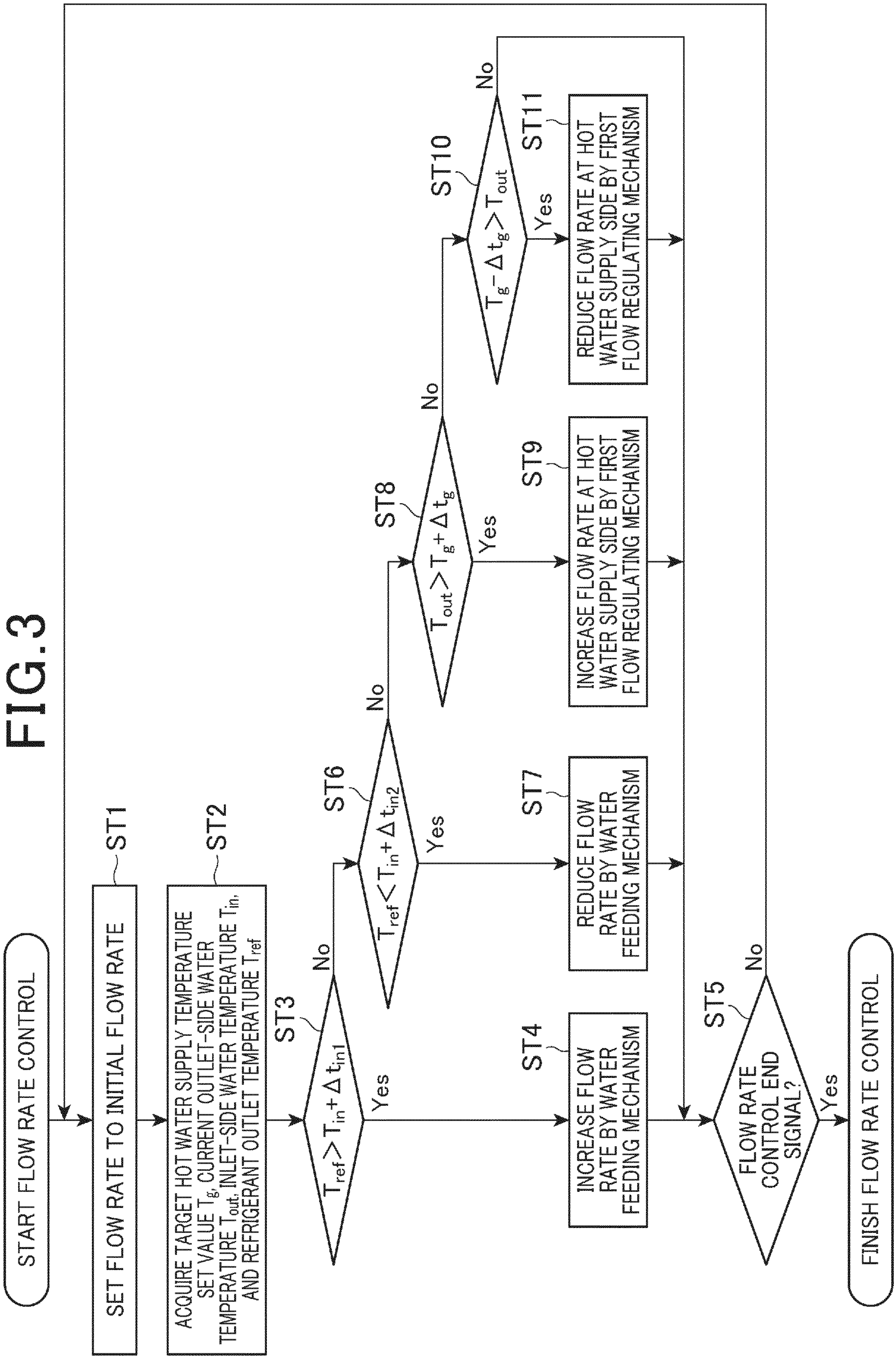

70
INLET-SIDE WATER TEMPERATURE SENSOR
72
OUTLET-SIDE WATER TEMPERATURE SENSOR
73
REFRIGERANT DISCHARGE TEMPERATURE SENSOR
71
CONTROL UNIT
COMPRESSOR
10
WATER FEEDING MECHANISM
60
FIRST FLOW REGULATING VALVE
61
EXPANSION MECHANISM
41

FIG.3


START FLOW RATE CONTROL
SET FLOW RATE TO INITIAL FLOW RATE
ST1
ACQUIRE TARGET HOT WATER SUPPLY TEMPERATURE SET VALUE T_g, CURRENT OUTLET-SIDE WATER TEMPERATURE T_{out}, INLET-SIDE WATER TEMPERATURE T_{in}, AND REFRIGERANT OUTLET TEMPERATURE T_{ref}
ST2
$T_{ref} > T_{in} + \Delta t_{in1}$
ST3
Yes
No
INCREASE FLOW RATE BY WATER FEEDING MECHANISM
ST4
$T_{ref} < T_{in} + \Delta t_{in2}$
ST6
Yes
No
REDUCE FLOW RATE BY WATER FEEDING MECHANISM
ST7
$T_{out} > T_g + \Delta t_g$
ST8
Yes
No
INCREASE FLOW RATE AT HOT WATER SUPPLY SIDE BY FIRST FLOW REGULATING MECHANISM
ST9
$T_g - \Delta t_g > T_{out}$
ST10
Yes
No
REDUCE FLOW RATE AT HOT WATER SUPPLY SIDE BY FIRST FLOW REGULATING MECHANISM
ST11
FLOW RATE CONTROL END SIGNAL?
ST5
Yes
No
FINISH FLOW RATE CONTROL

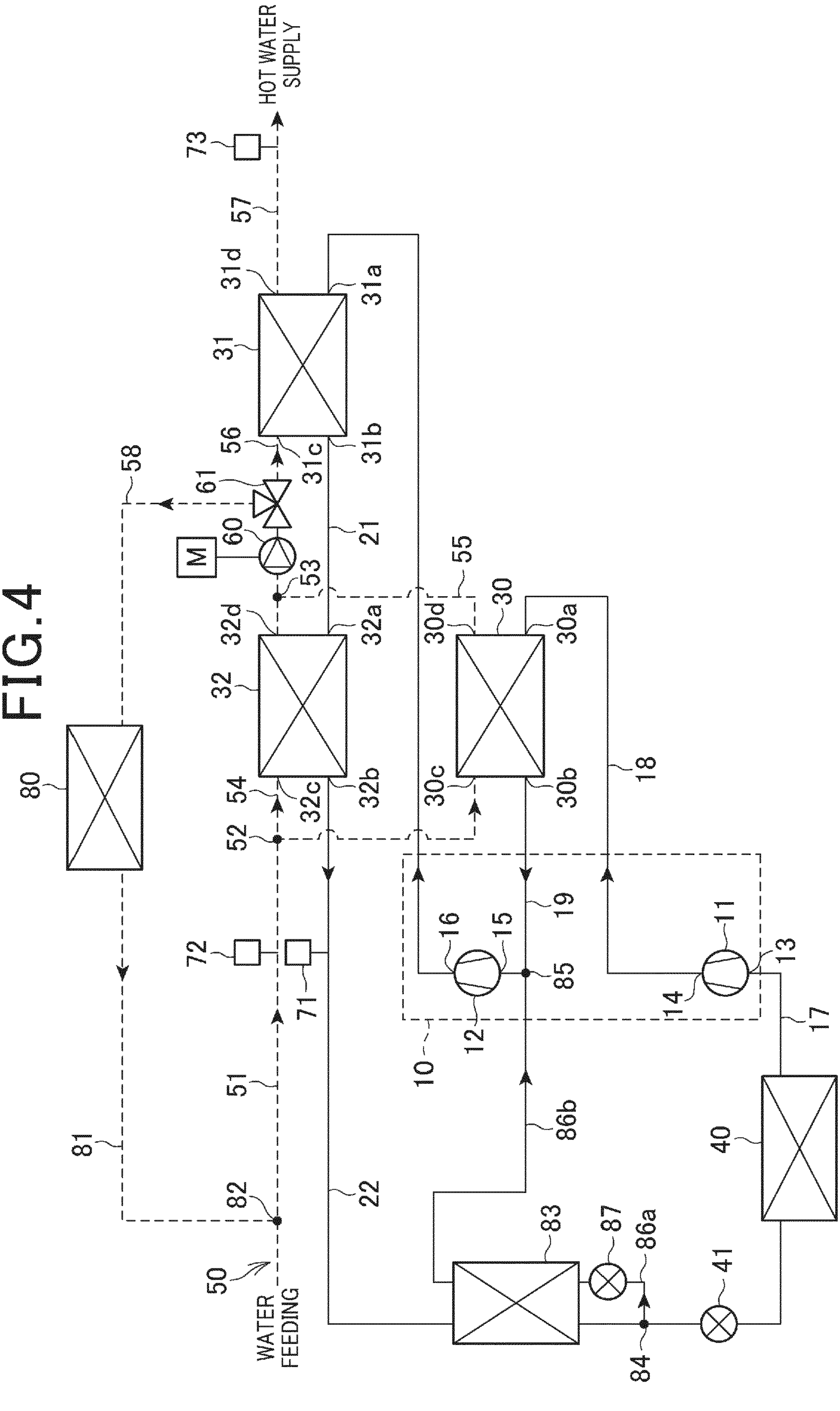

HOT WATER SUPPLY
WATER FEEDING
M
10
11
12
13
14
15
16
17
18
19
21
22
30
30a
30b
30c
30d
31
31a
31b
31c
31d
32
32a
32b
32c
32d
40
41
50
51
52
53
54
55
56
57
58
60
61
71
72
73
80
81
82
83
84
85
86a
86b
87

FIG.4

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 497197 A **[0003]**
- EP 2407734 A1 **[0004]**