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(54) REFRIGERATION DEVICE

(57) Provided is a refrigeration apparatus which, even if refrigerant leakage occurs, can keep the extent of the refrigerant leakage small, effectively utilize portions in which leakage is not occurring, and inhibit contamination of a refrigerant circuit with air. When refrigerant leakage is detected inside either of a first usage unit (50) and a second usage unit (60) that are connected in parallel to each other, a controller (70) closes a shutoff valve on the upstream side of a usage-side heat exchanger of the leaking unit and performs control so as to ensure a state in which, with respect to a check valve on the downstream side of the usage-side heat exchanger of the leaking unit, the refrigerant pressure on the downstream side is greater than the refrigerant pressure on the leaking unit usage-side heat exchanger side.

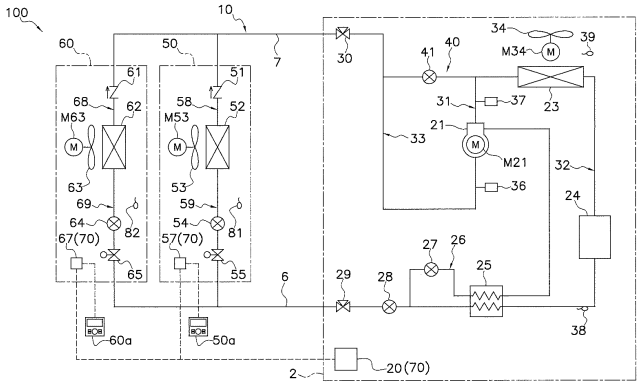

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigeration apparatus.

BACKGROUND ART

[0002] Conventionally, when a refrigeration cycle is performed using a refrigerant circuit configured as a result of a compressor, a heat source-side heat exchanger, an expansion valve, and a usage-side heat exchanger being connected, refrigerant leakage sometimes occurs for some reason from the usage-side heat exchanger or a nearby portion.

[0003] To address this, in the example disclosed in patent document 1 (JP-ANo. 2002-228281) for example, when refrigerant leakage is detected, it is proposed to reduce as much as possible leakage of the refrigerant into the space where the usage-side heat exchanger is installed by automatically performing a pump-down operation to recover the refrigerant to the heat source-side heat exchanger by controlling the compressor and valves.

SUMMARY OF INVENTION

<Technical Problem>

[0004] In contrast to this, for example, in a refrigerant circuit configured as a result of plural usage-side heat exchangers being connected, if refrigerant leakage occurs in one of the plural usage-side heat exchangers, it is conceivable to discontinue the supply of the refrigerant to the usage-side heat exchanger in which the refrigerant leakage is occurring and continue to circulate the refrigerant in the usage-side heat exchanger in which the leakage is not occurring.

[0005] Because of this, it becomes possible to inhibit leakage of the refrigerant from the leaking portion and continue the temperature management by the usage-side heat exchanger in which the refrigerant leakage is not occurring.

[0006] However, if the compressor continues to be driven even after refrigerant leakage occurs in this way, sometimes the refrigerant pressure in the neighborhood of the leaking portion in the refrigerant circuit falls below atmospheric pressure.

[0007] If the refrigerant pressure in the neighborhood of the leaking portion falls below atmospheric pressure in this way, there is the concern that air in the atmosphere will become taken into the refrigerant circuit via the leaking portion from outside the refrigerant circuit and damage the refrigerant circuit, such as damage the compressor.

[0008] The present invention has been made in view of the aforementioned points, and it is an object of the present invention to provide a refrigeration apparatus which, even if refrigerant leakage occurs, can keep the extent of the refrigerant leakage small, effectively utilize portions in which leakage is not occurring, and inhibit contamination of the refrigerant circuit with air.

<Solution to Problem>

[0009] A refrigeration apparatus pertaining to the first aspect comprises a refrigerant circuit and a control component. The refrigerant circuit has a compressor, a radiator, an expansion mechanism, plural evaporators connected in parallel to each other, plural check valves, and plural shutoff valves. The check valves are provided in correspondence to refrigerant outlet sides of the evaporators and stop the flow of refrigerant backflowing from downstream side to upstream side toward their corresponding evaporators. The shutoff valves are provided in correspondence to refrigerant inlet sides of the evaporators and can shut off the flow of refrigerant. The evaporators are housed in individual units. When a refrigerant leakage situation inside any of the units housing the evaporators meets the predetermined condition, the control component uses the shutoff valve corresponding to the evaporator housed in the unit in which the predetermined condition has been met to shut off the flow of refrigerant and performs pressure control so as to ensure a state in which, with respect to the check valve corresponding to the evaporator housed in the unit in which the predetermined condition has been met, the refrigerant pressure on the opposite side of the corresponding evaporator side is greater than the refrigerant pressure on the corresponding evaporator side.

[0010] Here, the case where the refrigerant leakage situation inside the units housing the evaporators meets the predetermined condition is not particularly limited and, for example, includes a case where it has been grasped by a sensor that the concentration, in the unit, of refrigerant that has leaked out from the refrigerant circuit has become equal to or greater than a predetermined concentration and a case where a value detected by a sensor of pressure or temperature in the section of the refrigerant circuit flowing through the unit has changed or fallen.

[0011] In this refrigeration apparatus, when the refrigerant leakage situation meets the predetermined condition in any of the plural units, the controller uses the shutoff valve corresponding to the evaporator of the unit in which the prede-

termined condition has been met (leaking unit) to shut off the flow of refrigerant. Because of this, the refrigerant that has been discharged from the compressor and traveled through the radiator is not supplied to the downstream side of the shutoff valve of the leaking unit but is supplied to the unit in which the leakage is not occurring. Furthermore, the refrigerant that has traveled through the evaporator of the unit in which the leakage is not occurring flows back toward the suction side of the compressor but is also inhibited by the check valve of the leaking unit from flowing into the leaking unit from the check valve side. Because of this, the supply of the refrigerant to the leaking unit can be discontinued, so the extent of the leakage can be kept small.

[0012] Moreover, circulation of the refrigerant can be continued with respect to the unit in which the leakage is not occurring, so it becomes possible to continue to refrigerate the refrigeration target with the evaporator of the unit in which the leakage is not occurring.

[0013] Additionally, even when the refrigerant continues to be circulated in the unit in which the leakage is not occurring, the pressure control is performed so as to ensure a state in which, in regard to the relationship between the refrigerant pressures anterior and posterior to the check valve connected to the evaporator of the leaking unit, the refrigerant pressure on the opposite side of the leaking unit evaporator side is greater than the refrigerant pressure on the leaking unit evaporator side. For this reason, it is possible to inhibit air from contaminating the refrigerant circuit via the leaking portion of the leaking unit.

[0014] A refrigeration apparatus pertaining to the second aspect is the refrigeration apparatus pertaining to the first aspect, wherein in the pressure control the control component increases the refrigerant pressure in a low-pressure line interconnecting the check valves and the suction side of the compressor.

[0015] In this refrigeration apparatus, when refrigerant leakage occurs, the control component increases the refrigerant pressure in the low-pressure line interconnecting the check valves and the suction side of the compressor, so it becomes possible to more reliably inhibit contamination with air from the leaking portion of the leaking unit.

[0016] A refrigeration apparatus pertaining to the third aspect is the refrigeration apparatus pertaining to the second aspect, wherein in the pressure control the control component increases the refrigerant pressure in the low-pressure line to atmospheric pressure or greater.

[0017] In this refrigeration apparatus, when refrigerant leakage occurs, the control component increases the refrigerant pressure in the low-pressure line interconnecting the check valves and the suction side of the compressor to atmospheric pressure or greater, so it becomes possible to more reliably inhibit contamination with air from the leaking portion of the leaking unit on which atmospheric pressure is acting.

[0018] A refrigeration apparatus pertaining to the fourth aspect is the refrigeration apparatus pertaining to any of the first aspect to the third aspect, wherein the capacity of the compressor is controllable. The control component performs control that lowers the capacity of the compressor when the pressure of the refrigerant flowing through the suction side of the compressor becomes equal to or less than a predetermined reference pressure. In the pressure control the control component raises the value of the reference pressure.

[0019] It will be noted that the pressure control here is not limited to just raising the value of the reference pressure, and another process (pressure control according to another aspect) may be executed at the same time as, or around the same time as, the process of raising the value of the reference pressure.

[0020] In this refrigeration apparatus, when the pressure of the refrigerant flowing through the suction side of the compressor becomes equal to or less than the predetermined reference pressure regardless of whether or not there is leakage, the control component performs the control that lowers the capacity of the compressor. Because of this, when for some reason the low pressure in the refrigerant circuit falls and becomes equal to or less than the reference pressure, it is possible to inhibit an excessive drop in pressure by lowering the capacity of the compressor.

[0021] In this refrigeration apparatus, in which such an excessive drop in pressure is inhibited, the process of raising the value of the reference pressure is performed when refrigerant leakage occurs.

[0022] When refrigerant leakage occurs, the number of evaporators upon which the suction of the compressor acts decreases because the supply of the refrigerant to the leaking unit is discontinued, so the low pressure in the refrigerant circuit tends to fall. Additionally, if the low pressure in the refrigerant circuit falls too much, there is the concern that air will become taken into the refrigerant circuit via the leaking portion of the leaking unit.

[0023] To address this, in this refrigeration apparatus, as mentioned above, the process of raising the value of the reference pressure is performed when refrigerant leakage occurs, so it is easy for the low pressure in the refrigerant circuit to fall below the reference pressure, and it is easy to execute the control that lowers the capacity of the compressor. Consequently, it becomes possible to not only change the reference value in the control relating to the low pressure when there is no leakage but also to inhibit contamination with air from the leaking portion of the leaking unit.

[0024] A refrigeration apparatus pertaining to the fifth aspect is the refrigeration apparatus pertaining to any of the first aspect to the fourth aspect, wherein the refrigerant circuit has a hot gas bypass pipe and a hot gas bypass valve. The hot gas bypass pipe interconnects a section of the refrigerant circuit between the discharge side of the compressor and the inlet side of the radiator and a section of the refrigerant circuit between the check valves and the suction side of the compressor. The hot gas bypass valve is provided in the hot gas bypass pipe. In the pressure control the control

component switches the hot gas bypass valve to an open state.

[0025] It will be noted that the pressure control here is not limited to just switching the hot gas bypass valve to an open state, and another process (pressure control according to another aspect) may be executed at the same time as, or around the same time as, the process of switching the hot gas bypass valve to an open state.

[0026] In this refrigeration apparatus, when refrigerant leakage occurs, the control component switches the hot gas bypass valve to an open state so that the refrigerant pressure on the discharge side of the compressor can be made to act between the check valves and the suction side of the compressor, so it becomes possible to more reliably inhibit contamination with air from the leaking portion of the leaking unit.

[0027] A refrigeration apparatus pertaining to the sixth aspect is the refrigeration apparatus pertaining to any of the first aspect to the fifth aspect, wherein the refrigerant circuit has an injection pipe and an injection valve. The injection pipe interconnects a section of the refrigerant circuit between the outlet of the radiator and the inlets of the units and a section of the refrigerant circuit between the check valves and the compressor. The injection valve is provided in the injection pipe. In the pressure control the control component switches the injection valve to an open state.

[0028] Here, the section between the check valves and the compressor may be a section between the check valves and the suction side of the compressor or may be a section between the check valves and a stage in the middle of the compression stroke of the compressor.

[0029] It will be noted that the pressure control here is not limited to just switching the injection valve to an open state, and another process (pressure control according to another aspect) may be executed at the same time as, or around the same time as, the process of switching the injection valve to an open state.

[0030] In this refrigeration apparatus, when refrigerant leakage occurs, the control component switches the injection valve to an open state so that the refrigerant pressure in the section between the outlet of the radiator and the inlets of the units can be made to act between the check valves and the compressor, so it becomes possible to more reliably inhibit contamination with air from the leaking portion of the leaking unit.

<Advantageous Effects of Invention>

[0031] In the refrigeration apparatus pertaining to the first aspect, even if refrigerant leakage occurs, it becomes possible to keep the extent of the refrigerant leakage small, effectively utilize portions in which leakage is not occurring, and inhibit contamination of the refrigerant circuit with air.

[0032] In the refrigeration apparatus pertaining to the second aspect, it becomes possible to more reliably inhibit contamination with air from the leaking portion of the leaking unit.

[0033] In the refrigeration apparatus pertaining to the third aspect, it becomes possible to more reliably inhibit contamination with air from the leaking portion of the leaking unit on which atmospheric pressure is acting.

[0034] In the refrigeration apparatus pertaining to the fourth aspect, it becomes possible to not only change the reference value in the control relating to the low pressure when there is no leakage but also inhibit contamination with air from the leaking portion of the leaking unit.

[0035] In the refrigeration apparatus pertaining to the fifth aspect, the refrigerant pressure on the discharge side of the compressor can be made to act between the check valves and the suction side of the compressor, so it becomes possible to more reliably inhibit contamination with air from the leaking portion of the leaking unit.

[0036] In the refrigeration apparatus pertaining to the sixth aspect, the refrigerant pressure in the section between the outlet of the radiator and the inlets of the units can be made to act between the check valves and the compressor, so it becomes possible to more reliably inhibit contamination with air from the leaking portion of the leaking unit.

BRIEF DESCRIPTION OF DRAWINGS

[0037]

FIG. 1 is a diagram of the overall configuration of a refrigeration apparatus pertaining to an embodiment of the invention.

FIG. 2 is a block diagram schematically showing the general configuration of a controller and parts connected to the controller.

FIG. 3 is a flowchart showing an example of a flow of processes executed by the controller in a refrigerant leakage control mode.

FIG. 4 is a diagram of the overall configuration of a refrigeration apparatus having a refrigerant circuit pertaining to example modification A.

FIG. 5 is a diagram of the overall configuration of a refrigeration apparatus having a refrigerant circuit pertaining to example modification B.

FIG. 6 is a diagram of the overall configuration of a refrigeration apparatus having a refrigerant circuit pertaining to

example modification C.

DESCRIPTION OF EMBODIMENT

[0038] A refrigeration apparatus 100 pertaining to an embodiment of the invention will be described below with reference to the drawings. It will be noted that the following embodiment is a specific example of the invention, is not intended to limit the technical scope of the invention, and can be appropriately changed in a range that does not depart from the spirit of the invention.

(1) Refrigeration Apparatus 100

[0039] FIG. 1 is a diagram of the general configuration of the refrigeration apparatus 100 pertaining to the embodiment of the invention. The refrigeration apparatus 100 is a apparatus that performs, by means of a vapor compression refrigeration cycle, refrigeration of usage-side spaces such as refrigerated storage rooms or interior spaces of showcases in a store.

[0040] The refrigeration apparatus 100 mainly has a heat source unit 2, plural (here, two) usage units (the first usage unit 50 and the second usage unit 60), a liquid refrigerant communication pipe 6 and a gas refrigerant communication pipe 7 that connect the heat source unit 2 to the first usage unit 50 and the second usage unit 60, refrigerant leakage sensors that detect refrigerant leakage inside the usage units (the first refrigerant leakage sensor 81 that detects refrigerant leakage inside the first usage unit 50 and the second refrigerant leakage sensor 82 that detects refrigerant leakage inside the second usage unit 60), plural remote controllers (the first remote controller 50a and the second remote controller 60a) serving as input devices and as display devices, and a controller 70 that controls the actions of the refrigeration apparatus 100.

[0041] In the refrigeration apparatus 100, a refrigerant circuit 10 is configured as a result of the first usage unit 50 and the second usage unit 60 being connected, in parallel to each other, to the one heat source unit 2 via the liquid refrigerant communication pipe 6 and the gas refrigerant communication pipe 7. In the refrigeration apparatus 100, a refrigeration cycle where refrigerant contained inside the refrigerant circuit 10 is compressed, cooled or condensed, reduced in pressure, heated or evaporated, and thereafter compressed again is performed. In the present embodiment, the refrigerant circuit 10 is charged with R32 as the refrigerant for carrying out the vapor compression refrigeration cycle.

(1-1) Heat Source Unit 2

[0042] The heat source unit 2 is connected to the first usage unit 50 and the second usage unit 60 via the liquid refrigerant communication pipe 6 and the gas refrigerant communication pipe 7 and configures part of the refrigerant circuit 10. The heat source unit 2 mainly has a compressor 21, a heat source-side heat exchanger 23 (radiator), a heat source-side fan 34, a receiver 24, a sub-cooler 25, a heat source-side expansion valve 28 (expansion mechanism), a hot gas bypass pipe 40, a hot gas bypass valve 41, an injection pipe 26, an injection valve 27, a liquid-side stop valve 29, and a gas-side stop valve 30.

[0043] Furthermore, the heat source unit 2 has a discharge-side refrigerant pipe 31 that interconnects the discharge side of the compressor 21 and the gas-side end of the heat source-side heat exchanger 23, a heat source-side liquid refrigerant pipe 32 that interconnects the liquid-side end of the heat source-side heat exchanger 23 and the liquid refrigerant communication pipe 6, and a suction-side refrigerant pipe 33 that interconnects the suction side of the compressor 21 and the gas refrigerant communication pipe 7.

[0044] Furthermore, the heat source unit 2 has the hot gas bypass pipe 40, which diverts some of the refrigerant flowing through the discharge-side refrigerant pipe 31 and returns the diverted refrigerant via the suction-side refrigerant pipe 33 to the suction side of the compressor 21, and the hot gas bypass valve 41, which is provided in the hot gas bypass pipe 40.

[0045] Furthermore, the heat source unit 2 has the injection pipe 26, which diverts some of the refrigerant flowing through the heat source-side liquid refrigerant pipe 32 and returns the diverted refrigerant to the compressor 21, and the injection valve 27, which is provided in the injection pipe 26. The injection pipe 26 branches from the section of the heat source-side liquid refrigerant pipe 32 on the downstream side of the sub-cooler 25, passes through the sub-cooler 25, and is then connected to the middle of the compression stroke of the compressor 21.

[0046] The compressor 21 is a device that compresses refrigerant at a low pressure in the refrigeration cycle to a high pressure. Here, as the compressor 21, a compressor with a closed structure in which a rotary-type or scroll-type positive-displacement compression element (not shown in the drawings) is driven to rotate by a compressor motor M21 is used. It will be noted that although it is not shown in the drawings, the compressor 21 of the present embodiment is configured as a result of a variable-capacity compressor and one or plural fixed-speed compressors being connected in parallel to each other. The compressor motor M21 is provided in the variable-capacity compressor, and the operating frequency

of the compressor motor M21 is controllable by an inverter. Although it is not particularly limited, when lowering the capacity of the compressor 21, the operating frequency of the variable-capacity compressor is lowered, and when further lowering the capacity of the compressor 21 when it is not enough to simply lower the operating frequency of the variable-capacity compressor, a process of stopping the fixed-speed compressor is performed.

[0047] The heat source-side heat exchanger 23 is a heat exchanger that functions as a radiator of refrigerant at a high pressure in the refrigeration cycle. Here, the heat source unit 2 has the heat source-side fan 34 for sucking outside air (heat source-side air) into the heat source unit 2, causing the air to exchange heat with the refrigerant in the heat source-side heat exchanger 23, and thereafter expelling the air to the outside. The heat source-side fan 34 is a fan for supplying to the heat source-side heat exchanger 23 the heat source-side air serving as a cooling source for the refrigerant flowing through the heat source-side heat exchanger 23. The heat source-side fan 34 is driven to rotate by a heat source-side fan motor M34.

[0048] The receiver 24 is a container that temporarily accumulates the refrigerant that has condensed in the heat source-side heat exchanger 23 and is disposed in the heat source-side liquid refrigerant pipe 32.

[0049] The sub-cooler 25 is a heat exchanger that further cools the refrigerant temporarily accumulated in the receiver 24 and is disposed in the heat source-side liquid refrigerant pipe 32 (more specifically, in the section on the downstream side of the receiver 24).

[0050] The heat source-side expansion valve 28 is an electric expansion valve whose opening degree is controllable, and the heat source-side expansion valve 28 is disposed in the heat source-side liquid refrigerant pipe 32 (more specifically, in the section on the downstream side of the sub-cooler 25).

[0051] The injection valve 27 is disposed in the injection pipe 26 (more specifically, in the section between where the injection pipe 26 branches from the heat source-side liquid refrigerant pipe 32 and the inlet of the sub-cooler 25). The injection valve 27 is an electric expansion valve whose opening degree is controllable. The injection valve 27 reduces, in accordance with its opening degree, the pressure of the refrigerant flowing through the injection pipe 26 before the refrigerant flows into the sub-cooler 25.

[0052] The liquid-side stop valve 29 is a manual valve disposed in the section of the heat source-side liquid refrigerant pipe 32 where the heat source-side liquid refrigerant pipe 32 connects to the liquid refrigerant communication pipe 6.

[0053] The gas-side stop valve 30 is a manual valve disposed in the section of the suction-side refrigerant pipe 33 where the suction-side refrigerant pipe 33 connects to the gas refrigerant communication pipe 7.

[0054] Various sensors are disposed in the heat source unit 2. Specifically, a suction pressure sensor 36, which detects a suction pressure that is the pressure of the refrigerant on the suction side of the compressor 21, and a discharge pressure sensor 37, which detects a discharge pressure that is the pressure of the refrigerant on the discharge side of the compressor 21, are disposed in the vicinity of the compressor 21 in the heat source unit 2. Furthermore, a receiver outlet temperature sensor 38, which detects a receiver outlet temperature that is the temperature of the refrigerant at the outlet of the receiver 24, is disposed in the section of the heat source-side liquid refrigerant pipe 32 between the outlet of the receiver 24 and the inlet of the sub-cooler 25. Moreover, a heat source-side air temperature sensor 39, which detects the temperature of the heat source-side air sucked into the heat source unit 2, is disposed in the vicinity of the heat source-side heat exchanger 23 or the heat source-side fan 34.

[0055] The heat source unit 2 has a heat source unit control component 20 that controls the actions of each part configuring the heat source unit 2. The heat source unit control component 20 has a microcomputer including a CPU and a memory. The heat source unit control component 20 is connected via a communication line to, and sends and receives control signals and so forth to and from, a first usage unit control component 57 of the first usage unit 50 and a second usage unit control component 67 of the second usage unit 60.

(1-2) First Usage Unit 50

[0056] The first usage unit 50 is connected to the heat source unit 2 via the liquid refrigerant communication pipe 6 and the gas refrigerant communication pipe 7 and configures part of the refrigerant circuit 10.

[0057] The first usage unit 50 has the first usage-side expansion valve 54 and the first usage-side heat exchanger 52 (evaporator). Furthermore, the first usage unit 50 has the first usage-side liquid refrigerant pipe 59, which interconnects the liquid-side end of the first usage-side heat exchanger 52 and the liquid refrigerant communication pipe 6, and the first usage-side gas refrigerant pipe 58, which interconnects the gas-side end of the first usage-side heat exchanger 52 and the gas refrigerant communication pipe 7.

[0058] The first usage-side expansion valve 54 is a throttling mechanism that functions as a means for reducing the pressure of the high-pressure refrigerant sent from the heat source unit 2. In the present embodiment, the first usage-side expansion valve 54 is a thermostatic expansion valve including a feeler bulb and operates (its opening degree is automatically determined) in accordance with changes in the temperature of the feeler bulb.

[0059] The first usage-side heat exchanger 52 is a heat exchanger that functions as an evaporator of the refrigerant at a low temperature in the refrigeration cycle to refrigerate the interior space air (usage-side air).

[0060] Here, the first usage unit 50 has the first usage-side fan 53 for sucking the usage-side air into the first usage unit 50, causing the usage-side air to exchange heat with the refrigerant in the first usage-side heat exchanger 52, and thereafter supplying the usage-side air to the usage-side space. The first usage-side fan 53 is a fan for supplying to the first usage-side heat exchanger 52 the usage-side air serving as a heating source for the refrigerant flowing through the first usage-side heat exchanger 52. The first usage-side fan 53 is driven to rotate by a first usage-side fan motor M53.

[0061] Furthermore, the first usage unit 50 has a first on/off valve 55 (shutoff valve) that can shut off the flow of refrigerant flowing into the first usage unit 50. The first on/off valve 55 is disposed on the liquid refrigerant inlet side (the liquid refrigerant communication pipe 6 side) of the first usage unit 50. Specifically, the first on/off valve 55 is disposed more on the inlet side than the first usage-side heat exchanger 52. More specifically, the first on/off valve 55 is disposed more on the inlet side than the first usage-side expansion valve 54. In the present embodiment, the first on/off valve 55 is an electromagnetic valve that is switched between an open state and a closed state. When the first on/off valve 55 is switched to the closed state, the first on/off valve 55 shuts off the flow of refrigerant flowing into the first usage unit 50 (more specifically, the first usage-side heat exchanger 52). The first on/off valve 55 is controlled so as to normally be in the open state.

[0062] Furthermore, the first usage unit 50 has the first check valve 51 that can shut off the flow of refrigerant flowing (backflowing) into the first usage unit 50 from the outlet side. The first check valve 51 is disposed on the gas refrigerant outlet side (the gas refrigerant communication pipe 7 side) of the first usage unit 50. Specifically, the first check valve 51 is disposed more on the outlet side than the first usage-side heat exchanger 52. The first check valve 51 allows the flow of refrigerant from the first usage-side gas refrigerant pipe 58 to the gas refrigerant communication pipe 7 but shuts off the flow of refrigerant from the gas refrigerant communication pipe 7 to the first usage-side gas refrigerant pipe 58 (more specifically, beyond the first check valve 51 toward the first usage-side heat exchanger 52).

[0063] Furthermore, the first usage unit 50 has a first usage unit control component 57 that controls the actions of each part configuring the first usage unit 50. The first usage unit control component 57 has a microcomputer including a CPU and a memory. The first usage unit control component 57 is connected via a communication line to, and sends and receives control signals and so forth to and from, the heat source unit control component 20. The first usage unit control component 57 is electrically connected to the first refrigerant leakage sensor 81, and signals from the first refrigerant leakage sensor 81 are output to the first usage unit control component 57.

(1-3) Second Usage Unit 60

[0064] The second usage unit 60 has the same configuration as the first usage unit 50, is connected to the heat source unit 2 via the liquid refrigerant communication pipe 6 and the gas refrigerant communication pipe 7, and configures part of the refrigerant circuit 10. The second usage unit 60 is connected in parallel to the first usage unit 50.

[0065] The second usage unit 60 has a second usage-side expansion valve 64 and a second usage-side heat exchanger 62 (evaporator). Furthermore, the second usage unit 60 has a second usage-side liquid refrigerant pipe 69, which interconnects the liquid-side end of the second usage-side heat exchanger 62 and the liquid refrigerant communication pipe 6, and a second usage-side gas refrigerant pipe 68, which interconnects the gas-side end of the second usage-side heat exchanger 62 and the gas refrigerant communication pipe 7.

[0066] The second usage-side expansion valve 64 is a throttling mechanism that functions as a means for reducing the pressure of the high-pressure refrigerant sent from the heat source unit 2. In the present embodiment, the second usage-side expansion valve 64 is, like the first usage-side expansion valve 54, a thermostatic expansion valve including a feeler bulb and operates (its opening degree is automatically determined) in accordance with changes in the temperature of the feeler bulb.

[0067] The second usage-side heat exchanger 62 is a heat exchanger that functions as an evaporator of the refrigerant at a low temperature in the refrigeration cycle to refrigerate the interior space air (usage-side air).

[0068] Here, the second usage unit 60 also has, like the first usage unit 50, a second usage-side fan 63 that is driven to rotate by a second usage-side fan motor M63.

[0069] Furthermore, the second usage unit 60 has a second on/off valve 65 (shutoff valve) that is disposed on the liquid refrigerant inlet side (the liquid refrigerant communication pipe 6 side) of the second usage unit 60 and can shut off the flow of refrigerant flowing into the second usage unit 60. Specifically, the second on/off valve 65 is disposed more on the inlet side than the second usage-side heat exchanger 62. More specifically, the second on/off valve 65 is disposed more on the inlet side than the second usage-side expansion valve 64. In the present embodiment, the second on/off valve 65 is an electromagnetic valve that is switched between an open state and a closed state. When the second on/off valve 65 is switched to the closed state, the second on/off valve 65 shuts off the flow of refrigerant flowing into the second usage unit 60 (more specifically, the second usage-side heat exchanger 62). The second on/off valve 65 is controlled so as to normally be in the open state.

[0070] Furthermore, the second usage unit 60 has a second check valve 61 that is disposed on the gas refrigerant outlet side (the gas refrigerant communication pipe 7 side) of the second usage unit 60 and can shut off the flow of

refrigerant flowing (backflowing) into the second usage unit 60 from the outlet side. Specifically, the second check valve 61 is disposed more on the outlet side than the second usage-side heat exchanger 62. The second check valve 61 allows the flow of refrigerant from the second usage-side gas refrigerant pipe 68 to the gas refrigerant communication pipe 7 but shuts off the flow of refrigerant from the gas refrigerant communication pipe 7 to the second usage-side gas refrigerant pipe 68 (more specifically, beyond the second check valve 61 toward the second usage-side heat exchanger 62).

[0071] Furthermore, the second usage unit 60 has a second usage unit control component 67 that controls the actions of each part configuring the second usage unit 60. The second usage unit control component 67 has a microcomputer including a CPU and a memory. The second usage unit control component 67 is connected via a communication line to, and sends and receives control signals and so forth to and from, the heat source unit control component 20. The second usage unit control component 67 is electrically connected to the second refrigerant leakage sensor 82, and signals from the second refrigerant leakage sensor 82 are output to the second usage unit control component 67.

(1-4) First Refrigerant Leakage Sensor 81 and Second Refrigerant Leakage Sensor 82

[0072] The first refrigerant leakage sensor 81 is a sensor for detecting refrigerant leakage inside the first usage unit 50. The second refrigerant leakage sensor 82 is a sensor for detecting refrigerant leakage inside the second usage unit 60. In this way, the refrigerant leakage sensors 81 and 82 are disposed inside casings of the corresponding usage units 50 and 60. In the present embodiment, a known general-purpose sensor is used for the first refrigerant leakage sensor 81 and the second refrigerant leakage sensor 82.

[0073] When the first refrigerant leakage sensor 81 and the second refrigerant leakage sensor 82 detect refrigerant leakage, they output, to the first usage unit control component 57 or the second usage unit control component 67 to which they are connected, an electrical signal (hereinafter called a "refrigerant leakage signal") indicating that refrigerant leakage is occurring.

(1-5) First Remote Controller 50a and Second Remote Controller 60a

[0074] The first remote controller 50a is an input device for the user of the first usage unit 50 to input various instructions for switching the operating state of the refrigeration apparatus 100. Furthermore, the first remote controller 50a also functions as a display device for displaying the operating state of the refrigeration apparatus 100 and predetermined notification information. The first remote controller 50a is connected via a communication line to, and sends signals to and receives signals from, the first usage unit control component 57.

[0075] The second remote controller 60a is also, like the first remote controller 50a, an input device for the user of the second usage unit 60 to input various instructions for switching the operating state of the refrigeration apparatus 100 and a display device. The second remote controller 60a is connected via a communication line to, and sends signals to and receives signals from, the second usage unit control component 67.

(2) Details of Controller 70

[0076] In the refrigeration apparatus 100, the controller 70 that controls the actions of the refrigeration apparatus 100 is configured as a result of the heat source unit control component 20 being connected via a communication line to the first usage unit control component 57 and the second usage unit control component 67.

[0077] FIG. 2 is a block diagram schematically showing the general configuration of the controller 70 and parts connected to the controller 70.

[0078] The controller 70 has plural control modes and controls the operation of the refrigeration apparatus 100 in accordance with the control mode to which it has transitioned. For example, the controller 70 has, as control modes, a normal operating mode, to which it transitions during normal times, and a refrigerant leakage control mode, to which it transitions when refrigerant leakage occurs.

[0079] The controller 70 is electrically connected to the actuators (specifically, the compressor 21 (the compressor motor M21), the heat source-side expansion valve 28, the injection valve 27, the hot gas bypass valve 41, and the heat source-side fan 34 (the heat source-side fan motor M34)) and the various sensors (the suction pressure sensor 36, the discharge pressure sensor 37, the receiver outlet temperature sensor 38, and the heat source-side air temperature sensor 39, etc.) included in the heat source unit 2. Furthermore, the controller 70 is electrically connected to the actuators (specifically, the first usage-side fan 53 (the first usage-side fan motor M53), the first usage-side expansion valve 54, and the first on/off valve 55) included in the first usage unit 50. Furthermore, the controller 70 is electrically connected to the actuators (specifically, the second usage-side fan 63 (the second usage-side fan motor M63), the second usage-side expansion valve 64, and the second on/off valve 65) included in the second usage unit 60. Furthermore, the controller 70 is electrically connected to the first refrigerant leakage sensor 81 and the second refrigerant leakage sensor 82 and

to the first remote controller 50a and the second remote controller 60a.

[0080] The controller 70 mainly has a storage component 71, a communication component 72, a mode control component 73, an actuator control component 74, and a display control component 75. It will be noted that these components in the controller 70 are realized as a result of components included in the heat source unit control component 20 and/or the usage unit control components 57, 67 functioning integrally.

(2-1) Storage Component 71

[0081] The storage component 71 is configured by a ROM, a RAM, and a flash memory, for example, and includes a volatile storage region and a nonvolatile storage region. Stored in the storage component 71 is a control program in which processes executed in the components of the controller 70 are defined. Furthermore, predetermined information (e.g., detection values of the sensors, commands that have been input to the first remote controller 50a and the second remote controller 60a, etc.) is appropriately stored in predetermined storage regions of the storage component 71 by the components of the controller 70.

(2-2) Communication Component 72

[0082] The communication component 72 is a functional component that fulfills a role as a communication interface for sending signals to and receiving signals from the devices connected to the controller 70. The communication component 72 receives requests from the actuator control component 74 and sends predetermined signals to designated actuators. Furthermore, the communication component 72 receives, and stores in predetermined storage regions of the storage component 71, signals that have been output from the various sensors (36 to 39), the first refrigerant leakage sensor 81, the second refrigerant leakage sensor 82, the first remote controller 50a, and the second remote controller 60a.

(2-3) Mode Control Component 73

[0083] The mode control component 73 is a functional component that performs, for example, switching of the control mode. The mode control component 73 switches the control mode to the normal operating mode when neither the first refrigerant leakage sensor 81 nor the second refrigerant leakage sensor 82 is detecting refrigerant leakage.

[0084] When refrigerant leakage is detected by either of the first refrigerant leakage sensor 81 and the second refrigerant leakage sensor 82, the mode control component 73 switches the control mode to the refrigerant leakage control mode, and switches to the refrigerant leakage control mode according to which sensor has detected the refrigerant leakage out of the first refrigerant leakage sensor 81 and the second refrigerant leakage sensor 82.

(2-4) Actuator Control Component 74

[0085] The actuator control component 74 controls the actions of the actuators (e.g., the compressor 21, the on/off valve 55, etc.) included in the refrigeration apparatus 100 in accordance with the situation in line with the control program. For example, in the normal operating mode, the actuator control component 74 controls in real time the rotational speed of the compressor 21, the rotational speeds of the heat source-side fan 34 and the usage-side fan 53, and the opening degrees of the heat source-side expansion valve 28 and the injection valve 27 in accordance with the set temperature and the detection values of the various sensors. Furthermore, in the normal operating mode, a target value for the suction pressure is set in accordance with the refrigerating load required in the first usage unit 50 and the second usage unit 60, and the operating frequency of the compressor 21 is controlled in such a way that the suction pressure becomes the target value. Here, when, due to some kind of trouble other than refrigerant leakage, the suction pressure in the refrigerant circuit 10 falls to a predetermined reference pressure (a low-pressure cut-off value) or less, low-pressure protection control that lowers the capacity of the compressor 21 is performed. Furthermore, in the normal operating mode, the hot gas bypass valve 41 is switched to a completely closed state so that the refrigerant does not flow in the hot gas bypass pipe 40.

[0086] Furthermore, in the refrigerant leakage control mode, the actuator control component 74 controls the actions of the actuators in such a way that a predetermined operation is performed. Specifically, the actuator control component 74 continues to control the operating frequency of the compressor 21 in such a way that the suction pressure becomes the target pressure as in the normal operating mode, and, in regard to the usage unit in which the refrigerant leakage is occurring (hereinafter called "the leaking unit") out of the first usage unit 50 and the second usage unit 60, switches the on/off valve (the first on/off valve 55 or the second on/off valve 65) to a closed state to thereby discontinue the supply of the refrigerant to the leaking unit. Meanwhile, in regard to the usage unit in which the refrigerant leakage is not occurring (hereinafter called "the operable unit") out of the first usage unit 50 and the second usage unit 60, the actuator control component 74 maintains the on/off valve (the first on/off valve 55 or the second on/off valve 65) in an open state to

thereby continue the refrigeration utilizing the heat exchanger of the operable unit. Additionally, although the actuator control component 74 tries to maintain the driven state of the compressor 21 just after refrigerant leakage detection as mentioned above, the actuator control component 74 controls the compressor 21 so that the suction pressure in the refrigerant circuit 10 does not fall too much by raising, higher than the value in the normal operating mode, the value of the predetermined reference pressure (the low-pressure cut-off value) in the low-pressure protection control in the refrigerant leakage control mode, so that the refrigerant pressure on the compressor 21 suction side of the check valve (the first check valve 51 or the second check valve 61) of the leaking unit is maintained higher than the refrigerant pressure on the usage-side heat exchanger side of the check valve of the leaking unit. Additionally, the actuator control component 74, so that the drop in the suction pressure can be more reliably inhibited, controls the hot gas bypass valve 41 to an open state in order to make the pressure of the high-pressure refrigerant on the discharge side of the compressor 21 act on the compressor 21 suction side of the check valve of the leaking unit.

(2-5) Display Control Component 75

[0087] The display control component 75 is a functional component that controls the actions of the first remote controller 50a and the second remote controller 60a serving as display devices.

[0088] The display control component 75 causes the first remote controller 50a and the second remote controller 60a to output predetermined information in order to display information pertaining to the operating state and situation to a manager.

[0089] For example, during a refrigeration operation in the normal operating mode, the display control component 75 causes the first remote controller 50a and the second remote controller 60a to display various types of information such as the set temperature.

[0090] Furthermore, in the refrigerant leakage control mode, the display control component 75 causes the first remote controller 50a and the second remote controller 60a to display information specifically indicating that refrigerant leakage is occurring and the usage unit in which the refrigerant leakage is occurring out of the first usage unit 50 and the second usage unit 60. Furthermore, in the refrigerant leakage control mode, the display control component 75 causes the first remote controller 50a and the second remote controller 60a to display notification information, which indicates that actions are being continued in regard to the operable unit that is the operable usage unit in which the refrigerant leakage is not occurring, and information urging that a service engineer be informed.

(3) Flow of Refrigerant in Normal Operating Mode

[0091] The flow of the refrigerant in the refrigerant circuit 10 in the normal operating mode will be described below.

[0092] In the refrigeration apparatus 100, at the time of operation, a refrigeration operation (refrigeration cycle operation) where the refrigerant with which the refrigerant circuit 10 is charged circulates mainly in the order of the compressor 21, the heat source-side heat exchanger 23 (radiator), the receiver 24, the sub-cooler 25, the heat source-side expansion valve 28 (expansion mechanism), the usage-side expansion valves 54, 64, and the usage-side heat exchangers 52, 62 (evaporator) is performed.

[0093] When the refrigeration operation is started, inside the refrigerant circuit 10 the refrigerant is sucked into the compressor 21, compressed, and thereafter discharged. Here, the low pressure in the refrigeration cycle is the suction pressure detected by the suction pressure sensor 36, and the high pressure in the refrigeration cycle is the discharge pressure detected by the discharge pressure sensor 37.

[0094] In the compressor 21, capacity control according to the refrigerating load required in the first usage unit 50 and the second usage unit 60 is performed. Specifically, a target value for the suction pressure is set in accordance with the refrigerating load required in the first usage unit 50 and the second usage unit 60, and the operating frequency of the compressor 21 is controlled in such a way that the suction pressure becomes the target value.

[0095] It will be noted that when, due to some kind of trouble other than refrigerant leakage, the suction pressure in the refrigerant circuit 10 falls to the predetermined reference pressure (the low-pressure cut-off value) or less, the low-pressure protection control that lowers the capacity of the compressor 21 is performed. In the present embodiment, as one example, the low-pressure cut-off value in this normal operating mode is set to a negative pressure value.

[0096] The gas refrigerant that has been discharged from the compressor 21 travels through the discharge-side refrigerant pipe 31 and flows into the gas-side end of the heat source-side heat exchanger 23.

[0097] It will be noted that in the normal operating mode the hot gas bypass valve 41 is switched to a completely closed state so that the refrigerant does not flow in the hot gas bypass pipe 40.

[0098] The gas refrigerant that has flowed into the gas-side end of the heat source-side heat exchanger 23 exchanges heat with the heat source-side air supplied by the heat source-side fan 34, radiates heat, condenses, and becomes liquid refrigerant in the heat source-side heat exchanger 23, and then the liquid refrigerant flows out from the liquid-side end of the heat source-side heat exchanger 23.

[0099] The liquid refrigerant that has flowed out from the liquid-side end of the heat source-side heat exchanger 23 travels through the section of the heat source-side liquid refrigerant pipe 32 between the heat source-side heat exchanger 23 and the receiver 24 and flows into the inlet of the receiver 24. The liquid refrigerant that has flowed into the receiver 24 is temporarily accumulated as liquid refrigerant in a saturated state in the receiver 24 and thereafter flows out from the outlet of the receiver 24.

[0100] The liquid refrigerant that has flowed out from the outlet of the receiver 24 travels through the section of the heat source-side liquid refrigerant pipe 32 between the receiver 24 and the sub-cooler 25 and flows into the inlet on the heat source-side liquid refrigerant pipe 32 side of the sub-cooler 25.

[0101] The liquid refrigerant that has flowed into the sub-cooler 25 exchanges heat with the refrigerant flowing through the injection pipe 26, is further cooled, and becomes liquid refrigerant in a sub-cooled state in the sub-cooler 25, and then the sub-cooled liquid refrigerant flows out from the outlet on the heat source-side liquid refrigerant pipe 32 side of the sub-cooler 25.

[0102] The liquid refrigerant that has flowed out from the outlet on the heat source-side liquid refrigerant pipe 32 side of the sub-cooler 25 travels through the section of the heat source-side liquid refrigerant pipe 32 between the sub-cooler 25 and the heat source-side expansion valve 28 and flows into the heat source-side expansion valve 28. At this time, some of the liquid refrigerant that has flowed out from the outlet on the heat source-side liquid refrigerant pipe 32 side of the sub-cooler 25 is branched from the section of the heat source-side liquid refrigerant pipe 32 between the sub-cooler 25 and the heat source-side expansion valve 28 to the injection pipe 26.

[0103] The refrigerant flowing through the injection pipe 26 is reduced in pressure by the injection valve 27 to an intermediate pressure in the refrigeration cycle. The refrigerant flowing through the injection pipe 26 after having been reduced in pressure by the injection valve 27 flows into the inlet on the injection pipe 26 side of the sub-cooler 25. The refrigerant that has flowed into the inlet on the injection pipe 26 side of the sub-cooler 25 exchanges heat with the refrigerant flowing through the heat source-side liquid refrigerant pipe 32, is heated, and becomes gas refrigerant in the sub-cooler 25. Then, the refrigerant that has been heated in the sub-cooler 25 flows out from the outlet on the injection pipe 26 side of the sub-cooler 25 and is returned to the middle of the compression stroke of the compressor 21.

[0104] The liquid refrigerant that has flowed into the heat source-side expansion valve 28 from the heat source-side liquid refrigerant pipe 32 is reduced in pressure by the heat source-side expansion valve 28, thereafter travels through the liquid-side stop valve 29 and the liquid refrigerant communication pipe 6, and flows into the first usage unit 50 and the second usage unit 60 that are in operation.

[0105] The refrigerant that has flowed into the first usage unit 50 travels through the first on/off valve 55 and part of the first usage-side liquid refrigerant pipe 59 and flows into the first usage-side expansion valve 54. The refrigerant that has flowed into the first usage-side expansion valve 54 is reduced in pressure by the first usage-side expansion valve 54 to a low pressure in the refrigeration cycle, travels through the first usage-side liquid refrigerant pipe 59, and flows into the liquid-side end of the first usage-side heat exchanger 52. The refrigerant that has flowed into the liquid-side end of the first usage-side heat exchanger 52 exchanges heat with the usage-side air supplied by the first usage-side fan 53, evaporates, and becomes gas refrigerant in the first usage-side heat exchanger 52, and then the gas refrigerant flows out from the gas-side end of the first usage-side heat exchanger 52. The gas refrigerant that has flowed out from the gas-side end of the first usage-side heat exchanger 52 flows via the first check valve 51 and the first usage-side gas refrigerant pipe 58 to the gas refrigerant communication pipe 7.

[0106] The refrigerant that has flowed into the second usage unit 60, as in the first usage unit 50, travels through the second on/off valve 65 and part of the second usage-side liquid refrigerant pipe 69 and flows into the second usage-side expansion valve 64. The refrigerant that has flowed into the second usage-side expansion valve 64 is reduced in pressure by the second usage-side expansion valve 64 to a low pressure in the refrigeration cycle, travels through the second usage-side liquid refrigerant pipe 69, and flows into the liquid-side end of the second usage-side heat exchanger 62. The refrigerant that has flowed into the liquid-side end of the second usage-side heat exchanger 62 exchanges heat with the usage-side air supplied by the second usage-side fan 63, evaporates, and becomes gas refrigerant in the second usage-side heat exchanger 62, and then the gas refrigerant flows out from the gas-side end of the second usage-side heat exchanger 62. The gas refrigerant that has flowed out from the gas-side end of the second usage-side heat exchanger 62 flows via the second check valve 61 and the second usage-side gas refrigerant pipe 68 to the gas refrigerant communication pipe 7.

[0107] The refrigerant that has flowed out from the first usage unit 50 and the refrigerant that has flowed out from the second usage unit 60 in this way merge in the gas refrigerant communication pipe 7, and the refrigerant travels through the gas-side stop valve 30 and the suction-side refrigerant pipe 33 and is sucked back into the compressor 21.

(4) Flow of Processes Executed by Controller 70 in Refrigerant Leakage Control Mode

[0108] An example of a flow of processes executed by the controller 70 when refrigerant leakage occurs in the normal operating mode will be described with reference to the flowchart of FIG. 3.

[0109] Here, a case where refrigerant leakage occurs in the first usage unit 50 out of the first usage unit 50 and the second usage unit 60 (a case where the first usage unit 50 is the leaking unit) and refrigerating actions are continued in the second usage unit 60 (a case where the second usage unit 60 is the operable unit) will be taken as an example and described, but the processes are the same no matter in which of the usage units the refrigerant leakage occurs.

[0110] In step S10, in a case where the controller 70 is receiving the refrigerant leakage signal from either the first refrigerant leakage sensor 81 or the second refrigerant leakage sensor 82 (i.e., a case where it is assumed that refrigerant leakage is occurring in either the first usage unit 50 or the second usage unit 60), the controller 70 proceeds to step S11. On the other hand, in a case where the controller 70 is not receiving the refrigerant leakage signal from either the first refrigerant leakage sensor 81 or the second refrigerant leakage sensor 82 (i.e., a case where it is assumed that refrigerant leakage is not occurring in either the first usage unit 50 or the second usage unit 60), the controller 70 continues the normal operating mode and repeats step S10.

[0111] In step S11, the controller 70 keeps driving the compressor 21 and closes the on/off valve (i.e., in this example, the first on/off valve 55) of the usage unit (the leaking unit) in which the refrigerant leakage is occurring out of the first usage unit 50 and the second usage unit 60. It will be noted that the on/off valve of the usage unit (the operable unit) in which the refrigerant leakage is not occurring out of the first usage unit 50 and the second usage unit 60 is kept open (i.e., in this example, the second on/off valve 65 is kept open). Then, the controller 70 moves to step S12.

[0112] In step S12, the controller 70 has the first remote controller 50a and the second remote controller 60a give notification of the information indicating that refrigerant leakage is occurring and which of the usage units is the leaking unit in which the refrigerant leakage is occurring. The notification here can be both a visual display and audio output.

[0113] In step S13, the controller 70 opens the hot gas bypass valve 41 to allow the refrigerant to flow in the hot gas bypass pipe 40. Here, the valve opening degree of the hot gas bypass valve 41 is not particularly limited; for example, the valve opening degree may be controlled in such a way as to become a predetermined opening degree decided beforehand, or may be controlled in such a way that the value of the suction pressure detected by the suction pressure sensor 36 is maintained at a value greater than atmospheric pressure, or may be controlled in such a way that the detection value of the suction pressure sensor 36 is greater after the hot gas bypass valve 41 has been opened than it is before the hot gas bypass valve 41 is opened. Thereafter, the controller 70 moves to step S14.

[0114] In step S14, the controller 70 raises the value of the predetermined reference pressure (the low-pressure cut-off value) in the low-pressure protection control in order to inhibit the suction pressure in the refrigerant circuit 10 from falling too much. Because of this, when refrigerant leakage occurs and the suction pressure falls, it becomes possible to perform, at an early stage, control that lowers the capacity of the compressor 21. It will be noted that in the present embodiment the predetermined reference pressure (the low-pressure cut-off value) was a negative pressure value in the normal operating mode, but in the refrigerant leakage control mode the controller 70 raises the value in such a way that it becomes a positive pressure value. Thereafter, the controller 70 moves to step S15.

[0115] In step S15, the controller 70 judges whether or not the amount of time that has elapsed since switching the hot gas bypass valve 41 to an open state in step S13 has exceeded a predetermined amount of time. Here, in a case where it has been judged that the amount of elapsed time has exceeded the predetermined amount of time, the controller 70 moves to step S16. In a case where it has been judged that the amount of elapsed time has not exceeded the predetermined amount of time, the controller 70 repeats step S15. By utilizing the hot gas bypass pipe 40 for the predetermined amount of time in this way, recovery of the refrigerant from the leaking unit to the heat source-side heat exchanger 23 and the receiver 24 and leakage of the refrigerant from the leaking unit end, and it becomes possible to stabilize the state of distribution of the refrigerant in the refrigerant circuit 10.

[0116] In step S16, the controller 70 closes the hot gas bypass valve 41 and then moves to step S17.

[0117] In step S17, standing by until a service engineer who has been made aware of the refrigerant leakage by the notification in step S12 arrives on site, the controller 70 waits for the input of a new command via the first remote controller 50a or the second remote controller 60a by, for example, the service engineer who has arrived on site and performs processes according to the command.

(5) Characteristics of Refrigeration Apparatus 100

(5-1)

[0118] In the refrigeration apparatus 100 pertaining to the embodiment, when refrigerant leakage occurs, further supply of the refrigerant to the leaking unit is discontinued by closing the on/off valve of the leaking unit (by closing the first on/off valve 55 in a case where refrigerant leakage occurs in the first usage unit 50 and closing the second on/off valve 65 in a case where refrigerant leakage occurs in the second usage unit 60). Because of this, the quantity of refrigerant leaking in the leaking unit can be inhibited from increasing.

(5-2)

[0119] Furthermore, by maintaining in an open state the on/off valve of the operable unit that is the unit in which the refrigerant leakage is not occurring (by maintaining the second on/off valve 65 in an open state in a case where refrigerant leakage occurs in the first usage unit 50 and maintaining the first on/off valve 55 in an open state in a case where refrigerant leakage occurs in the second usage unit 60), it is possible to continue refrigerating actions in the operable unit even when refrigerating actions in the leaking unit have been stopped. Because of this, it becomes possible to continue to refrigerate the refrigeration target at least with the operable unit that is the unit in which the refrigerant leakage is not occurring, so it becomes possible to inhibit trouble affecting the refrigeration target caused by refrigeration being discontinued.

(5-3)

[0120] Furthermore, although the refrigerant continues to be supplied to the operable unit, the refrigerant that has evaporated in the usage-side heat exchanger of the operable unit and flowed out from the operable unit flows back toward the suction side of the compressor 21. Here, a check valve is provided in the section of the leaking unit on the compressor 21 suction side, so even when the refrigerant flows from the operable unit to the suction side of the compressor 21, the refrigerant is inhibited from flowing in toward the leaking unit. Because of this also, the quantity of refrigerant leaking in the leaking unit can be inhibited from increasing.

(5-4)

[0121] Moreover, in the refrigeration apparatus 100 pertaining to the embodiment, when refrigerant leakage occurs, the controller 70 opens the hot gas bypass valve 41 to allow the refrigerant to flow in the hot gas bypass pipe 40, thereby causing the high pressure of the refrigerant discharged from the compressor 21 to act between the check valve of the leaking unit and the suction side of the compressor 21 so that the refrigerant pressure can be increased. For this reason, it becomes possible to avoid a situation where the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21 becomes lower than the refrigerant pressure at the portion leaking refrigerant on the upstream side of the check valve of the leaking unit (the usage-side gas refrigerant pipe, the usage-side heat exchanger, the usage-side liquid refrigerant pipe, the usage-side expansion valve) and to inhibit air from contaminating the refrigerant circuit 10 via the leaking portion of the leaking unit. Because of this, damage to devices such as the compressor 21, which can occur when air contaminates the refrigerant circuit 10, can be inhibited.

(5-5)

[0122] Moreover, in the refrigeration apparatus 100 pertaining to the embodiment, when refrigerant leakage occurs, the controller 70 raises the value of the predetermined reference pressure (the low-pressure cut-off value) in the low-pressure protection control in the refrigerant leakage control mode higher than the value in the normal operating mode and controls the compressor 21 in such a way that the suction pressure in the refrigerant circuit 10 does not fall too much.

[0123] Here, even when the controller 70 is controlling the operating frequency of the compressor 21 in such a way that the suction pressure becomes the target value, there is the concern that the low pressure in the refrigerant circuit 10 will transiently fall as a result of refrigerant leakage occurring and the on/off valve of the leaking unit being closed. For example, in a situation where there are a usage unit whose load is large and whose refrigerant flow rate is large and a usage unit whose load is small and whose refrigerant flow rate is small or which has no load and in which refrigerant is not flowing, when refrigerant leakage occurs in the usage unit whose load is large, the on/off valve becomes closed in the leaking unit whose load was large and whose refrigerant flow rate was large. In this case, if the operating frequency of the compressor 21 continues to be controlled in such a way that the suction pressure becomes the target value, there is the concern that the low pressure in the refrigerant circuit 10 will transiently fall because the quantity of refrigerant that the compressor 21 can suck in abruptly falls.

[0124] To address this, in the refrigeration apparatus 100 of the embodiment, even when such a transient drop in the low pressure occurs, in the refrigerant leakage control mode the value of the predetermined reference pressure (the low-pressure cut-off value) in the low-pressure protection control is raised, so it becomes possible to lower, at an early stage, the capacity of the compressor 21 before the low pressure in the refrigerant circuit 10 falls a large extent (before it falls to the value of the predetermined reference pressure (the low-pressure cut-off value) in the low-pressure protection control in the normal operating mode).

[0125] Because of this, it becomes possible to inhibit the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21 from falling too much. For this reason, it is possible to avoid a situation where the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21

becomes lower than the refrigerant pressure at the portion leaking refrigerant on the upstream side of the check valve of the leaking unit (the usage-side gas refrigerant pipe, the usage-side heat exchanger, the usage-side liquid refrigerant pipe, the usage-side expansion valve) and to inhibit air from contaminating the refrigerant circuit 10 via the leaking portion of the leaking unit. Because of this, damage to devices such as the compressor 21, which can occur when air contaminates the refrigerant circuit 10, can also be inhibited.

(6) Example Modifications

[0126] The embodiment can be appropriately modified as described in the following example modifications. It will be noted that each example modification may also be combined with another example modification and applied to the extent that incompatibilities do not arise.

(6-1) Example Modification A

[0127] In the embodiment, the refrigeration apparatus 100, where the first on/off valve 55 and the thermostatic first usage-side expansion valve 54 are provided on the refrigerant inlet side of the first usage-side heat exchanger 52 in the first usage unit 50 and where the second on/off valve 65 and the thermostatic second usage-side expansion valve 64 are provided on the refrigerant inlet side of the second usage-side heat exchanger 62 in the second usage unit 60, was taken as an example and described.

[0128] However, as shown in FIG. 4, the refrigeration apparatus may also be a refrigeration apparatus 100a where a first usage-side electronic expansion valve 155 is provided instead of the first on/off valve 55 and the thermostatic first usage-side expansion valve 54 and where a second usage-side electronic expansion valve 165 is provided instead of the second on/off valve 65 and the thermostatic second usage-side expansion valve 64.

[0129] Here, the first usage-side electronic expansion valve 155 and the second usage-side electronic expansion valve 165 are both electrically connected to the controller 70 and are expansion valves whose opening degrees are controllable by the controller 70.

[0130] Regarding the expansion actions in the first usage-side electronic expansion valve 155 and the second usage-side electronic expansion valve 165 in the normal operating mode, the controller 70 appropriately adjusts the opening degrees of these electronic expansion valves, whereby it is possible to achieve the same effects as those of the refrigeration apparatus 100 of the embodiment.

[0131] Furthermore, regarding the actions of the first usage-side electronic expansion valve 155 and the second usage-side electronic expansion valve 165 in the refrigerant leakage control mode, the controller 70 performs control that completely closes (reduces to a minimum opening degree) the electronic expansion valve of the leaking unit out of the first usage-side electronic expansion valve 155 and the second usage-side electronic expansion valve 165 and performs control the continues the expansion actions in the electronic expansion valve of the operable unit, whereby it is possible to achieve the same effects as those of the refrigeration apparatus 100 of the embodiment.

[0132] It will be noted that even if the electronic expansion valve is controlled to its minimum opening degree, the refrigerant tends to flow slightly when there is a difference in the pressure of the refrigerant anterior and posterior to the electronic expansion valve. In this respect, the refrigeration apparatus of the embodiment, where the on/off valves are provided separately from the usage-side expansion valves, is superior in terms of more reliably inhibiting refrigerant leakage.

(6-2) Example Modification B

[0133] In the embodiment, the refrigeration apparatus 100 provided with the hot gas bypass pipe 40 and the hot gas bypass valve 41 was taken as an example and described.

[0134] However, as shown in FIG. 5, the refrigeration apparatus may also be a refrigeration apparatus 100b from which the hot gas bypass pipe 40 and the hot gas bypass valve 41 are omitted.

[0135] In this case, the control that uses the hot gas bypass pipe 40 to abruptly increase the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21 can no longer be performed, but control that raises the predetermined reference pressure (the low-pressure cut-off value) in the low-pressure protection control is performed in the refrigerant leakage control mode, so by reducing the capacity of the compressor 21, a situation where the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21 becomes lower than the refrigerant pressure at the portion leaking refrigerant on the upstream side of the check valve of the leaking unit can be avoided, so that air can be inhibited from contaminating the refrigerant circuit 10 via the leaking portion of the leaking unit.

[0136] Furthermore, even when the pressure increasing process using the hot gas bypass pipe 40 cannot be performed in this way, for example, when refrigerant leakage occurs, by increasing the quantity of refrigerant that is returned to the

middle of the compression stroke of the compressor 21 by causing the controller 70 to perform control that raises the opening degree of the injection valve 27 in the injection pipe 26, it is also possible to inhibit the extent of the drop in the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21.

[0137] Furthermore, causing the controller 70 to perform the control that increases the opening degree of the injection valve 27 in the injection pipe 26 when refrigerant leakage occurs is not limited to a case where the hot gas bypass pipe 40 and the hot gas bypass valve 41 are not provided; for example, in the embodiment where the hot gas bypass pipe 40 and the hot gas bypass valve 41 are provided, the controller 70 may also be configured to perform the control that increases the opening degree of the injection valve 27 at the same time, or around the same time, as when the controller 70 opens the hot gas bypass valve 41.

(6-3) Example Modification C

[0138] In example modification B, the refrigeration apparatus 100b, where the hot gas bypass pipe 40 and the hot gas bypass valve 41 are not provided and where, when there is refrigerant leakage, the controller 70 performs the control that increases the opening degree of the injection valve 27 provided in the injection pipe 26 connected to the middle stage of the compression stroke of the compressor 21, was taken as an example and described.

[0139] In contrast to this, for example, as shown in FIG. 6, the refrigeration apparatus may also be a refrigeration apparatus 100c where, when there is refrigerant leakage, the controller 70 performs control that increases the opening degree of the injection valve 27 provided in an injection pipe 126 connected to the suction-side refrigerant pipe 33 on the suction side of the compressor 21.

[0140] Even in this case, by increasing the opening degree of the injection valve 27, it becomes possible to inhibit the extent of the drop in the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21.

[0141] Furthermore, causing the controller 70 to perform the control that increases the opening degree of the injection valve 27 in the injection pipe 126 when refrigerant leakage occurs is, as in example modification B, not limited to a case where the hot gas bypass pipe 40 and the hot gas bypass valve 41 are not provided; for example, in the embodiment where the hot gas bypass pipe 40 and the hot gas bypass valve 41 are provided, the controller 70 may also be configured to perform the control that increases the opening degree of the injection valve 27 at the same time, or around the same time, as when the controller 70 opens the hot gas bypass valve 41.

(6-4) Example Modification D

[0142] In the embodiment, a case where the predetermined reference pressure (the low-pressure cut-off value) in the low-pressure protection control is a negative pressure value in the normal operating mode and where the value is raised to a positive pressure value in the refrigerant leakage control mode was taken as an example and described.

[0143] However, the value of the predetermined reference pressure (the low-pressure cut-off value) in the low-pressure protection control is appropriately settable in accordance with the type of refrigerant used in the refrigerant circuit 10 and the operating situation; for example, the value may be a positive pressure value even in the normal operating mode and become a positive pressure value greater in value also in the refrigerant leakage control mode.

[0144] Even in this case, it becomes possible to lower the operating capacity of the compressor 21 in such a way that the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21 does not fall to a pressure lower than atmospheric pressure.

(6-5) Example Modification E

[0145] In the embodiment, a case where the controller 70 performs the control that lowers the capacity of the compressor 21 by raising the value of the low-pressure cut-off value in the low-pressure protection control when there is refrigerant leakage was taken as an example and described.

[0146] In contrast to this, for example, when there is refrigerant leakage, the controller 70 may also be configured to perform control that forcibly lowers the operating capacity of the compressor 21 from the state just prior to refrigerant detection. Even in this case, it becomes possible to inhibit the extent of the drop in the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21.

[0147] Furthermore, for example, when there is refrigerant leakage, the operating capacity of the compressor 21 may be controlled in such a way that the refrigerant pressure closer to the suction side of the compressor 21 than the check valve of the leaking unit (the first check valve 51 or the second check valve 61) is maintained at atmospheric pressure or greater. Even in this case, it becomes possible to inhibit contamination with air from the leaking portion.

(6-6) Example Modification F

[0148] In the embodiment, a case where, when there is refrigerant leakage, the controller 70 performs the control that inhibits the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21 from becoming lower was taken as an example and described.

[0149] Here, the control that inhibits the refrigerant pressure between the check valve of the leaking unit and the suction side of the compressor 21 from becoming lower is not limited to performing control in such a way that the pressure detected by the suction pressure sensor 36 becomes equal to or greater than atmospheric pressure.

[0150] Between the position on the suction side of the compressor 21 where the suction pressure sensor 36 is provided in the refrigerant circuit 10 and the first check valve 51 of the first usage unit 50 and the second check valve 61 of the second usage unit 60, there is the gas refrigerant communication pipe 7, and pressure loss arises when the refrigerant travels through the gas refrigerant communication pipe 7.

[0151] Consequently, when this pressure loss component is taken into consideration, even if the pressure detected by the suction pressure sensor 36 becomes lower than atmospheric pressure, in that state sometimes the refrigerant pressure on the gas refrigerant communication pipe 7 side of the check valve of the leaking unit becomes greater than the refrigerant pressure on the usage-side gas refrigerant pipe side of the check valve of the leaking unit. In this situation, even if the pressure detected by the suction pressure sensor 36 becomes lower than atmospheric pressure, contamination with air from the leaking portion of the leaking unit can be prevented. Consequently, a lower limit for the pressure detected by the suction pressure sensor 36-one where, even though the pressure detected by the suction pressure sensor 36 is lower than atmospheric pressure, the refrigerant pressure on the gas refrigerant communication pipe 7 side of the check valve of the leaking unit can be made greater than the refrigerant pressure on the usage-side gas refrigerant pipe side of the check valve of the leaking unit-may also be determined, and the controller 70 may be configured to perform control of the capacity of the compressor 21 and control of the hot gas bypass valve 41 in such a way that the state in which the refrigerant pressure is equal to or greater than the lower limit can be maintained.

(6-7) Example Modification G

[0152] In the embodiment, the first refrigerant leakage sensor 81 and the second refrigerant leakage sensor 82 were disposed in order to detect refrigerant leakage in each usage units 50, 60. However, in a case where refrigerant leakage in each usage unit 50 is detectable without reliance upon the refrigerant leakage sensor 81, the refrigerant leakage sensor 81 is not invariably necessary in the refrigeration apparatus 100.

[0153] For example, in a case where a sensor such as a refrigerant pressure sensor or a refrigerant temperature sensor is disposed in each usage unit 50 and refrigerant leakage in each usage unit 50 is individually detectable on the basis of a change in the value detected by the sensor, the refrigerant leakage sensor 81 may also be omitted.

(6-8) Example Modification H

[0154] In the embodiment, the refrigeration apparatus 100 that performs refrigeration of refrigerated storage rooms or interior spaces of showcases in a store was taken as an example and described.

[0155] However, the refrigeration apparatus is not limited to this and may also be a refrigeration apparatus that refrigerates the interiors of shipping containers or may also be an air conditioning apparatus (air conditioner) that realizes air conditioning by, for example, cooling the interior of a building.

(6-9) Example Modification I

[0156] In the embodiment, R32 was used as the refrigerant circulating through the refrigerant circuit 10.

[0157] However, the refrigerant used in the refrigerant circuit 10 is not particularly limited. For example, in the refrigerant circuit 10, HFO1234yf, HFO1234ze, or a mixed refrigerant comprising these refrigerants may also be used instead of R32. Furthermore, in the refrigerant circuit 10, an HFC refrigerant such as R407C or R410Amay also be used. Furthermore, in the refrigerant circuit 10, a flammable refrigerant such as propane or a toxic refrigerant such as ammonia may also be used.

INDUSTRIAL APPLICABILITY

[0158] The present invention is applicable to a refrigeration apparatus.

REFERENCE SIGNS LIST

[0159]

2:	Heat Source Unit
10:	Refrigerant Circuit
20:	Heat Source Unit Control Component
21:	Compressor
23:	Heat Source-side Heat Exchanger (Radiator)
24:	Receiver
25:	Sub-cooler
26:	Injection Pipe
27:	Injection Valve
28:	Heat Source-side Expansion Valve (Expansion Mechanism)
36:	Suction Pressure Sensor
37:	Discharge Pressure Sensor
40:	Hot Gas Bypass Pipe
41:	Hot Gas Bypass Valve
50:	First Usage Unit
51:	First Check Valve (Check Valve)
52:	First Usage-side Heat Exchanger (Evaporator)
54:	First Usage-side Expansion Valve
55:	First On/OffValve (Shutoff Valve)
57:	First Usage Unit Control Component
58:	First Usage-side Gas Refrigerant Pipe
59:	First Usage-side Liquid Refrigerant Pipe
60:	Second Usage Unit
61:	Second Check Valve (Check Valve)
62:	Second Usage-side Heat Exchanger (Evaporator)
64:	Second Usage-side Expansion Valve
65:	Second On/Off Valve (Shutoff Valve)
67:	Second Usage Unit Control Component
68:	Second Usage-side Gas Refrigerant Pipe
69:	Second Usage-side Liquid Refrigerant Pipe
70:	Controller (Control Component)
81:	First Refrigerant Leakage Sensor
82:	Second Refrigerant Leakage Sensor
100, 100a, 100b, 100c:	Refrigeration Apparatus
126:	Injection Pipe
155:	First Usage-side Electronic Expansion Valve (Shutoff Valve)
165:	Second Usage-side Electronic Expansion Valve (Shutoff Valve)

CITATION LIST

<Patent Literature>

[0160] Patent Document 1: JP-ANo. 2002-228281

Claims

1. A refrigeration apparatus (100, 100a, 100b, 100c) comprising:

a refrigerant circuit (10) having

a compressor (21),
a radiator (23),
an expansion mechanism (28),

plural evaporators (52, 62) connected in parallel to each other,
check valves (51, 61) that are provided in correspondence to refrigerant outlet sides of the evaporators and stop the flow of refrigerant backflowing from downstream side to upstream side toward their corresponding evaporators, and
shutoff valves (55, 65, 155, 165) that are provided in correspondence to refrigerant inlet sides of the evaporators and can shut off the flow of refrigerant; and

a control component (70) which, when a refrigerant leakage situation inside any of units (50, 60) housing the evaporators meets a predetermined condition, uses the shutoff valve corresponding to the evaporator housed in the unit in which the predetermined condition has been met to shut off the flow of refrigerant and performs pressure control so as to ensure a state in which, with respect to the check valve corresponding to the evaporator housed in the unit in which the predetermined condition has been met, the refrigerant pressure on the opposite side of the corresponding evaporator side is greater than the refrigerant pressure on the corresponding evaporator side.

2. The refrigeration apparatus according to claim 1, wherein in the pressure control the control component increases the refrigerant pressure in a low-pressure line interconnecting the check valves and the suction side of the compressor.

3. The refrigeration apparatus according to claim 2, wherein in the pressure control the control component increases the refrigerant pressure in the low-pressure line to atmospheric pressure or greater.

4. The refrigeration apparatus according to any one of claims 1 to 3, wherein
the capacity of the compressor is controllable,
the control component performs control that lowers the capacity of the compressor when the pressure of the refrigerant flowing through the suction side of the compressor becomes equal to or less than a predetermined reference pressure, and
in the pressure control the control component raises the value of the reference pressure.

5. The refrigeration apparatus according to any one of claims 1 to 4, wherein
the refrigerant circuit has

a hot gas bypass pipe (40) that interconnects a section of the refrigerant circuit between the discharge side of the compressor and the inlet side of the radiator and a section of the refrigerant circuit between the check valves and the suction side of the compressor and
a hot gas bypass valve (41) that is provided in the hot gas bypass pipe, and

in the pressure control the control component switches the hot gas bypass valve to an open state.

6. The refrigeration apparatus according to any one of claims 1 to 5, wherein
the refrigerant circuit has

an injection pipe (26, 126) that interconnects a section of the refrigerant circuit between the outlet of the radiator and the inlets of the units and a section of the refrigerant circuit between the check valves and the compressor and
an injection valve (27) that is provided in the injection pipe, and

in the pressure control the control component switches the injection valve to an open state.

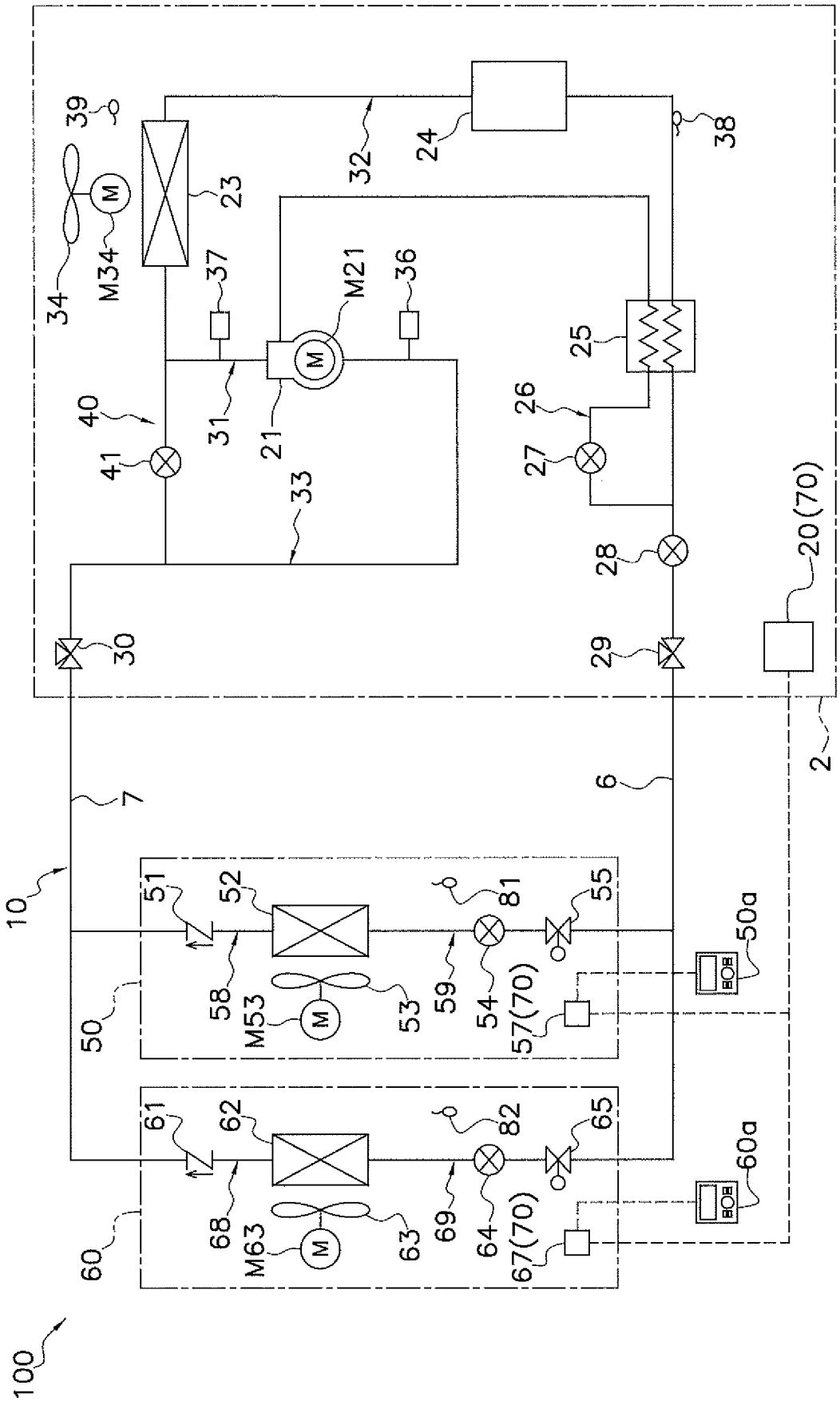

100
10
7
6
2
20(70)
30
29
28
27
26
25
24
23
32
38
39
34
M34
37
M21
36
31
21
33
40
41
51
52
58
M53
53
59
54
57(70)
81
55
50a
50
61
62
68
M63
63
69
64
67(70)
82
65
60a
60

FIG. 1

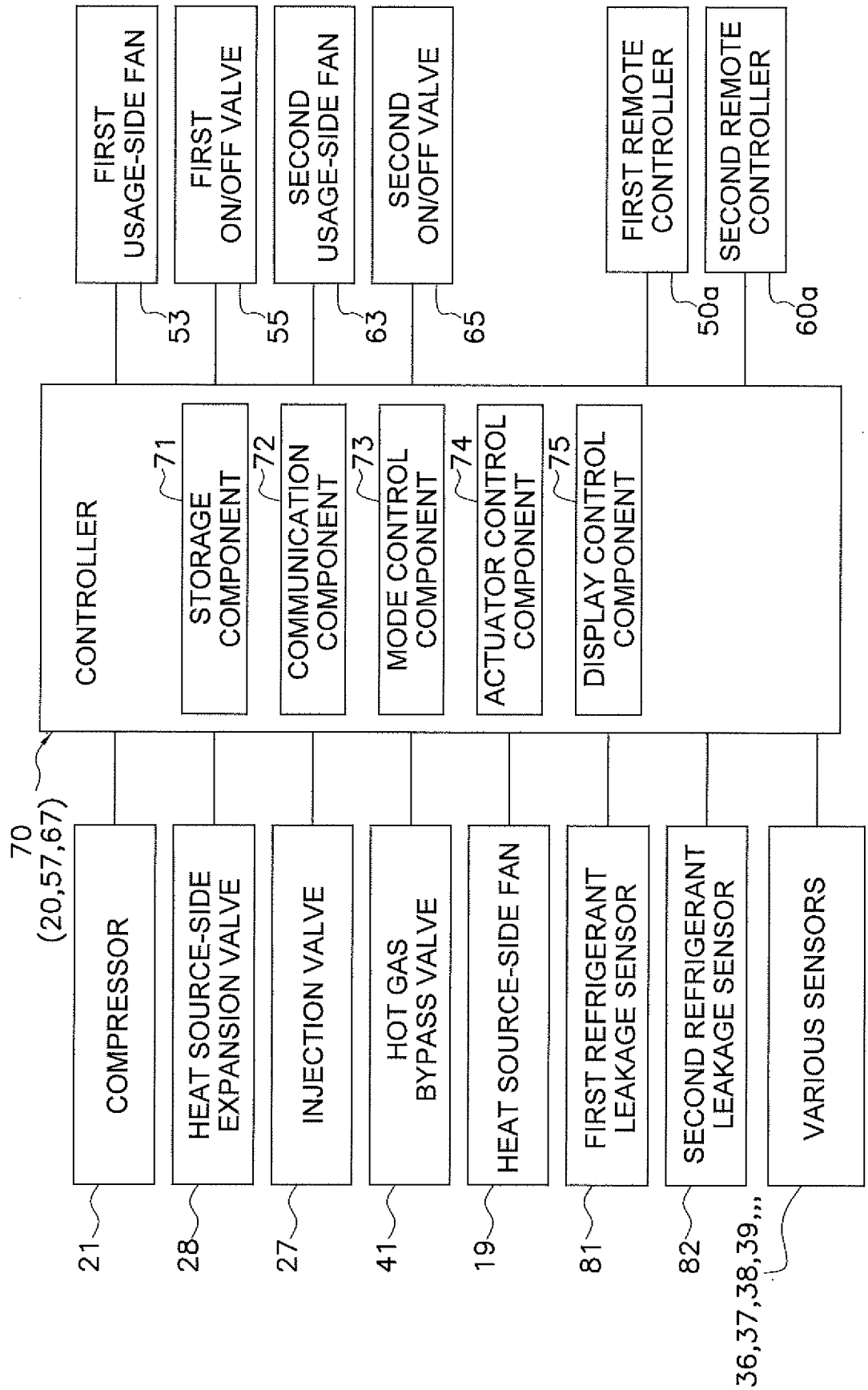

FIRST USAGE-SIDE FAN
FIRST ON/OFF VALVE
SECOND USAGE-SIDE FAN
SECOND ON/OFF VALVE
FIRST REMOTE CONTROLLER
SECOND REMOTE CONTROLLER
53
55
63
65
50a
60a
CONTROLLER
STORAGE COMPONENT
COMMUNICATION COMPONENT
MODE CONTROL COMPONENT
ACTUATOR CONTROL COMPONENT
DISPLAY CONTROL COMPONENT
71
72
73
74
75
70
(20,57,67)
COMPRESSOR
HEAT SOURCE-SIDE EXPANSION VALVE
INJECTION VALVE
HOT GAS BYPASS VALVE
HEAT SOURCE-SIDE FAN
FIRST REFRIGERANT LEAKAGE SENSOR
SECOND REFRIGERANT LEAKAGE SENSOR
VARIOUS SENSORS
21
28
27
41
19
81
82
36,37,38,39,,,

FIG. 2

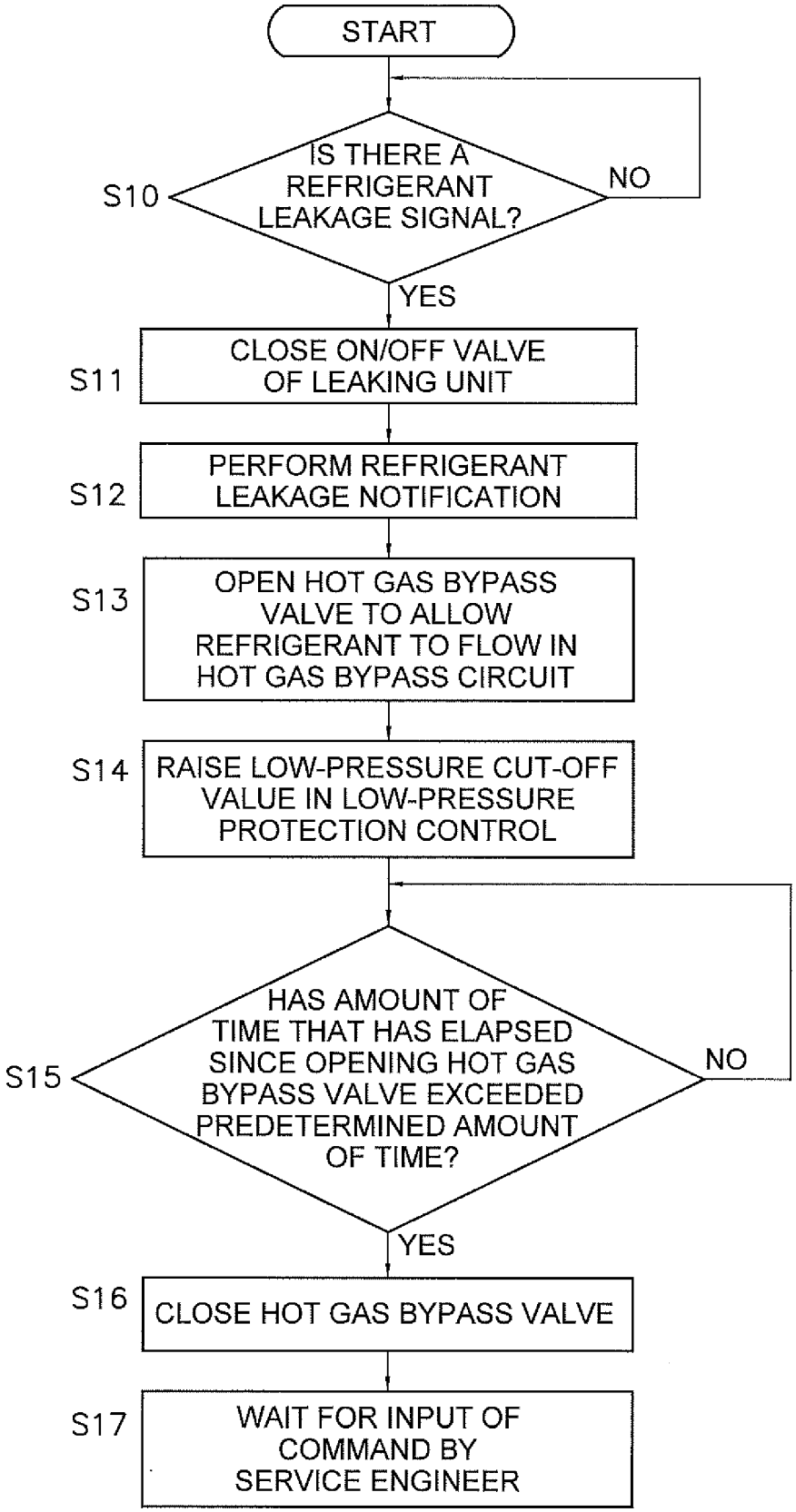

START
S10
IS THERE A REFRIGERANT LEAKAGE SIGNAL?
NO
YES
S11
CLOSE ON/OFF VALVE OF LEAKING UNIT
S12
PERFORM REFRIGERANT LEAKAGE NOTIFICATION
S13
OPEN HOT GAS BYPASS VALVE TO ALLOW REFRIGERANT TO FLOW IN HOT GAS BYPASS CIRCUIT
S14
RAISE LOW-PRESSURE CUT-OFF VALUE IN LOW-PRESSURE PROTECTION CONTROL
S15
HAS AMOUNT OF TIME THAT HAS ELAPSED SINCE OPENING HOT GAS BYPASS VALVE EXCEEDED PREDETERMINED AMOUNT OF TIME?
NO
YES
S16
CLOSE HOT GAS BYPASS VALVE
S17
WAIT FOR INPUT OF COMMAND BY SERVICE ENGINEER

FIG. 3

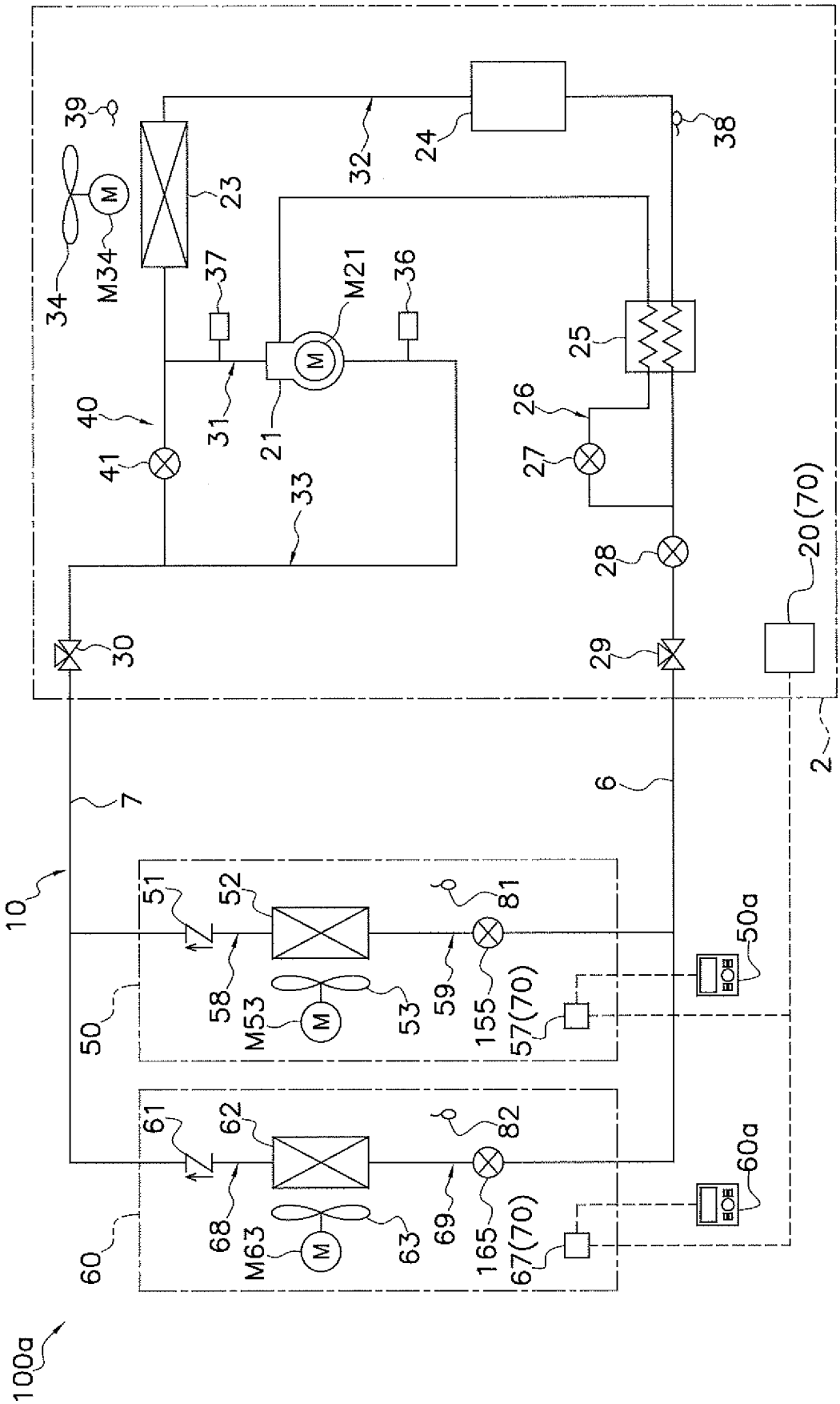
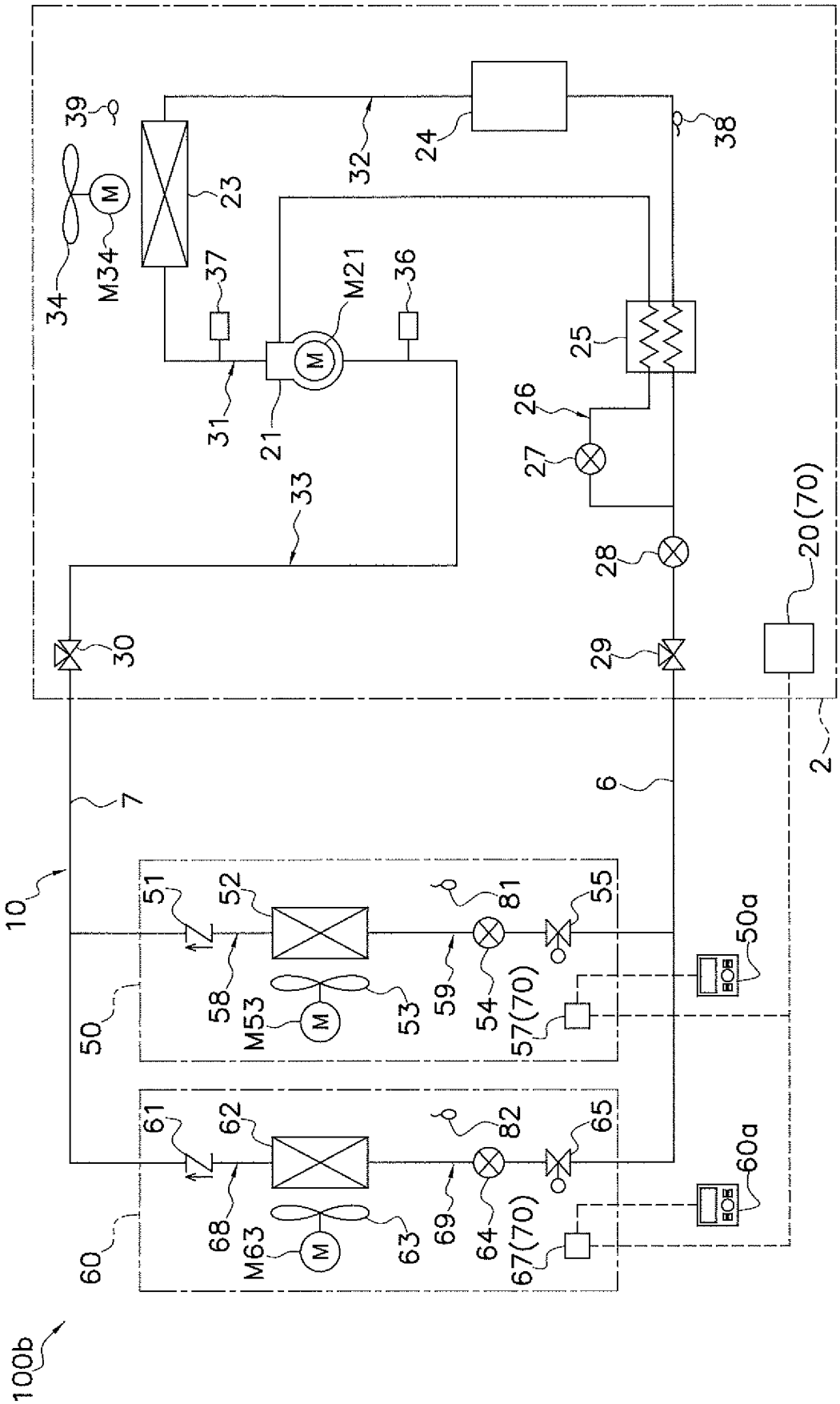

100a
10
2
6
7
20(70)
21
23
24
25
26
27
28
29
30
31
32
33
34
36
37
38
39
40
41
50
50a
51
52
53
57(70)
58
59
60
60a
61
62
63
67(70)
68
69
81
82
155
165
M21
M34
M53
M63
M

FIG. 4


100b
10
2
6
7
20(70)
23
24
25
26
27
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32
33
34
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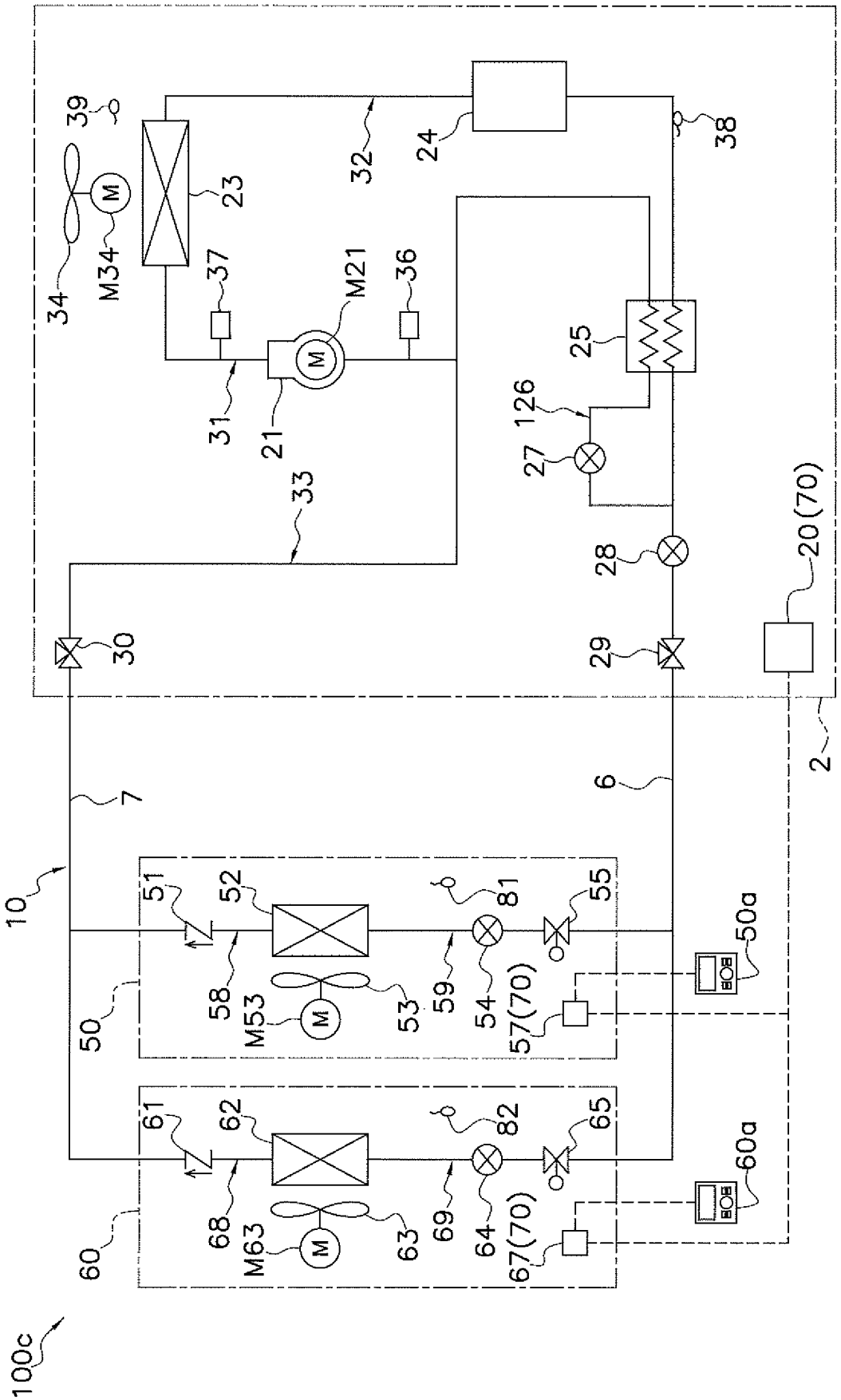
38
39
21
M21
M34
50
51
52
53
54
55
57(70)
58
59
60
61
62
63
64
65
67(70)
68
69
81
82
M53
M63
50a
60a

FIG. 5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33
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36
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39
M21
M34
126
50
50a
51
52
53
54
55
57(70)
58
59
60
60a
61
62
63
64
65
67(70)
68
69
81
82
M53
M63

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/005290

A. CLASSIFICATION OF SUBJECT MATTER
F25B49/02(2006.01)i, *F24F11/02*(2006.01)i, *F25B1/00*(2006.01)i, *F25B5/02*(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)
F25B1/00, F25B5/02, F25B13/00, F25B49/02, F24F11/02

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 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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.
A	JP 59-3346 Y2 (Daikin Industries, Ltd.), 30 January 1984 (30.01.1984), entire text; all drawings (Family: none)	1-6
A	JP 11-223431 A (Hitachi, Ltd.), 17 August 1999 (17.08.1999), entire text; all drawings (Family: none)	1-6
A	JP 5-118720 A (Hitachi, Ltd.), 14 May 1993 (14.05.1993), entire text; all drawings (Family: none)	1-6

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

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 April 2017 (26.04.17)	16 May 2017 (16.05.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/005290

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E,A	JP 2017-67428 A (Daikin Industries, Ltd.), 06 April 2017 (06.04.2017), entire text; all drawings (Family: none)	1-6

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002228281 A **[0003] [0160]**