(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 492 835 A1

(12) # EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
05.06.2019 Bulletin 2019/23

(21) Application number: **16910469.2**

(22) Date of filing: **26.07.2016**

(51) Int Cl.:
F25B 1/00 *(2006.01)*

(86) International application number:
PCT/JP2016/071816

(87) International publication number:
WO 2018/020566 (01.02.2018 Gazette 2018/05)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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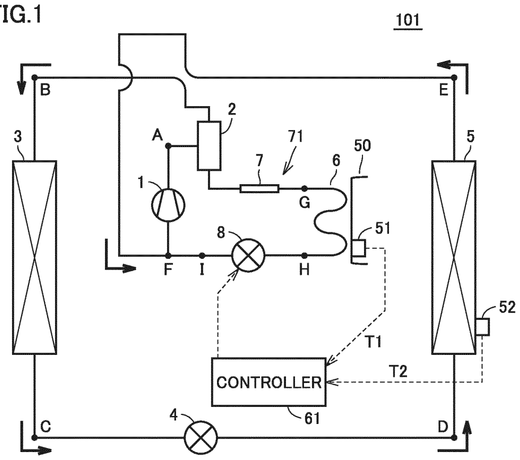
(54) **REFRIGERATION CYCLE DEVICE**

(57) A refrigeration cycle apparatus (101) includes a drain pan (50) configured to receive drain water obtained by condensing moisture in the air by an evaporator (5), a temperature detector (51) configured to detect a temperature related to a temperature of the drain water, an oil separator (2) provided between the compressor (1) and the condenser (3) and configured to separate refrigerating machine oil and the refrigerant from each other, an oil return passage (71) configured to return the refrigerating machine oil separated by the oil separator (2) to a suction port of the compressor (1) and configured to dissipate heat of the refrigerating machine oil passing therethrough to the drain water in the drain pan (50), and a valve (8) for adjusting a flow rate of the refrigerating machine oil of the oil return passage (71). The valve (8) is configured to have a degree of opening varying in accordance with an output of the temperature detector (51). This configuration can prevent freezing of the drain water in the drain pan (50) while suppressing performance degradation in normal operation.

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to refrigeration cycle apparatuses, and particularly, to the prevention of freezing of drain water generated in an evaporator.

BACKGROUND ART

[0002] A compressor of a refrigeration cycle apparatus contains refrigerating machine oil for secured lubricating property of the compressor. When the operation of the compressor is started, gas refrigerant is output from the compressor to a refrigerant circuit. A mixed solution of the liquid refrigerant and the refrigerating machine oil is taken out of the refrigerant circuit along with a flow of the gas refrigerant. Much of the refrigerating machine oil taken from the compressor out of the refrigerant circuit as the mixed solution is collected by an oil separator provided on a discharge side of the compressor and is returned to the compressor.

[0003] Japanese Patent Laying-Open No. 2010-32196 (PTL 1) discloses a refrigerator capable of effectively reducing the power of a compressor. This literature describes, as a refrigerator according to the fourth invention, an apparatus that releases the heat of the refrigerating machine oil into a drain pan when returning refrigerating machine oil separated by an oil separator to the compressor. This suppresses freezing of the drain water in the drain pan provided below an outdoor heat exchanger, appropriately discharging the drain water out of the drain pan.

CITATION LIST

PATENT LITERATURE

[0004] PTL 1: Japanese Patent Laying-Open No. 2010-32196

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] The refrigerator disclosed in Japanese Patent Laying-Open No. 2010-32196 is provided with a heating side cooler configured to release the heat of oil into the drain pan from the refrigerating machine oil separated from the refrigerant by the oil separator. However, the amount of the refrigerating machine oil cannot be controlled when the refrigerating machine oil separated by the oil separator is returned to the compressor. Consequently, a transient depletion of the refrigerating machine oil in the compressor, which occurs in the activation of the compressor or in the completion of defrosting of the compressor, cannot be suppressed.

[0006] When the amount of the refrigerating machine oil is not controlled, it is necessary to fill the refrigerant circuit with a sufficient amount of refrigerating machine oil to prevent a transient depletion of the refrigerating machine oil. In this case, torque required for the compressor increases due to excess oil in normal operation, which reduces the performance of the refrigeration cycle apparatus.

[0007] The present invention has an object to provide a refrigeration cycle apparatus capable of preventing freezing of drain water in a drain pan while suppressing performance degradation in normal operation.

SOLUTION TO PROBLEM

[0008] In a refrigeration cycle apparatus according to the present invention, refrigerant circulates in a compressor, a condenser, an expansion valve, and an evaporator. The refrigeration cycle apparatus includes a drain pan, a temperature detector, an oil separator, an oil return passage, and a valve. The drain pan is configured to receive drain water obtained by condensing moisture in the air by the evaporator. The temperature detector is configured to detect a temperature related to a temperature of the drain water. The oil separator is provided between the compressor and the condenser and is configured to separate refrigerating machine oil and the refrigerant from each other. The oil return passage has at least a portion disposed in the drain pan and is configured to return the refrigerating machine oil separated in the oil separator to a suction port of the compressor. The valve adjusts a flow rate of the refrigerating machine oil of the oil return passage. The valve is configured to have a degree of opening varying in accordance with an output of the temperature detector.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] According to the present invention, the degree of opening of the valve varies in accordance with the temperature of the drain pan. This suppresses a lack of the refrigerating machine oil owing to an increased amount of return oil when necessary and allows the oil separator to store the refrigerating machine oil to prevent an excessive amount of refrigerating machine oil in normal times.

[0010] Therefore, freezing of drain water in the drain pan can be prevented while suppressing performance degradation in normal operation.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

Fig. 1 shows a configuration of a refrigeration cycle apparatus according to Embodiment 1 of the present invention.

Fig. 2 shows a study example of a configuration in which an oil return passage does not pass through a drain pan.

Fig. 3 is a p-h diagram showing a state in which high-temperature refrigerating machine oil has flowed into a suction port of a compressor.

Fig. 4 is a waveform chart for illustrating a transient oil depletion state occurring in the compressor.

Fig. 5 is a flowchart showing an example of control performed by a controller 61.

Fig. 6 is a p-h diagram showing changes in the state of refrigerant of the refrigeration cycle apparatus of Embodiment 1.

Fig. 7 shows a configuration of a refrigeration cycle apparatus 102 according to Embodiment 2.

Fig. 8 is a flowchart showing an example of control performed by a controller 62 according to Embodiment 2.

Fig. 9 shows a configuration of a refrigeration cycle apparatus 103 according to Embodiment 3.

Fig. 10 shows a physical arrangement relationship among an oil-air heat exchanger 11, an evaporator 5, and a drain pan 50.

Fig. 11 is a flowchart showing an example of control performed by a controller 63 according to Embodiment 3.

Fig. 12 shows a configuration of a refrigeration cycle apparatus 104 according to Embodiment 4.

DESCRIPTION OF EMBODIMENTS

[0012] Embodiments of the present invention will be described below in detail with reference to the drawings. Although several embodiments will be described below, an appropriate combination of the configurations described in the respective embodiments has been intended at the time of application. The same or corresponding parts are designated by the same references, and description thereof will not be repeated.

[Embodiment 1]

[0013] Fig. 1 shows a configuration of a refrigeration cycle apparatus according to Embodiment 1 of the present invention. In a refrigeration cycle apparatus 101 shown in Fig. 1, refrigerant circulates in the order of a compressor 1, a condenser 3, an expansion valve 4, and an evaporator 5. Refrigeration cycle apparatus 101 includes a drain pan 50, a temperature detector 51, a temperature detector 52, an oil separator 2, an oil return passage 71, an adjustment valve 8, and a controller 61.

[0014] Oil separator 2 is provided between a discharge port (point A) of compressor 1 and condenser 3 and is configured to separate refrigerant and refrigerating machine oil (hereinafter, also merely referred to as "oil") from each other. Oil return passage 71 is configured to return the oil separated by oil separator 2 to a suction port (point F) of compressor 1. Drain pan 50 is configured to receive drain water obtained by condensing moisture in the air by evaporator 5.

[0015] Refrigeration cycle apparatus 101 is characterized by including temperature detector 51 and adjusting a flow rate of the oil of oil return passage 71 by adjustment valve 8 in accordance with an output of temperature detector 51. A configuration devoid of such temperature detector 51, oil return passage 71, and adjustment valve 8 suffers from the following problem.

[0016] Fig. 2 shows a study example of a configuration in which an oil return passage does not pass through a drain pan. In the configuration of Fig. 2, an oil return passage 507 limits a flow rate of the oil of oil return passage 507, and accordingly, a decompression device 508 is provided between a point G and a point H. Oil return passage 507 is disposed without passing through a drain pan (not shown), and compared with oil return passage 71 of Fig. 1, has a small length and radiates a small amount of heat. Since the same components as those of Fig. 1 are denoted by the same references, description thereof will be omitted for Fig. 2.

[0017] When the outside air has low temperature and high humidity, frost is formed in an outdoor evaporator. When frost is formed on the evaporator, the refrigeration cycle apparatus performs a defrosting operation (also referred to as defrosting) of temporarily reversing the direction in which refrigerant circulates through, for example, switch of a four-way valve (not shown) as required. At low temperatures, drain water generated by defrosting in the evaporator may also freeze. When the drain water stored in the drain pan freezes, drainage from the drain pan may be hindered, allowing ice to grow, which causes the evaporator to freeze from the lower side. A lump of ice generated in the lower portion of the evaporator as described above is referred to as "root ice." Then, the ventilation resistance of evaporator 5 increases, reducing the ability of the refrigeration cycle apparatus (such as an air conditioner or a water heater).

[0018] When the drain pan freezes, the defrosting operation may be performed frequently, and accordingly, the heating operation (hot-water supply operation) is stopped in defrosting operation. This may reduce comfort of indoor heating or reduce the temperature of stored hot water.

[0019] There is another problem associated with high-temperature oil flowing into a suction pipe. Fig. 3 is a p-h diagram showing a state in which high-temperature oil has flowed into a suction port of a compressor. In Fig. 3, points A to H respectively correspond to the states of the refrigerant at points A to H in the pipe of Fig. 2. High-temperature oil from oil separator 2 flows in the order of points G, H, and F, thus changing the state of the refrigerant at an input of the compressor at point F to increase a degree of superheat. This increases an input (an enthalpy difference of the refrigerant) of the compressor.

[0020] Although a film of a lubricant on the friction surface has higher stability as its viscosity is higher, when the oil has high temperature, an oil film is formed unsatisfactorily due to a decreasing viscosity, leading to reduced lubricating property. Also, the oxidation of the oil advances due to higher temperature, which may reduce reliability.

[0021] In the configuration of Fig. 2, a part of the refrigerant is returned from oil separator 2 to compressor 1 together with oil. Since an amount of refrigerant flowing through condenser 3 and evaporator 5 which are heat exchangers decreases, and the rotational speed of compressor 1 needs to be increased correspondingly. Thus, the original efficiency of refrigeration cycle apparatus 501 decreases by the provision of oil return passage 507.

[0022] Fig. 4 is a waveform chart for illustrating a transient oil depletion state occurring in a compressor. When the oil filling amount is not enough, a transient oil depletion as shown in Fig. 4 may occur, for example, in the activation of the compressor or in the completion of defrosting. An operation that is highly likely to cause a lack of refrigerating machine oil in compressor 1 as in the activation of the compressor or in the completion of defrosting will be referred to as an "oil depleting operation" below. In order to prevent a lack of lubrication in oil depleting operation, an amount of refrigerating machine oil, which is an excessive amount in normal operation, needs to fill a refrigerant circuit, leading to a reduction in efficiency in normal operation.

[0023] Refrigeration cycle apparatus 101 of Embodiment 1 is characterized by including temperature detector 51, oil return passage 71, and adjustment valve 8 as a measure taken against the above. Referring to Fig. 1 again, temperature detector 51 is configured to detect a temperature related to a temperature of drain water. Specifically, temperature detector 51 detects a surface temperature of drain pan 50. It should be noted that temperature detector 51 may detect a temperature of the drain water in drain pan 50.

[0024] Oil return passage 71 is configured to dissipate the heat of oil passing therethrough to drain water in drain pan 50. Oil return passage 71 includes an oil return pipe 7 and an oil-water heat exchanger 6. Adjustment valve 8 adjusts the flow rate of the oil in oil return passage 71. Adjustment valve 8 is configured to have a degree of opening varying in accordance with an output of temperature detector 51.

[0025] In refrigeration cycle apparatus 101, a part of oil return passage 71 is disposed in drain pan 50. This allows a part of oil return passage 71 to function as a means for heating drain pan 50, and drain pan 50 also functions as a means for cooling the oil flowing through oil return passage 71. Controller 61 adjusts an oil return amount or a heat exchange amount by adjustment valve 8 depending on the operating condition.

[0026] In the following embodiments, a "normal operation" refers to an operation when a refrigeration cycle is stabilized after the activation of a compressor. An "oil depleting operation" refers to an operation in which the oil in compressor 1 is taken out of compressor 1 and compressor 1 may suffer a breakdown due to, for example, poor lubrication of compressor 1, as described above. For example, an operation in activation or in switching from a defrost operation to a heating operation corresponds to the "oil depleting operation". A "drain antifreezing circuit" refers to an oil return circuit passing through oil-water heat exchanger 6 in the embodiments below.

[0027] A refrigerant flow will now be described in detail.

[0028] As shown in Fig. 1, refrigeration cycle apparatus 101 of the present embodiment has a configuration in which at least compressor 1, oil separator 2, condenser 3 (high-pressure-side heat exchanger), expansion valve 4, evaporator 5 (low-pressure-side heat exchanger), oil-water heat exchanger 6, oil return pipe 7, and adjustment valve 8 are connected by a pipe. Preferably, a four-way valve may be provided between a low-pressure duct (point E) and a high-pressure duct (point B) so as to reverse a refrigerant flow in defrosting operation.

[0029] Drain pan 50 is provided below evaporator 5. As indicated by the arrows in Fig. 1, in refrigeration cycle apparatus 101, high-temperature, high-pressure refrigerant discharged from compressor 1 flows into condenser 3, and low-temperature, low-pressure refrigerant that has passed through expansion valve 4 flows into evaporator 5.

[0030] Oil separator 2 is connected between the discharge port (point A) of compressor 1 and condenser 3 by the pipe (point B). Oil return pipe 7 is disposed at the bottom of oil separator 2. Oil-water heat exchanger 6 is connected between oil return pipe 7 (point G) and adjustment valve 8 (point H). Adjustment valve 8 is connected between the low-pressure pipe (point F) connecting compressor 1 and evaporator 5 to each other and oil-water heat exchanger 6 (point H).

[0031] A mixture of the high-temperature, high-pressure gas refrigerant and oil discharged from compressor 1 flows into oil separator 2 and is separated into gas refrigerant and oil. The gas refrigerant flows from oil separator 2 into condenser 3, whereas the oil flows from oil separator 2 into oil return pipe 7. In this manner, the oil separated by oil separator 2 passes through oil return pipe 7, oil-water heat exchanger 6, and adjustment valve 8 and is returned to the low-pressure pipe (point F) connected to the suction port of compressor 1.

[0032] On that occasion, the oil discharged from oil return pipe 7 passes through oil-water heat exchanger 6 while dissipating heat to the drain water in oil pan 50. High-temperature oil that has passed through oil-water heat exchanger 6 is decompressed by adjustment valve 8. Low-pressure, low-temperature oil that has been decompressed by adjustment valve 8 flows into a low-pressure pipe (point I) and meets, at a junction (point F), the low-temperature, low-pressure refrigerant that has been discharged from evaporator 5 and passes through the low-pressure point (point E). The low-temperature, low-pressure refrigerant and oil that have met is sucked by compressor 1.

[0033] A temperature detector 51 and a temperature detector 52 are provided in the refrigerant circuit through which refrigerant and oil circulate as described above.

Temperature detector 52 detects an outside air temperature (e.g., detects the temperature of a fluid (outside air) flowing outside of evaporator 5 in the heating operation). Temperature detector 51 detects a surface temperature of drain pan 50. Further, a temperature detector that detects a temperature of a fluid pipe of evaporator 5 may be provided.

[0034] Controller 61 computes a freezing determination temperature of drain water calculated from a detection value detected by the above detection unit and controls each actuator (e.g., a frequency of compressor 1 or a degree of opening of adjustment valve 8) in accordance with this freezing determination temperature and the current operating condition of refrigeration cycle apparatus 101.

[0035] Although the freezing determination temperature can be set to 0°C when, for example, T2<0°C, the freezing determination temperature may be determined appropriately experimentally.

[0036] For example, controller 61 increases an oil return amount when temperature detector 51 detects that a surface temperature T1 of drain pan 50 is lower than the freezing determination temperature. Also, controller 61 increases an oil return amount when detecting that the operating state of refrigeration cycle apparatus 101 is the oil depleting operation (e.g., in the activation of an operation or in the completion of defrosting). An oil return amount can be increased by, for example, increasing the degree of opening of adjustment valve 8.

[0037] On the other hand, controller 61 reduces an oil return amount and increases an oil amount in oil separator 2 when temperature detector 51 detects that surface temperature T1 of drain pan 50 is equal to or higher than the freezing determination temperature and when the operating state of refrigeration cycle apparatus 101 is not the oil depleting operation (e.g., in the activation of an operation or in the completion of defrosting). The oil return amount can be reduced by, for example, reducing the degree of opening of adjustment valve 8.

[0038] Fig. 5 is a flowchart showing an example of control performed by controller 61. A process of this flowchart is called from a main routine and executed for every certain period of time or every time a predetermined condition is satisfied. With reference to Figs. 1 and 5, in step S1, controller 61 detects an operating condition. Since controller 61 controls refrigeration cycle apparatus 101, for example, controls compressor 1, controller 61 can detect whether the current operating state of refrigeration cycle apparatus 101 is the oil depleting operation state, for example, in the activation of the compressor or in switching from the defrosting operation.

[0039] In step S2, controller 61 determines whether the operating state of refrigeration cycle apparatus 101 corresponds to the oil depleting operation (e.g., in the activation of the compressor or in switching from the defrosting operation). The process proceeds to step S3 when the state corresponds to the oil depleting operation (YES in S2), and otherwise (NO in S2), the process proceeds to step S4.

[0040] In step S4, controller 61 detects surface temperature T1 of drain pan 50 by temperature detector 51 and determines whether surface temperature T1 is higher than the freezing determination temperature. The process proceeds to step S5 when surface temperature T1 is higher than the freezing determination temperature (YES in S4), and the process proceeds to step S3 when surface temperature T1 is equal to or lower than the freezing determination temperature (NO in S4).

[0041] In step S3, controller 61 increases the degree of opening of adjustment valve 8 to increase the oil return amount. On the other hand, in step S4, controller 61 reduces the degree of opening of adjustment valve 8 to reduce the oil return amount.

[0042] In other words, controller 61 increases the degree of opening of adjustment valve 8 when surface temperature T1 of drain pan 50 is lower than the freezing determination temperature. On the other hand, controller 61 reduces the degree of opening of adjustment valve 8 when surface temperature T1 of drain pan 50 is equal to or higher than the freezing determination temperature and when the operating state is the normal operation which is less likely to cause oil depletion.

[0043] After the completion of the process of step S3 or step S4, control is returned to the main routine in step S6.

[0044] Changes in the enthalpy of the refrigeration cycle apparatus shown in Fig. 1 will now be described. Fig. 6 is a p-h diagram showing changes in the state of the refrigerant of the refrigeration cycle apparatus of Embodiment 1. States A to I in Fig. 6 respectively indicate the states of refrigerant corresponding to points A to I in Fig. 1.

[0045] Flows of refrigerant and oil will be described with reference to Fig. 6. The high-pressure, high-temperature gas refrigerant and oil (state A) discharged from compressor 1 flow into oil separator 2. The gas refrigerant and oil are separated from each other in oil separator 2, so that gas refrigerant (state B) flows into condenser 3 and the oil flows into oil return pipe 7.

[0046] The high-pressure, high-temperature oil (state G) that has passed through oil return pipe 7 flows into oil-water heat exchanger 6 and enters state H while dissipating heat to the drain water in drain pan 50. The oil (state H) that has passed through oil-water heat exchanger 6 is decompressed by adjustment valve 8 (state I). The oil (state I) flows into a low-pressure pipe between compressor 1 and evaporator 5, meets the refrigerant (state E) discharged from evaporator 5, and turns into mixed refrigerant (state F) to be sucked by compressor 1.

[0047] In oil depleting operation, the oil return amount is increased by increasing the degree of opening of adjustment valve 8. On the other hand, in normal operation, the oil return amount is reduced by reducing the degree of opening of adjustment valve 8 to cause the oil to remain in oil separator 2. Causing the oil in state I after heat radiation to meet the refrigerant in state E reduces an effect of heating by the return oil, thus suppressing an increase in the input of the compressor (an enthalpy difference of the refrigerant).

[0048] The refrigeration cycle apparatus according to Embodiment 1 described above can achieve the following effects.

(1) Suppressing freezing of drain pan 50 can prevent performance degradation of the evaporator and also suppress a reduction in comfort due to a prolonged defrosting time. Suppressing freezing of drain water also improves drainage performance, which may miniaturize a drain pan.

(2) Dissipating the heat of high-temperature, high-pressure refrigerating machine oil can suppress a reduction in the lubricating property in the compressor due to a reduced viscosity of the refrigerating machine oil and also suppress oxidation of the refrigerating machine oil, thus improving the reliability of the compressor.

(3) Suppressing a transient oil depletion of a compressor can ensure a lubricating property, thus improving the reliability of the compressor.

(4) In normal operation, the oil in the refrigerant circuit is stored in the oil separator, eliminating the need for delivering excess oil by a compressor, which improves the efficiency of the compressor. Also, a reduction in the heat transfer performance of the heat exchanger due to excess oil can be suppressed.

(5) In normal operation, an amount of refrigerant passing through an oil return passage (an amount by which a heat exchanger is bypassed) can be reduced, reducing the frequency of a compressor correspondingly.

[Embodiment 2]

[0049] In Embodiment 1, adjustment valve 8 that can adjust a flow rate of oil return passage 71 is provided. In Embodiment 2, a bypass passage that does not pass through oil-water heat exchanger 6 when oil is returned from oil separator 2 to compressor 1 is provided, and a flow rate adjusting mechanism that enables distribution suitable for the environmental condition and operating condition is placed.

[0050] Fig. 7 shows a configuration of a refrigeration cycle apparatus 102 according to Embodiment 2. With reference to Fig. 7, refrigeration cycle apparatus 102 includes, in the configuration of refrigeration cycle apparatus 101 of Embodiment 1, an oil return passage 72 in place of oil return passage 71 and a controller 62 in place of controller 61.

[0051] Oil return passage 72 includes a flow rate adjusting mechanism 9, oil-water heat exchanger 6, a bypass passage 20, and a junction 10. Controller 62 controls adjustment valve 8, flow rate adjusting mechanism 9, and compressor 1.

[0052] Oil-water heat exchanger 6 is configured to dissipate heat of the oil passing therethrough to the drain water in drain pan 50. Bypass passage 20 is configured to cause the oil to flow therethrough while bypassing oil-water heat exchanger 6. Flow rate adjusting mechanism 9 of refrigeration cycle apparatus 102 is configured to change a ratio between the flow rate of the oil passing through heat exchanger 6 and the flow rate of the oil passing through bypass passage 20.

[0053] Flow rate adjusting mechanism 9 may have any configuration that enables adjustment of an amount of oil passing through oil-water heat exchanger 6 and bypass passage 20. For example, flow rate adjusting mechanism 9 can have a configuration in which a flow rate adjustment valve is provided at each of branch destinations branched from a pipe or a configuration in which a four-way valve, a three-way valve, or the like is provided at a branch portion. In the example of Fig. 7, flow rate adjusting mechanism 9 includes a flow rate adjustment valve 9A and a flow rate adjustment valve 9B. Flow rate adjustment valve 9A is disposed between a point at which oil return pipe 7 is branched and oil-water heat exchanger 6. Flow rate adjustment valve 9B is disposed between the point at which oil return pipe 7 is branched and bypass passage 20. It should be noted that flow rate adjusting mechanism 9 may be provided at junction 10.

[0054] Since the other part of the configuration of refrigeration cycle apparatus 102 is similar to the configuration of refrigeration cycle apparatus 101 described with reference to Fig. 1, description thereof will not be repeated here.

[0055] In the present embodiment, in oil depleting operation, oil is caused to pass through an "oil depletion suppressing circuit" as an oil return circuit and is returned to the compressor. The "oil depletion suppressing circuit" refers to the shortest oil return circuit through which oil passes from a discharge port to a suction port of compressor 1 in the embodiment below. For example, bypass passage 20 in which oil is caused to flow from an oil separator directly to the suction port of the compressor corresponds to the "oil depletion suppressing circuit".

[Control of Valve, Flows of Refrigerant and Oil]

[0056] Control of various valves performed in refrigeration cycle apparatus 102 and a refrigerant flow will now be described.

[0057] Controller 62 computes a freezing determination temperature based on the outputs of temperature detectors 51 and 52. Controller 62 controls control parameters of the respective actuators (e.g., the frequency of compressor 1, the degree of opening of adjustment valve 8, and the degree of opening of each of flow rate adjustment valves 9A and 9B) based on the computed freezing determination temperature and the operating condition of refrigeration cycle apparatus 102.

[0058] A mixture of high-temperature, high-pressure gas refrigerant and oil discharged from compressor 1 flows into oil separator 2 and is separated into gas refrigerant and oil. The gas refrigerant (point B) flows from oil separator 2 into condenser 3, whereas the oil flows from oil separator 2 into oil return pipe 7.

[0059] On that occasion, the oil (point G) discharged from oil return pipe 7 flows into flow rate adjusting mechanism 9 and is distributed to bypass passage 20 (oil depletion suppressing circuit) and oil-water heat exchanger 6 (drain antifreezing circuit). The oil that has flowed into oil-water heat exchanger 6 passes through oil-water heat exchanger 6 while dissipating heat to the drain water. The oil passing through oil-water heat exchanger 6 flows as in Embodiment 1, and the state of the refrigerant also changes as described with reference to Fig. 6.

[0060] The oil discharged from flow rate adjusting mechanism 9 to bypass passage 20 meets, at junction 10 (point H), the oil that has passed through oil-water heat exchanger 6. The resultant oil obtained at junction 10 is decompressed by adjustment valve 8 (point I).

[0061] The low-pressure, low-temperature oil decompressed by adjustment valve 8 flows into the low-pressure pipe (point I) and meets, at the junction (point F), low-temperature, low-pressure refrigerant passing through the low-pressure pipe (point E) discharged from evaporator 5. The low-temperature, low-pressure refrigerant and oil that have met are sucked by compressor 1.

[0062] Controller 62 computes a freezing determination temperature of drain water calculated from the detection values detected by detectors 51 and 52, and controls the respective actuators (e.g., the frequency of compressor 1, and the degrees of opening of adjustment valve 8 and flow rate adjusting mechanism 9) in accordance with the freezing determination temperature and the current operating condition of refrigeration cycle apparatus 102. For example, although the freezing determination temperature can be set to 0°C when T2<0°C, the freezing determination temperature may be determined appropriately experimentally.

[0063] Controller 62 controls flow rate adjusting mechanism 9 to increase the flow rate of the oil of oil-water heat exchanger 6 when surface temperature T1 of drain pan 50 is lower than the freezing determination temperature of the drain water. For example, controller 62 reduces the degree of opening of flow rate adjustment valve 9A while increasing the degree of opening of flow rate adjustment valve 9B.

[0064] When detecting that the operating state of refrigeration cycle apparatus 102 is the oil depleting operation (e.g., the operation in the activation of an operation or in the completion of defrosting), controller 62 controls flow rate adjusting mechanism 9 to increase the flow rate of bypass passage 20. Controller 62 reduces the degree of opening of flow rate adjustment valve 9B while increasing the degree of opening of flow rate adjustment valve 9A.

[0065] On the other hand, when temperature detector 51 detects that surface temperature T1 of drain pan 50 is equal to or higher than the freezing determination temperature and when the operating state of refrigeration cycle apparatus 102 is not the oil depleting operation (e.g., in the activation of an operation or in the completion of defrosting), controller 62 reduces the degree of opening of adjustment valve 8 and increases the degrees of opening of flow rate adjustment valves 9A and 9B. In other words, in normal operation, controller 62 reduces an oil return amount by reducing the degree of opening of adjustment valve 8, thus allowing the oil to remain in each of oil separator 2, bypass passage 20 (oil depletion suppressing circuit), and oil-water heat exchanger 6 (drain antifreezing circuit).

[0066] Fig. 8 is a flowchart showing an example of control performed by controller 62 according to Embodiment 2. A process of this flowchart is called from a main routine and executed for every certain period of time or every time a predetermined condition is satisfied. With reference to Figs. 7 and 8, in step S11, controller 62 detects the operating condition. Since controller 62 controls refrigeration cycle apparatus 102, for example, controls compressor 1, controller 62 can detect whether the current operating state of refrigeration cycle apparatus 102 is the oil depleting operating state, for example, in the activation of the compressor or in switching from the defrosting operation.

[0067] In step S12, controller 62 determines whether the operating state of refrigeration cycle apparatus 102 corresponds to the oil depleting operation (e.g., in the activation of the compressor or in switching from the defrosting operation). The process proceeds to step S13 when the operating state corresponds to the oil depleting operation (YES in S12), and otherwise (NO in S12), the process proceeds to step S14.

[0068] In step S14, controller 62 detects surface temperature T1 of drain pan 50 by temperature detector 51 and determines whether surface temperature T1 is lower than the freezing determination temperature. The process proceeds to step S15 when surface temperature T1 is equal to or lower than the freezing determination temperature (NO in S14), and the process proceeds to step S16 when surface temperature T1 is higher than the freezing determination temperature (YES in S14).

[0069] In step S13, controller 62 reduces the degree of opening of flow rate adjustment valve 9B while increasing the degree of opening of flow rate adjustment valve 9A. The ratio of the oil passing through oil-water heat exchanger 6 in the oil passing through oil return passage 72 thus decreases.

[0070] In step S15, controller 62 reduces the degree of opening of flow rate adjustment valve 9A while increasing the degree of opening of flow rate adjustment valve 9B. This increases the ratio of the oil passing through oil-water heat exchanger 6 in the oil passing through oil return passage 72.

[0071] In step S16, adjustment valves 9A and 9B are fully opened, whereas the degree of opening of adjustment valve 8 is reduced. In normal operation, controller 62 reduces the oil return amount by reducing the degree of opening of adjustment valve 8 to cause the oil to remain in each of oil separator 2, bypass passage 20 (oil depletion suppressing circuit), and oil-water heat exchanger 6 (drain antifreezing circuit).

[0072] When the degree of opening of the valve is determined in the process of any of steps S13, S15, and S16, control is returned to the main routine in step S17.

[0073] Refrigeration cycle apparatus 102 according to Embodiment 2 described above can achieve effects similar to those of refrigeration cycle apparatus 101 of Embodiment 1. Further, flow rate adjustment valves 9A and 9B and adjustment valve 8 can more finely control a heat radiation amount for preventing freezing of a drain pan and an oil return amount for preventing an oil depletion of a compressor, further improving the reliability of the refrigeration cycle apparatus.

[Embodiment 3]

[0074] In Embodiment 2, the bypass passage that does not pass through oil-water heat exchanger 6 when oil is returned from oil separator 2 to compressor 1 is provided. In Embodiment 3, oil is returned from oil separator 2 to compressor 1 by causing oil to passing through an oil-air heat exchanger in place of a bypass passage.

[0075] Fig. 9 shows a configuration of a refrigeration cycle apparatus 103 according to Embodiment 3. With reference to Fig. 9, refrigeration cycle apparatus 103 includes, in the configuration of refrigeration cycle apparatus 102 shown in Fig. 7, an oil return circuit 73 in place of oil return circuit 72.

[0076] Oil return circuit 73 includes, in the configuration of oil return circuit 72, a branch passage 20A, an oil-air heat exchanger 11, a temperature detector 53, and a controller 63 in place of bypass passage 20 and controller 62. Branch passage 20A causes oil to be returned from oil separator 2 to compressor 1 by passing the oil through oil-air heat exchanger 11.

[0077] Oil-water heat exchanger 6 is configured to dissipate the heat of the oil passing therethrough to the drain water in drain pan 50. In contrast, oil-air heat exchanger 11 is disposed between evaporator 5 and drain pan 50 and is configured to dissipate the heat of the oil that has bypassed oil-water heat exchanger 6 to evaporator 5.

[0078] Controller 63 receives outputs of temperature detectors 51 to 53 and controls adjustment valve 8 and flow rate adjusting mechanism 9. Flow rate adjusting mechanism 9 is configured to change a ratio between the flow rate of the oil passing through oil-water heat exchanger 6 and the flow rate of the oil passing through oil-air heat exchanger 11.

[0079] Since the configuration of the other part of refrigeration cycle apparatus 103 is similar to that of refrigeration cycle apparatus 102 shown in Fig. 7, description thereof will not be repeated.

[0080] Fig. 10 shows a physical arrangement relationship among oil-air heat exchanger 11, evaporator 5, and drain pan 50. Oil-air heat exchanger 11 is placed below evaporator 5. The refrigerant from point D in Fig. 9 passes through a refrigerant pipe branched into a plurality of portions in evaporator 5 as shown in Fig. 10, and the divided portions of the refrigerant meet after passing through evaporator 5. The resultant refrigerant then flows from point E to point F in Fig. 9. The oil from point G in Fig. 9 passes through the oil pipe of oil-air heat exchanger 11 as shown in Fig. 10 and flows toward point H in Fig. 9.

[0081] The refrigerant pipe of evaporator 5 and the oil pipe of oil-air heat exchanger 11 are preferably embedded in a common fin on top and bottom. The air cooled by the fin near evaporator 5 causes condensation, and the condensation turns into drain water and flows down along the fin. Then, when the drain water reaches the vicinity of the oil pipe of oil-air heat exchanger 11, it is heated by the high-temperature oil.

[0082] In a configuration devoid of oil-air heat exchanger 11, when the outside temperature is low, drain water may freeze at the lower end of the fin before a droplet of drain water drops onto drain pan 50. The frozen drain water grows into so-called root ice. In the present embodiment, the oil return circuit passing through oil-air heat exchanger 11 is also referred to as a "freezing suppression circuit". Oil-air heat exchanger 11 functions as the freezing suppression circuit that prevents freezing of drain water before dropping onto drain pan 50. The high-temperature, high-pressure oil discharged from flow rate adjusting mechanism 9 flows into oil-air heat exchanger 11 (freezing suppression circuit) and passes through oil-air heat exchanger 11 while dissipating heat to the drain water remaining at the lower end of evaporator 5.

[Control of Valve, Flows of Refrigerant and Oil]

[0083] Control of various valves performed by refrigeration cycle apparatus 103 and a refrigerant flow will now be described.

[0084] Referring back to Fig. 9 again, temperature detector 51 detects a surface temperature T1 of drain pan 50, temperature detector 52 detects an outside air temperature T2, and temperature detector 53 detects a liquid pipe temperature T3 of evaporator 5.

[0085] Controller 63 computes a freezing determination temperature of drain water based on the outputs of temperature detectors 51 to 53. Then, controller 63 controls adjustment valve 8 and flow rate adjusting mechanism 9 in accordance with each freezing determination temperature and operating condition. For example, controller 63 increases the flow rate of the oil of oil-air heat exchanger 11 (freezing suppression circuit) when liquid pipe temperature T3 of evaporator 5 is lower than a prescribed temperature. To increase the flow rate of the oil of oil-air heat exchanger 11, for example, controller 63 increases the degree of opening of flow rate adjustment valve 9A on the freezing suppression circuit side and reduces the degree of opening of flow rate adjustment valve 9B on the other side.

[0086] High-temperature, high-pressure gas refrigerant and oil discharged from compressor 1 flow into oil separator 2 and are separated into gas refrigerant and oil. The gas refrigerant (point B) flows from oil separator 2 into condenser 3, whereas the oil flows from oil separator 2 into oil return pipe 7.

[0087] At this time, the oil (point G) that has passed through oil return pipe 7 flows into flow rate adjusting mechanism 9 and is distributed to branch passage 20A (freezing suppression circuit) and oil-water heat exchanger 6 (drain antifreezing circuit). The oil that has flowed into oil-water heat exchanger 6 passes through oil-water heat exchanger 6 while dissipating heat to the drain water in drain pan 50. The oil passing from branch passage 20A to oil-air heat exchanger 11 is cooled while dissipating heat to air and drain water dropping down along the fin.

[0088] The oil that has passed oil-air heat exchanger 11 from flow rate adjusting mechanism 9 via branch passage 20A meets the oil that has passed through oil-water heat exchanger 6 at junction 10 (point H). The resultant oil obtained at junction 10 is decompressed by adjustment valve 8 (point I).

[0089] The low-pressure, low-temperature oil that has been decompressed by adjustment valve 8 flows into the low-pressure pipe (point I) and meets, at the junction (point F), low-temperature, low-pressure refrigerant that has been discharged from evaporator 5 and passes through the low-pressure pipe (point E). The low-temperature, low-pressure refrigerant and oil that have met is sucked by compressor 1.

[0090] Controller 63 increases the flow rate of the oil of the shortest oil return circuit included in oil return passage 73 when the operation of refrigeration cycle apparatus 103 is the oil depleting operation. In the example of Fig. 9, the path passing through oil-water heat exchanger 6 is shorter than branch passage 20A, and accordingly, in oil depleting operation, the degrees of opening of flow rate adjustment valves 9A and 9B are controlled to increase the flow rate of the path passing through oil-water heat exchanger 6. Bypass passage 20 shown in Fig. 7 may be added to the configuration shown in Fig. 9, and a flow rate adjustment valve for bypass passage may be further added to flow rate adjusting mechanism 9. In this case, the shortest oil return circuit serves as a bypass passage.

[0091] Controller 63 increases the flow rate of the oil of oil-water heat exchanger 6 (drain antifreezing circuit) when surface temperature T1 of drain pan 50 is lower than the freezing determination temperature. Controller 63 increases the flow rate of the oil of oil-air heat exchanger 11 (freezing suppression circuit) when liquid pipe temperature T3 of evaporator 5 is lower than the freezing determination temperature.

[0092] In normal operation, controller 63 reduces the oil return amount by reducing the degree of opening of adjustment valve 8, thus causing the oil to remain in oil separator 2 or each oil return circuit.

[0093] Fig. 11 is a flowchart showing an example of control performed by a controller 63 according to Embodiment 3. A process of this flowchart is called from a main routine and executed for every certain period of time or every time a predetermined condition is satisfied. With reference to Figs. 9 and 11, in step S21, controller 63 detects the operating condition. Since controller 63 controls refrigeration cycle apparatus 103, for example, controls compressor 1, controller 63 can detect whether the current operating state of refrigeration cycle apparatus 103 is the oil depleting operating state, for example, in the activation of the compressor or in switching from the defrosting operation.

[0094] In step S22, controller 63 determines whether the operating state of refrigeration cycle apparatus 103 corresponds to the oil depleting operation (e.g., in the activation of the compressor or in switching from the defrosting operation). The process proceeds to step S23 when the operating state corresponds to the oil depleting operation (YES in S22), and otherwise (NO in S22), the process proceeds to step S24.

[0095] In step S24, controller 63 detects liquid pipe temperature T3 of evaporator 5 by temperature detector 53 and determines whether liquid pipe temperature T3 is lower than the freezing determination temperature. The process proceeds to step S25 when liquid pipe temperature T3 is equal to or lower than the freezing determination temperature (NO in S24), and the process proceeds to step S26 when liquid pipe temperature T3 is higher than the freezing determination temperature (YES in S24).

[0096] In step S25, controller 63 reduces the degree of opening of flow rate adjustment valve 9B while increasing the degree of opening of flow rate adjustment valve 9A. This increases the ratio of the oil passing through oil-air heat exchanger 11 that prevents icing of evaporator 5 in the oil passing through oil return passage 73.

[0097] In step S26, controller 63 detects surface temperature T1 of drain pan 50 by temperature detector 51 and determines whether surface temperature T1 is lower than the freezing determination temperature. The process proceeds to step S27 when surface temperature T1 is equal to or lower than the freezing determination temperature (NO in S26), and the process proceeds to step S28 when surface temperature T1 is higher than the freezing determination temperature (YES in S26).

[0098] In step S27, controller 63 reduces the degree of opening of flow rate adjustment valve 9A while increasing the degree of opening of flow rate adjustment valve 9B. This increases the ratio of the oil passing through oil-water heat exchanger 6 in the oil passing through oil return passage 73.

[0099] In step S28, flow rate adjustment valves 9A and 9B are fully opened, whereas the degree of opening of adjustment valve 8 is reduced. When the degree of opening of the valve is determined in the process of any of steps S23, S25, S27, and S28, control is returned to the main routine in step S29.

[0100] Refrigeration cycle apparatus 103 according to Embodiment 3 described above can achieve effects similar to those of refrigeration cycle apparatus 102 of Embodiment 2. Further, oil-air heat exchanger 11 below evaporator 5 heats the drain water before dropping onto drain pan 50, thus suppressing icing at the lower portion of evaporator 5 to improve the performance of refrigeration cycle apparatus 103.

[Embodiment 4]

[0101] In Embodiments 1 to 3, the manner of operating a refrigeration cycle apparatus that is highly likely to cause oil depletion in a compressor is detected as the oil depleting operation, and control is then performed. In Embodiment 4, a detector that detects oil depletion in a compressor more directly is provided.

[0102] Fig. 12 shows a configuration of a refrigeration cycle apparatus 104 according to Embodiment 4. With reference to Fig. 12, refrigeration cycle apparatus 104 includes a controller 64 in place of controller 63 and also includes a sensor 54 in the configuration of refrigeration cycle apparatus 103 of Fig. 9. Sensor 54 detects a lack of oil in compressor 1. Controller 64 adjusts the degree of opening of valve 8 in accordance with an output of temperature detector 51 and an output of sensor 54.

[0103] More specifically, sensor 54 is provided in compressor 1 and detects oil depletion in compressor 1. Sensor 54 may be, for example, a liquid level detection sensor that detects the liquid level of the oil in compressor 1 or an oil concentration sensor that detects an oil concentration in refrigerant.

[0104] Controller 64 determines whether the operation is the oil depleting operation performed in step S22 of Fig. 11, based on a detection value PI detected by sensor 54. Since the other control is similar to that of Embodiment 3 described with reference to Fig. 11, description thereof will not be repeated.

[0105] Sensor 54 may be incorporated in the configuration of Embodiment 1. In this case, sensor 54 may be added to Fig. 1, and an output of sensor 54 may be used in determination of step S2 in Fig. 5. Alternatively, sensor 54 may be incorporated in the configuration of Embodiment 2. In this case, sensor 54 may be added to Fig. 7, and an output of sensor 54 may be used in determination of step S12 in Fig. 8.

[0106] Embodiment 4 can achieve effects similar to those of Embodiments 1, 2, and 3.

[0107] Since drain pan 50 easily corrodes due to drain water, a measure is preferably taken to suppress corrosion. For example, an additive capable of suppressing corrosion can be added to refrigerant, or electrolyzed water containing active oxygen species can be used, thereby suppressing corrosion.

[0108] It is to be understood that the embodiments disclosed herein are presented for the purpose of illustration and non-restrictive in every respect. It is therefore intended that the scope of the present invention is defined by claims, not only by the embodiments described above, and encompasses all modifications and variations equivalent in meaning and scope to the claims.

REFERENCE SIGNS LIST

[0109] 1 compressor, 2 oil separator, 3 condenser, 4 expansion valve, 5 evaporator, 6 oil-water heat exchanger, 7 oil pipe, 8 adjustment valve, 9 flow rate adjusting mechanism, 9A, 9B flow rate adjustment valve, 10 junction, 11 oil-air heat exchanger, 20, 29 bypass passage, 20A branch passage, 50 drain pan, 51-53 temperature detector, 54 detector, 61-64 controller, 71-73, 507 oil path, 101-104 refrigeration cycle apparatus, 508 decompression device.

Claims

1. A refrigeration cycle apparatus in which refrigerant circulates in a compressor, a condenser, an expansion valve, and an evaporator, the refrigeration cycle apparatus comprising:

a drain pan configured to receive drain water obtained by condensing moisture in air by the evaporator;
a temperature detector configured to detect a temperature related to a temperature of the drain water;
an oil separator provided between the compressor and the condenser and configured to separate refrigerating machine oil and the refrigerant from each other;
an oil return passage having at least a portion disposed in the drain pan and configured to return the refrigerating machine oil separated by the oil separator to a suction port of the compressor; and
a valve configured to adjust a flow rate of the refrigerating machine oil of the oil return passage, the valve being configured to have a degree of opening varying in accordance with an output of the temperature detector.

2. The refrigeration cycle apparatus according to claim 1, wherein
the temperature detector detects a temperature of the drain pan, and
the refrigeration cycle apparatus further comprises a controller configured to increase the degree of opening of the valve when the temperature detected by the temperature detector is lower than a predetermined value.

3. The refrigeration cycle apparatus according to claim 1, wherein the oil return passage includes
a heat exchanger configured to dissipate heat of the refrigerating machine oil passing therethrough to the drain water in the drain pan, and

a bypass passage configured to cause the refrigerating machine oil to flow therethrough while bypassing the heat exchanger.

4. The refrigeration cycle apparatus according to claim 3, further comprising a flow rate adjusting mechanism configured to change a ratio between a flow rate at which the refrigerating machine oil passes through the heat exchanger and a flow rate at which the refrigerant machine oil passes through the bypass passage.

5. The refrigeration cycle apparatus according to claim 1, wherein the oil return passage includes
a first heat exchanger configured to dissipate heat of the refrigerating machine oil passing therethrough to the drain water in the drain pan, and
a second heat exchanger disposed between the evaporator and the drain pan and configured to dissipate heat of the refrigerating machine oil bypassing the first heat exchanger to the evaporator.

6. The refrigeration cycle apparatus according to claim 5, further comprising a flow rate adjusting mechanism configured to change a ratio between a flow rate at which the refrigerating machine oil passes through the first heat exchanger and a flow rate at which the refrigerating machine oil passes through the second heat exchanger.

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

a sensor configured to detect a lack of the refrigerating machine oil in the compressor; and
a controller configured to adjust the degree of opening of the valve in accordance with an output of the temperature detector and an output of the sensor.

FIG.1

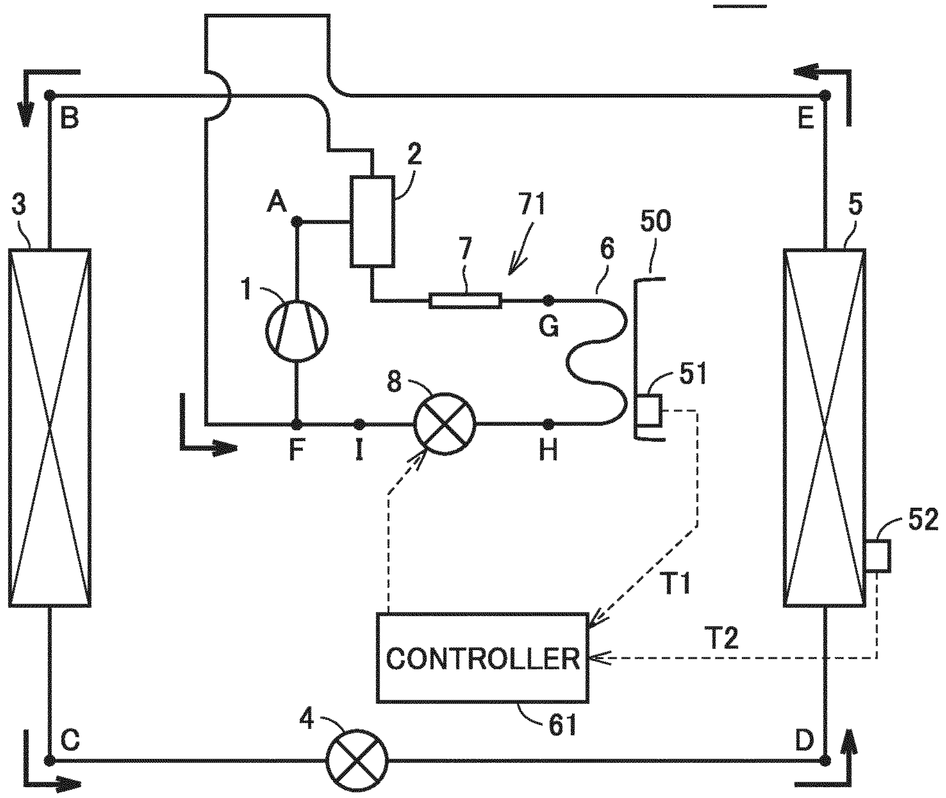


FIG.2

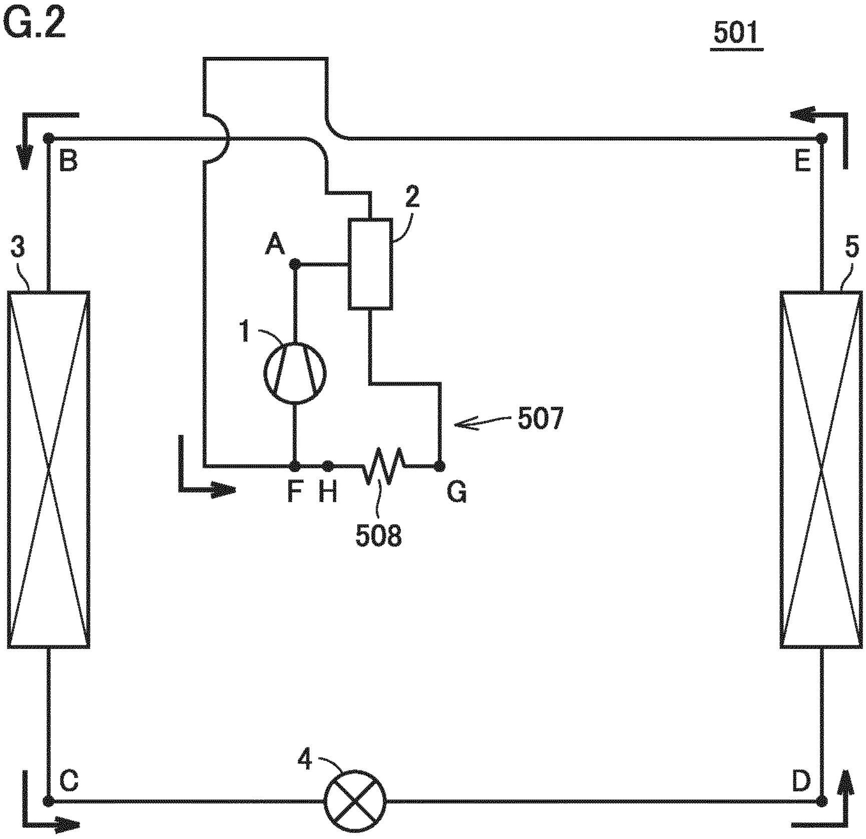

501
B
E
2
A
3
5
1
507
F H
G
508
4
C
D

FIG.3

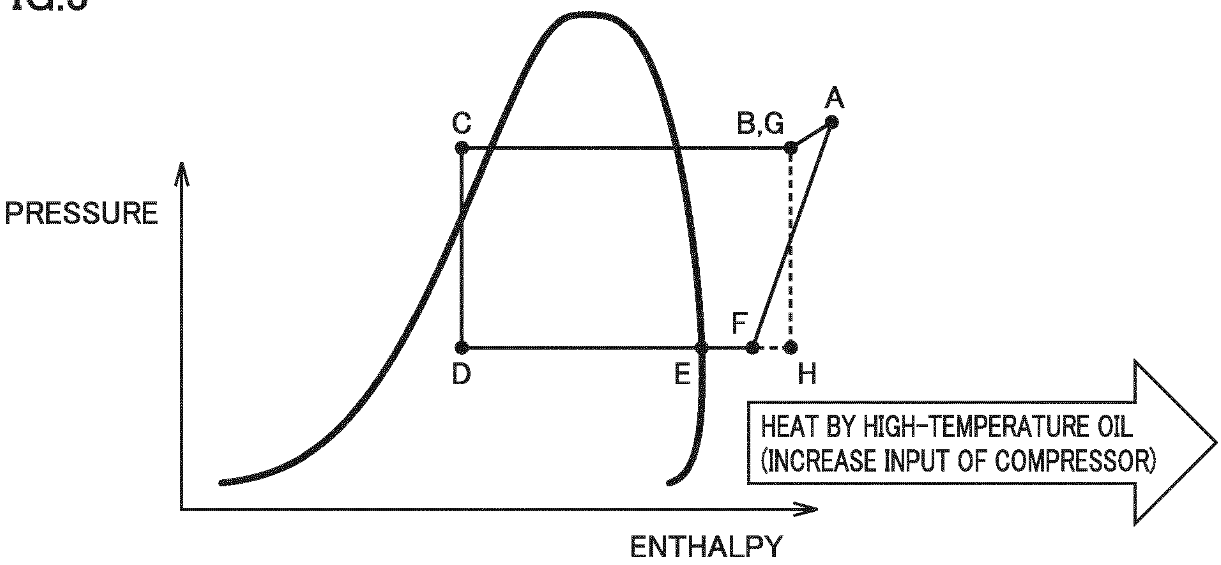

A
C
B,G
PRESSURE
F
D
E
H
HEAT BY HIGH-TEMPERATURE OIL
(INCREASE INPUT OF COMPRESSOR)
ENTHALPY

FIG.4

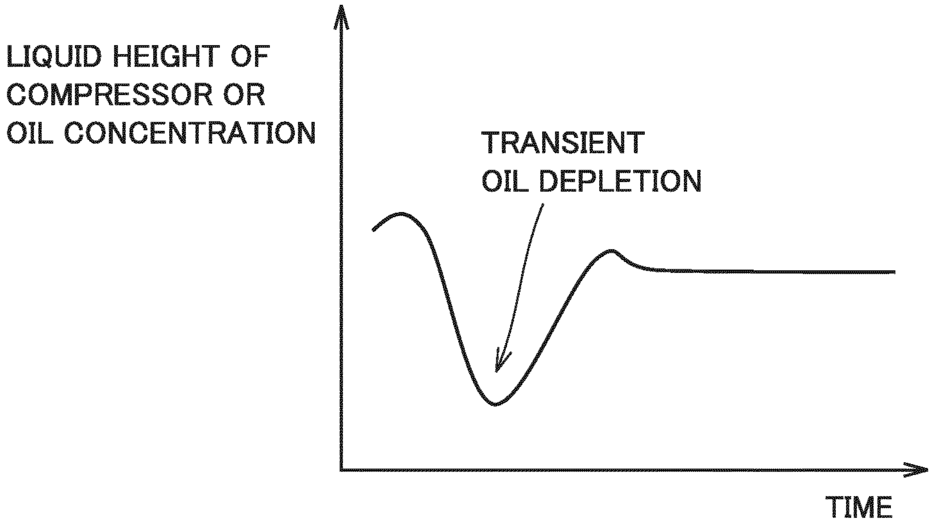

LIQUID HEIGHT OF
COMPRESSOR OR
OIL CONCENTRATION
TRANSIENT
OIL DEPLETION
TIME

FIG.5

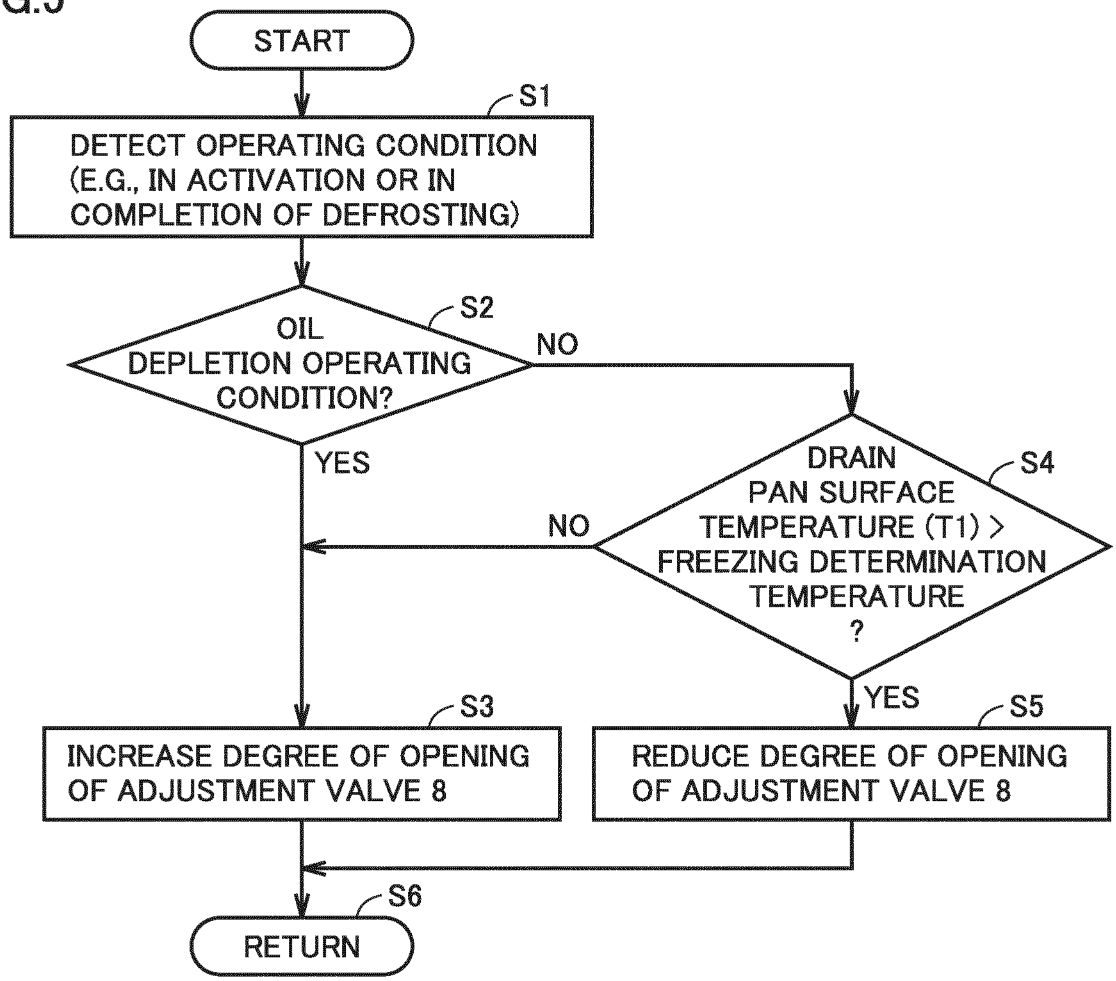

START
S1
DETECT OPERATING CONDITION
(E.G., IN ACTIVATION OR IN
COMPLETION OF DEFROSTING)
S2
OIL
DEPLETION OPERATING
CONDITION?
NO
YES
DRAIN
PAN SURFACE
TEMPERATURE (T1) >
FREEZING DETERMINATION
TEMPERATURE
?
S4
NO
YES
S3
INCREASE DEGREE OF OPENING
OF ADJUSTMENT VALVE 8
S5
REDUCE DEGREE OF OPENING
OF ADJUSTMENT VALVE 8
S6
RETURN

FIG.6

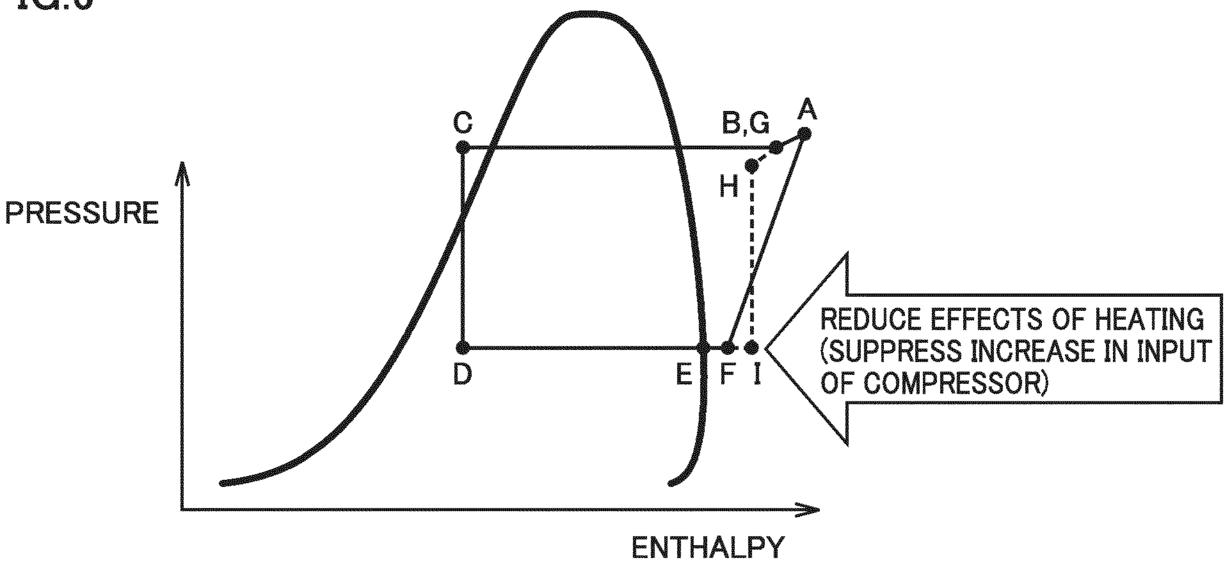

PRESSURE
ENTHALPY
C
B,G
A
H
D
E
F
I
REDUCE EFFECTS OF HEATING (SUPPRESS INCREASE IN INPUT OF COMPRESSOR)

FIG.7

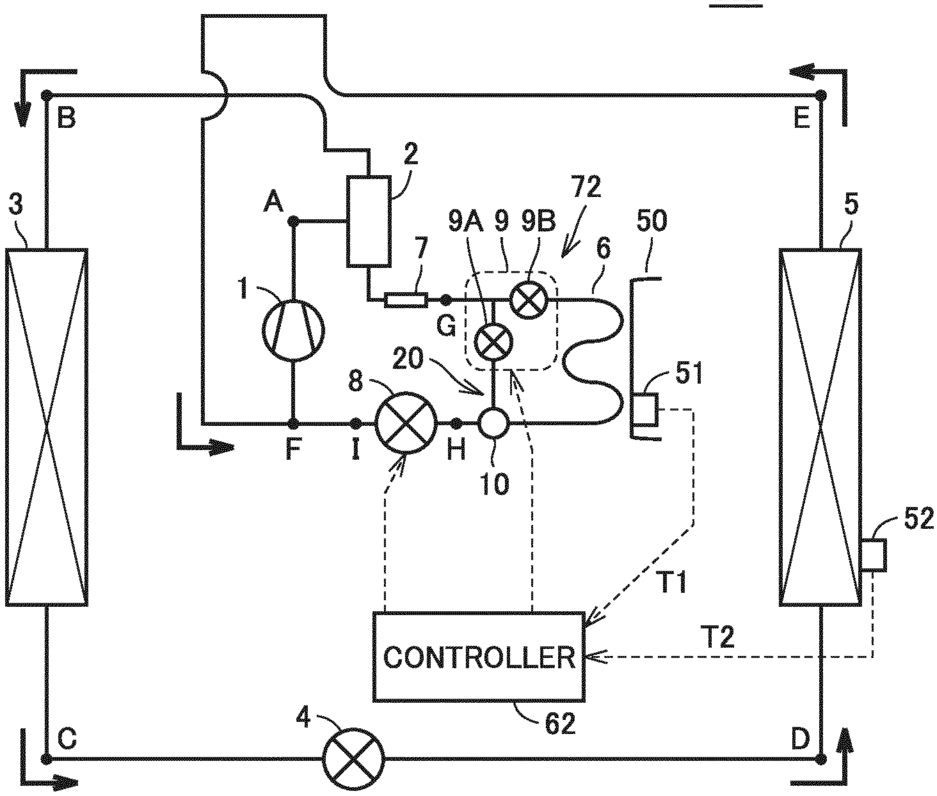

102
B
E
2
3
A
9A 9 9B
72
50
5
7
6
1
G
20
8
51
F
I
H
10
52
T1
T2
CONTROLLER
62
4
C
D

FIG.8

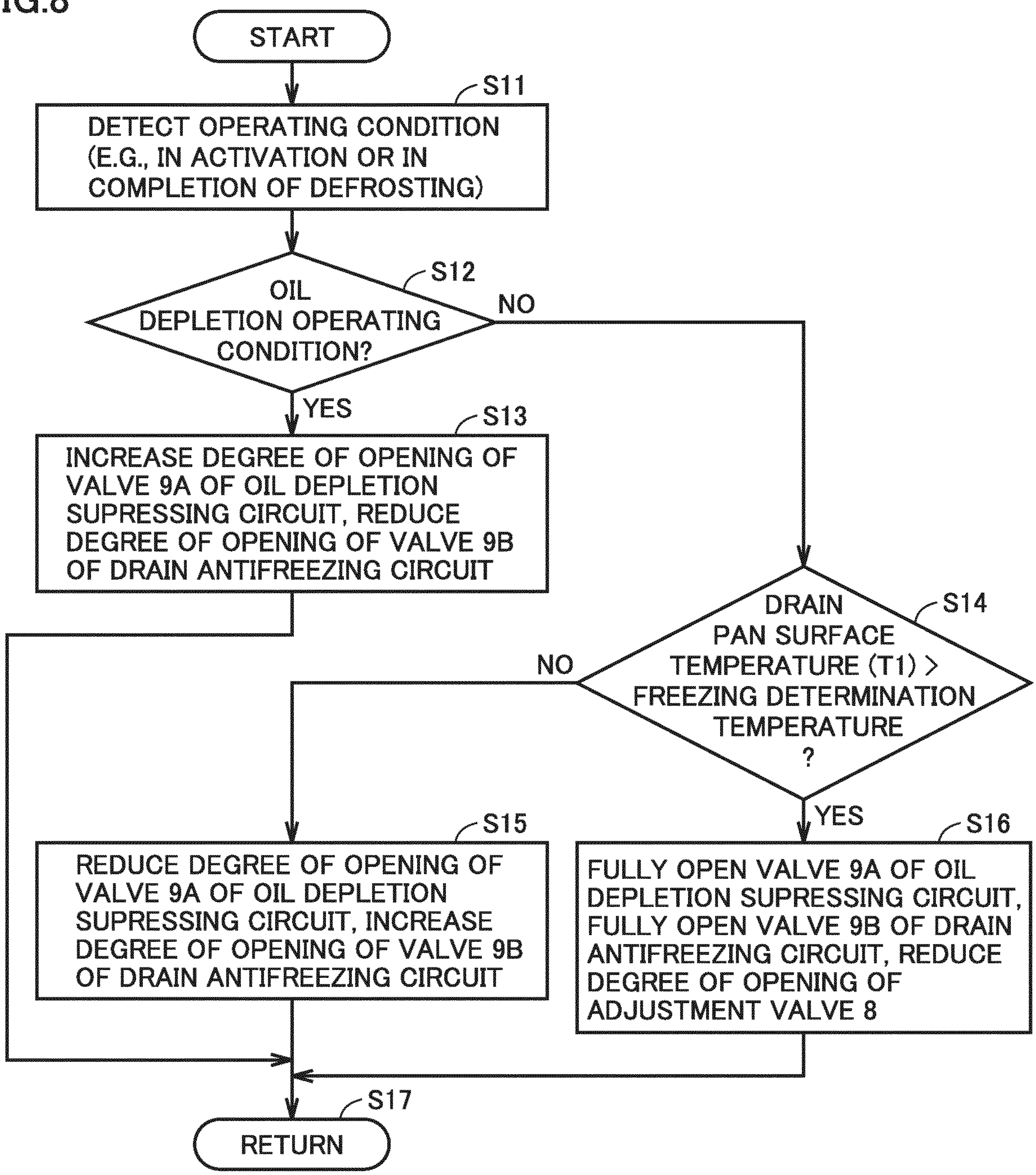

START
S11
DETECT OPERATING CONDITION (E.G., IN ACTIVATION OR IN COMPLETION OF DEFROSTING)
S12
OIL DEPLETION OPERATING CONDITION?
NO
YES
S13
INCREASE DEGREE OF OPENING OF VALVE 9A OF OIL DEPLETION SUPRESSING CIRCUIT, REDUCE DEGREE OF OPENING OF VALVE 9B OF DRAIN ANTIFREEZING CIRCUIT
S14
DRAIN PAN SURFACE TEMPERATURE (T1) > FREEZING DETERMINATION TEMPERATURE ?
NO
YES
S15
REDUCE DEGREE OF OPENING OF VALVE 9A OF OIL DEPLETION SUPRESSING CIRCUIT, INCREASE DEGREE OF OPENING OF VALVE 9B OF DRAIN ANTIFREEZING CIRCUIT
S16
FULLY OPEN VALVE 9A OF OIL DEPLETION SUPRESSING CIRCUIT, FULLY OPEN VALVE 9B OF DRAIN ANTIFREEZING CIRCUIT, REDUCE DEGREE OF OPENING OF ADJUSTMENT VALVE 8
S17
RETURN

FIG.9

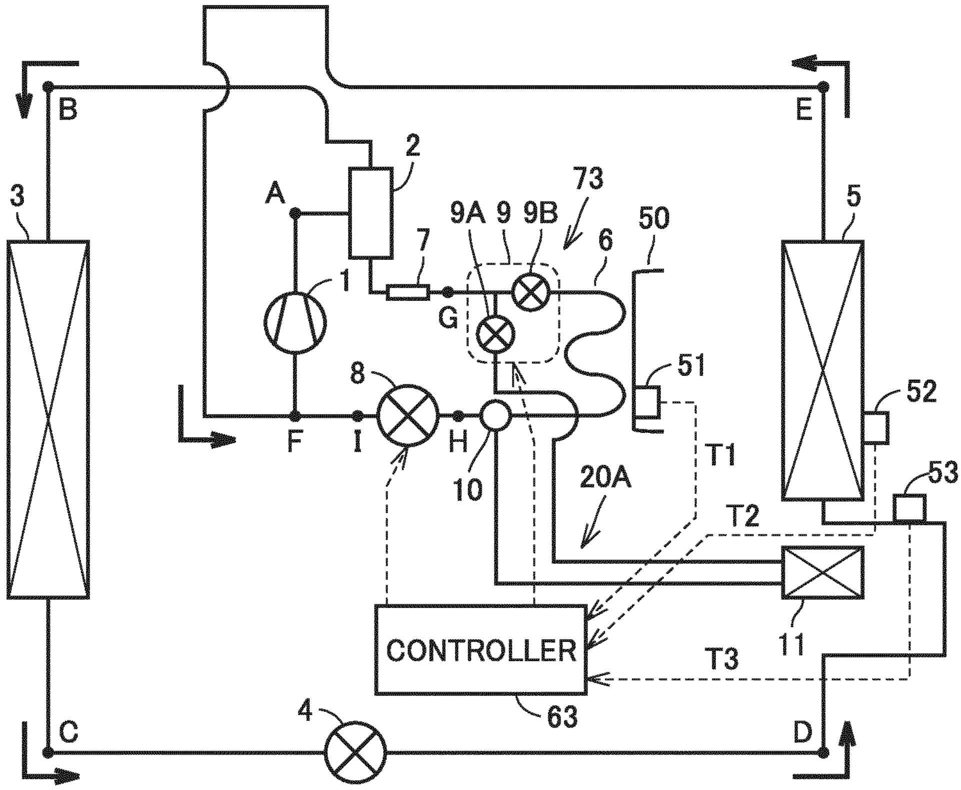

103
B
E
A
2
73
3
9A 9 9B
6
50
5
7
1
G
51
8
52
F
I
H
10
T1
20A
53
T2
CONTROLLER
11
T3
63
4
C
D

FIG.10

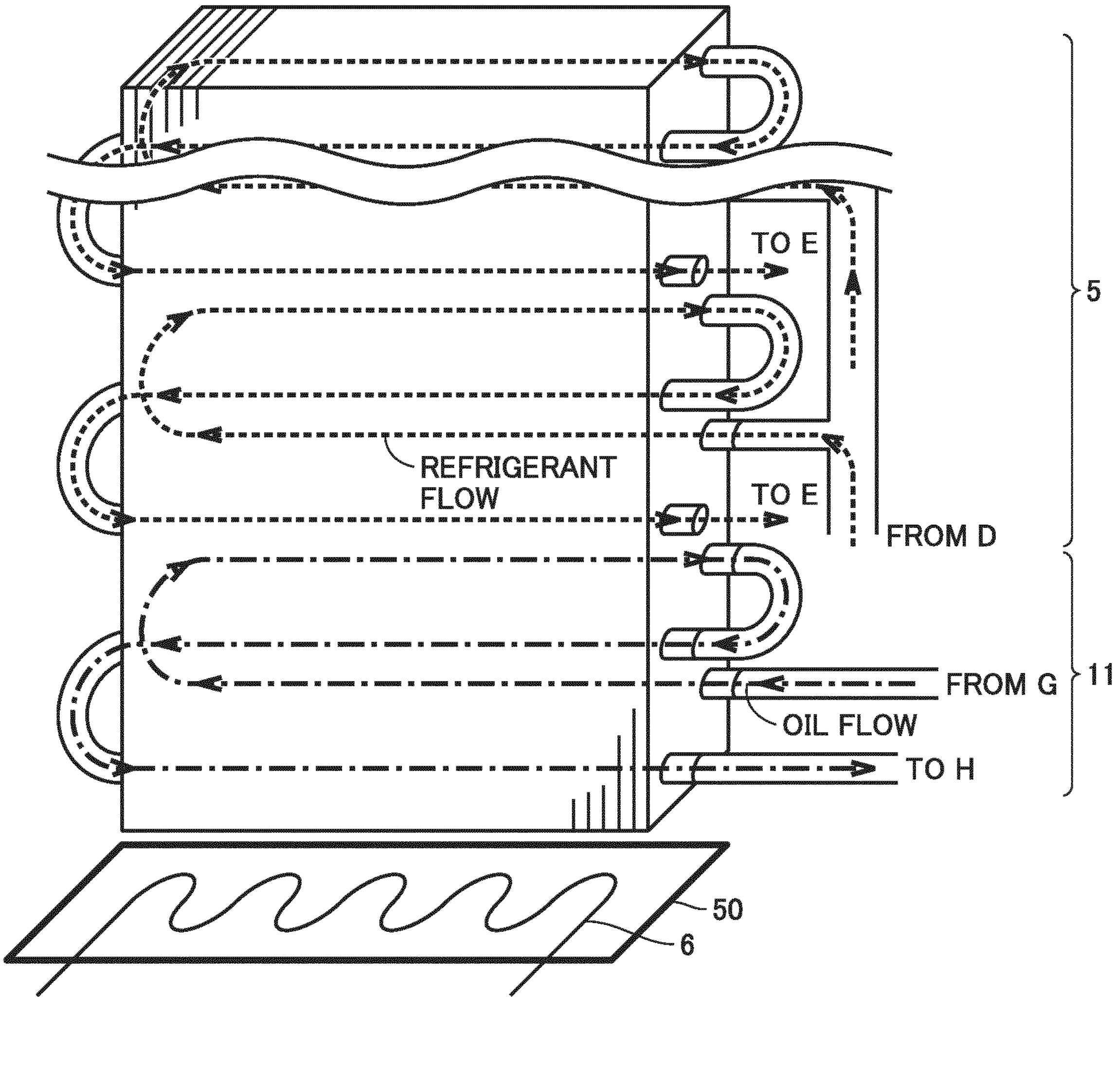


FIG.11

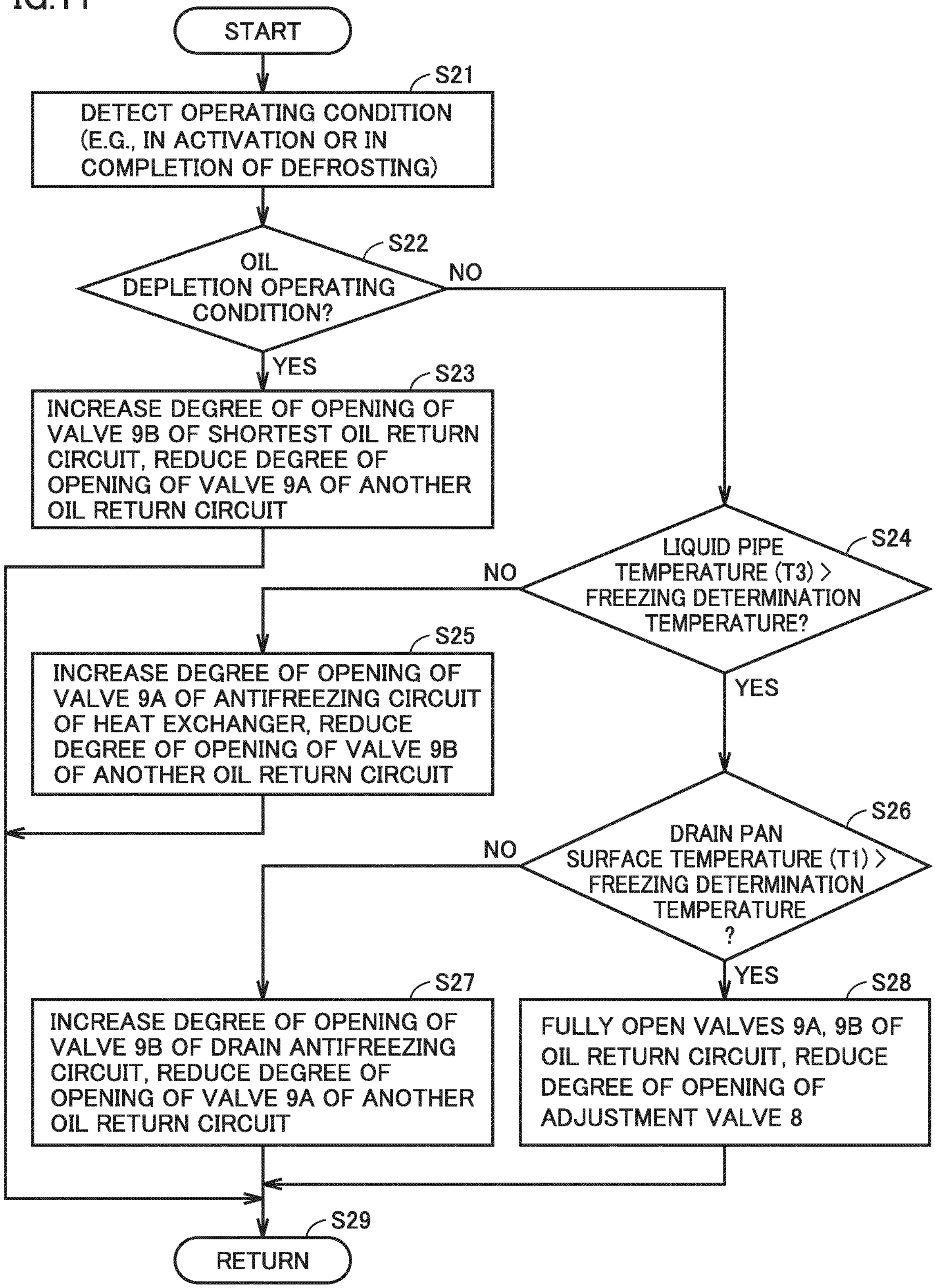
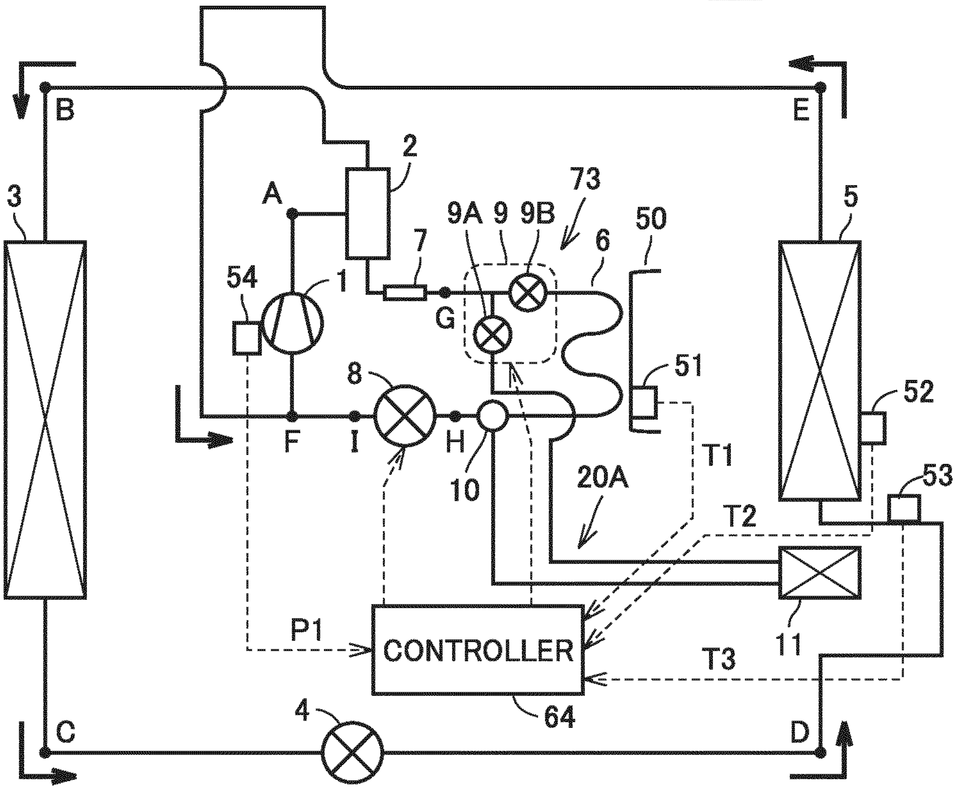

START
S21
DETECT OPERATING CONDITION (E.G., IN ACTIVATION OR IN COMPLETION OF DEFROSTING)
S22
OIL DEPLETION OPERATING CONDITION?
NO
YES
S23
INCREASE DEGREE OF OPENING OF VALVE 9B OF SHORTEST OIL RETURN CIRCUIT, REDUCE DEGREE OF OPENING OF VALVE 9A OF ANOTHER OIL RETURN CIRCUIT
S24
LIQUID PIPE TEMPERATURE (T3) > FREEZING DETERMINATION TEMPERATURE?
NO
YES
S25
INCREASE DEGREE OF OPENING OF VALVE 9A OF ANTIFREEZING CIRCUIT OF HEAT EXCHANGER, REDUCE DEGREE OF OPENING OF VALVE 9B OF ANOTHER OIL RETURN CIRCUIT
S26
DRAIN PAN SURFACE TEMPERATURE (T1) > FREEZING DETERMINATION TEMPERATURE ?
NO
YES
S27
INCREASE DEGREE OF OPENING OF VALVE 9B OF DRAIN ANTIFREEZING CIRCUIT, REDUCE DEGREE OF OPENING OF VALVE 9A OF ANOTHER OIL RETURN CIRCUIT
S28
FULLY OPEN VALVES 9A, 9B OF OIL RETURN CIRCUIT, REDUCE DEGREE OF OPENING OF ADJUSTMENT VALVE 8
S29
RETURN

FIG.12


104
B
E
3
5
2
A
73
9A 9 9B
50
6
7
54
1
G
51
52
8
F
I
H
10
T1
20A
53
T2
P1
CONTROLLER
11
T3
4
64
C
D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/071816

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B1/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 05-340616 A (Daikin Industries, Ltd.), 21 December 1993 (21.12.1993), paragraphs [0024] to [0025]; fig. 2 to 4 (Family: none)	1-7
A	JP 10-253179 A (Mitsubishi Electric Corp.), 25 September 1998 (25.09.1998), paragraphs [0077] to [0079]; fig. 11 (Family: none)	1-7
A	JP 2010-107141 A (Daikin Industries, Ltd.), 13 May 2010 (13.05.2010), paragraphs [0088] to [0095]; fig. 6 (Family: none)	1-7

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
12 October 2016 (12.10.16)	25 October 2016 (25.10.16)

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

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/071816

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-089736 A (Hitachi Appliances, Inc.), 06 May 2011 (06.05.2011), paragraph [0057]; fig. 8 (Family: none)	1-7

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2010032196 A **[0003] [0004] [0005]**