



(12)

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

- (43)

Date of publication:
30.11.2016 Bulletin 2016/48

(51)

Int Cl.:
F25B 11/02 ^(2006.01) **F25B 1/00** ^(2006.01)
F25B 43/02 ^(2006.01)
- (21)

Application number: **14877666.9**

(86)

International application number:
PCT/JP2014/050257
- (22)

Date of filing: **09.01.2014**

(87)

International publication number:
WO 2015/104823 (16.07.2015 Gazette 2015/28)

(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 (71) Applicant: Mitsubishi Electric Corporation Chiyoda-ku Tokyo 100-8310 (JP) (72) Inventors: • KATO, Yohei Tokyo 100-8310 (JP)	• SHIMAZU, Yusuke Tokyo 100-8310 (JP) • YANACHI, Satoru Tokyo 100-8310 (JP) • OTSUBO, Yusuke Tokyo 100-8310 (JP) • UCHINO, Shinichi Tokyo 100-8310 (JP) (74) Representative: Pfenning, Meinig & Partner mbB Patent- und Rechtsanwälte Theresienhöhe 11a 80339 München (DE)
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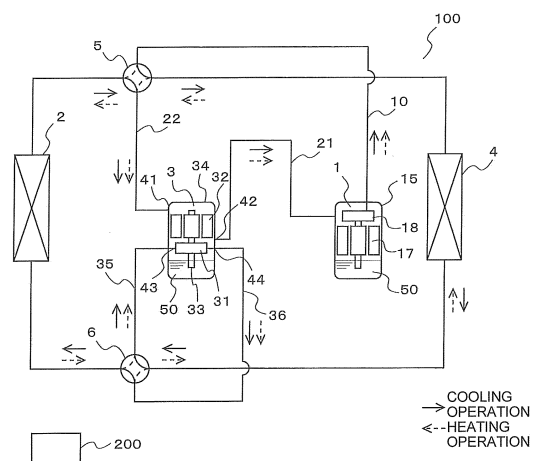
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REFRIGERATION CYCLE DEVICE

(57)

A refrigeration cycle apparatus includes a refrigerant circuit including a compressor (1), a condenser, an expander (3), and an evaporator, which are connected by pipes so that refrigerant is circulated therethrough. The expander (3) includes: an expander shell (34) defining an outer shell; an expansion unit (31) arranged in the expander shell (34) and configured to expand the refrigerant flowing out from the condenser to generate driving force, and configured for causing the expanded refrigerant to flow into the evaporator; and a power generator (32) arranged in the expander shell (34) and configured to rotate by the driving force generated by the expansion unit (31). The expander shell (34) includes: an inlet (41) configured for allowing the refrigerant to flow into the expander shell; and an outlet (42) configured for allowing the refrigerant flowing into the expander shell to flow into a suction-side pipe (21) of the compressor (1). The expander shell (34) is configured such that refrigerating machine oil (50) contained in the refrigerant is stored therein, and is supplied to at least one of the expansion unit (31) and the power generator (32).

FIG. 1



Description

Technical Field

[0001] The present invention relates to a refrigeration cycle apparatus including an expander configured to recover expansion power of refrigerant as electric power.

Background Art

[0002] There is a conventional refrigeration cycle apparatus including a compressor and an expander arranged to a refrigerant circuit. A compressor casing and an expander casing communicate to each other through a communication pipe, and a discharge pipe and the expander casing communicate to each other through a branch outlet pipe to uniformly apply pressure to the inside of the two casings. An oil regulating valve is arranged to an oil flow pipe connecting an oil reservoir of the compressor to an oil reservoir of the expander. In the proposed related art, when the oil regulating valve is opened, the oil reservoir in the compressor casing and the oil reservoir in the expander casing communicate to each other, and refrigerating machine oil flows through the oil flow pipe (see, for example, Patent Literature 1).

[0003] Further, there is a conventional refrigeration cycle apparatus including a compressor and an expander arranged to a refrigerant circuit. In the compressor, refrigerant compressed by a compression mechanism is discharged to internal space of a compressor casing. In the compressor, refrigerating machine oil accumulated at the bottom of the compressor casing is supplied to the compression mechanism. In the proposed related art, the refrigerating machine oil accumulated at the bottom of the compressor casing is directly introduced to an expansion mechanism of the expander through an oil supply pipe (see, for example, Patent Literature 2).

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2007-285674 (Abstract)
Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2008-224053 (Abstract)

Summary of Invention

Technical Problem

[0005] In the technique disclosed in Patent Literature 1, the compressor shell (compressor casing) and the expander shell (expander casing) are connected by a pipe. Part of gas refrigerant in the compressor shell is caused to flow into the expander shell so that part of the refrigerating machine oil in the compressor is caused to flow into the expander shell.

erating machine oil in the compressor is caused to flow into the expander shell.

[0006] Therefore, the pressure in the compressor shell and the pressure in the expander shell are equal to each other. Thus, there is a problem in that the technique disclosed in Patent Literature 1 cannot be applied to a configuration in which the pressure in the compressor shell and the pressure in the expander shell are different from each other, for example, a configuration in which the pressure in the compressor shell is high and the pressure in the expander shell is low, or vice versa.

[0007] Further, high-pressure and high-temperature refrigerant flows into the expander shell, and thus, there is a problem in that a power generator (motor) in the expander shell is difficult to cool.

[0008] In the technique disclosed in Patent Literature 2, the refrigerating machine oil accumulated at the bottom of the compressor shell (compressor casing) is directly introduced into an expansion unit (expansion mechanism) in the expander through the oil supply pipe.

[0009] Therefore, there is a problem in that, when the refrigerating machine oil in the compressor shell is depleted, the oil cannot be supplied into the expander.

[0010] Further, when the refrigerating machine oil flows through the oil supply pipe, there is a problem in that the refrigerant that dissolves in the refrigerating machine oil is decompressed to form bubbles, and refrigerant gas is mixed into the refrigerating machine oil so that the lubricity thereof is lowered.

[0011] The present invention has been made to solve the problems described above, and an object of the present invention is to provide a refrigeration cycle apparatus capable of storing refrigerating machine oil in an expander shell irrespective of the pressure in a compressor shell and suppressing depletion of the refrigerating machine oil in an expander.

Solution to Problem

[0012] According to an aspect of the present invention, there is provided a refrigeration cycle apparatus including a refrigerant circuit, the refrigerant circuit including a compressor, a condenser, an expander, and an evaporator, which are connected by pipes so that refrigerant is circulated through the refrigerant circuit, the expander including: an expander shell defining an outer shell of the expander; an expansion unit arranged in the expander shell, the expansion unit being configured to expand the refrigerant flowing out from the condenser to generate driving force, and configured for causing the expanded refrigerant to flow into the evaporator; and a power generator arranged in the expander shell, the power generator being configured to rotate by the driving force generated by the expansion unit, the expander shell including: an inlet configured for allowing the refrigerant to flow into the expander shell; and an outlet configured for allowing the refrigerant flowing into the expander shell from the inlet to flow into a suction-side pipe of the compressor,

the expander shell being configured such that refrigerating machine oil contained in the refrigerant is stored therein, and is supplied to at least one of the expansion unit and the power generator. Advantageous Effects of Invention

[0013] According to the aspect of the present invention, the refrigerant flows from the inlet of the expander shell, the refrigerating machine oil contained in the refrigerant is stored in the expander shell, and the refrigerant flows from the outlet of the expander shell into the suction-side pipe of the compressor. Therefore, the refrigerating machine oil can be stored in the expander shell irrespective of the pressure in the compressor shell, and depletion of the refrigerating machine oil in the expander can be suppressed. Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 1 of the present invention.

[Figs. 2] Figs. 2 are diagrams for illustrating configurations of an expander 3 of a refrigeration cycle apparatus 100 according to Embodiment 2 of the present invention.

[Fig. 3] Fig. 3 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 3 of the present invention.

[Fig. 4] Fig. 4 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 4 of the present invention.

[Fig. 5] Fig. 5 is a diagram for illustrating another configuration of a refrigeration cycle apparatus 100 according to Embodiment 4 of the present invention.

[Fig. 6] Fig. 6 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 5 of the present invention.

[Fig. 7] Fig. 7 is a diagram for illustrating another configuration of a refrigeration cycle apparatus 100 according to Embodiment 5 of the present invention.

[Fig. 8] Fig. 8 is a diagram for illustrating another configuration of a refrigeration cycle apparatus 100 according to Embodiment 5 of the present invention.

[Fig. 9] Fig. 9 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 6 of the present invention.

[Fig. 10] Fig. 10 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 7 of the present invention.

Description of Embodiments

Embodiment 1

<Configuration of Refrigeration Cycle Apparatus 100>

[0015] Fig. 1 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 1 of the present invention.

[0016] As illustrated in Fig. 1, the refrigeration cycle apparatus 100 includes a compressor 1, a load-side heat exchanger 2, an expander 3, a heat source-side heat exchanger 4, a first four-way valve 5, and a second four-way valve 6. The compressor 1, the load-side heat exchanger 2, the expander 3, and the heat source-side heat exchanger 4 are connected by pipes to form a refrigerant circuit through which refrigerant is circulated.

10 (Compressor 1)

[0017] The compressor 1 is, for example, a hermetically sealed compressor. An outer shell of the compressor 1 is defined by a compressor shell 15. An electric motor unit 17 and a compression unit 18 are accommodated in the compressor shell 15.

15 **[0018]** Further, refrigerating machine oil 50 is stored in the compressor shell 15. The refrigerating machine oil 50 is supplied to each of the electric motor unit 17 and the compression unit 18 to be used for lubrication.

20 **[0019]** The compressor 1 sucks low-pressure refrigerant from a suction-side pipe 21 into the compressor shell 15. The compression unit 18 is driven by the electric motor unit 17. The low-pressure refrigerant sucked into the compressor shell 15 is compressed by the compression unit 18. The high-pressure refrigerant compressed by the compression unit 18 is discharged to a discharge-side pipe 10.

25 **[0020]** In this way, the pressure in the compressor shell 15 is a low pressure. In other words, the compressor shell 15 is a so-called low-pressure shell.

30 **[0021]** In Embodiment 1, a case in which the pressure in the compressor shell 15 is a low pressure is described, but the present invention is not limited thereto.

35 **[0022]** For example, the following configuration may be employed. The compression unit 18 directly sucks the low-pressure refrigerant from the suction-side pipe 21. The high-pressure refrigerant compressed by the compression unit 18 is released into the compressor shell 15. Then, the refrigerant released into the compressor shell 15 is discharged to the discharge-side pipe 10.

40 **[0023]** In this way, the configuration in which the pressure inside the compressor shell 15 is a high pressure may be employed. In other words, the compressor shell 15 may be a so-called high-pressure shell.

(Expander 3)

50 **[0024]** An outer shell of the expander 3 is defined by an expander shell 34. An expansion unit 31 and a power generator 32 (motor) are accommodated in the expander shell 34. The expansion unit 31 and the power generator 32 are coupled to each other through a rotation shaft 33.

55 **[0025]** Further, the refrigerating machine oil 50 is stored in the expander shell 34. The refrigerating machine oil 50 is supplied to at least one of the expansion unit 31 and the power generator 32 to be used for lubrication.

[0026] The expansion unit 31 includes an expansion unit inlet 43 configured for allowing the refrigerant to flow therein, and an expansion unit outlet 44 configured for allowing the refrigerant to flow out therefrom. The expansion unit inlet 43 is connected to an inlet pipe 35. The expansion unit outlet 44 is connected to an outlet pipe 36.

[0027] The inlet pipe 35 is connected to a condenser (the load-side heat exchanger 2 or the heat source-side heat exchanger 4) through the second four-way valve 6.

[0028] The outlet pipe 36 is connected to an evaporator (the load-side heat exchanger 2 or the heat source-side heat exchanger 4) through the second four-way valve 6.

[0029] The expansion unit 31 expands the refrigerant flowing from the inlet pipe 35 into the expansion unit inlet 43, and causes the expanded refrigerant to flow from the expansion unit outlet 44 to the outlet pipe 36. Further, the expansion unit 31 rotationally drives the rotation shaft 33 by using expansion power generated when the refrigerant is expanded.

[0030] The power generator 32 is coupled to the expansion unit 31 through the rotation shaft 33, and is rotated by the driving force generated by the expansion unit 31 to generate electric power. In this way, the expansion power of the expansion unit 31 is recovered as electric power.

[0031] An inlet 41 configured for allowing the refrigerant to flow into the expander shell 34 and an outlet 42 configured for allowing the refrigerant to flow out from the expander shell 34 are formed in the expander shell 34 of the expander 3.

[0032] The inlet 41 is connected to a low-pressure pipe 22. The low-pressure pipe 22 is connected to the evaporator (the load-side heat exchanger 2 or the heat source-side heat exchanger 4) through the first four-way valve 5. The low-temperature and low-pressure refrigerant discharged from the evaporator flows into the expander shell 34. The refrigerant flowing into the expander shell 34 is separated into gas refrigerant and the refrigerating machine oil 50. In this way, the refrigerating machine oil 50 contained in the refrigerant that is discharged from the evaporator is stored in the expander shell 34.

[0033] The outlet 42 is connected to the suction-side pipe 21 of the compressor 1. The refrigerant flowing out from the expander shell 34 passes through the suction-side pipe 21 of the compressor 1, and is sucked into the compressor 1.

(Load-side Heat Exchanger 2)

[0034] The load-side heat exchanger 2 is, for example, a fin-and-tube heat exchanger. The load-side heat exchanger 2 exchanges heat between air as a load-side medium and the refrigerant. The load-side medium is not limited to air, and, for example, water or antifreeze may be used as a heat source.

(Heat Source-side Heat Exchanger 4)

[0035] The heat source-side heat exchanger 4 is, for example, a fin-and-tube heat exchanger. The heat source-side heat exchanger 4 exchanges heat between outside air as a heat source-side medium and the refrigerant. The heat source-side medium is not limited to outside air (air), and, for example, water or antifreeze may be used as a heat source.

(First Four-way Valve 5 and Second Four-way Valve 6)

[0036] The first four-way valve 5 and the second four-way valve 6 are used to switch the flow of the refrigerant circuit.

[0037] When the load-side heat exchanger 2 is caused to function as a condenser (radiator) and the heat source-side heat exchanger 4 is caused to function as an evaporator (heating operation), the first four-way valve 5 connects the discharge-side pipe 10 of the compressor 1 to the heat source-side heat exchanger 4, and connects the load-side heat exchanger 2 to the low-pressure pipe 22. Further, the second four-way valve 6 connects the load-side heat exchanger 2 to the inlet pipe 35, and connects the outlet pipe 36 to the heat source-side heat exchanger 4.

[0038] On the other hand, when the load-side heat exchanger 2 is caused to function as an evaporator and the heat source-side heat exchanger 4 is caused to function as a condenser (radiator) (cooling operation), the first four-way valve 5 connects the low-pressure pipe 22 to the load-side heat exchanger 2, and connects the heat source-side heat exchanger 4 to the discharge-side pipe 10 of the compressor 1. Further, the second four-way valve 6 connects the heat source-side heat exchanger 4 to the inlet pipe 35, and connects the outlet pipe 36 to the load-side heat exchanger 2.

[0039] When the heating operation and the cooling operation are not switched, there is no need to provide the first four-way valve 5 and the second four-way valve 6.

(Controller 200)

[0040] A controller 200 includes, for example, a micro-computer, and has a CPU, a RAM, a ROM, and other components. A control program and the like are stored in the ROM. Detection values from various kinds of sensors configured to detect, for example, the pressure, the temperature, and other conditions of the refrigerant in the refrigerant circuit, or temperatures of the load-side medium and the heat source-side medium are input to the controller 200. The controller 200 controls each unit of the refrigeration cycle apparatus 100 based on the detection values from the sensors. Further, the controller 200 controls switching of the first four-way valve 5 and the second four-way valve 6.

[0041] Next, the heating operation and the cooling operation of the refrigeration cycle apparatus 100 according

to this embodiment are described.

<Flow of Refrigerant during Heating Operation>

[0042] During the heating operation, the first four-way valve 5 and the second four-way valve 6 are switched to states indicated by the dotted lines in Fig. 1.

[0043] The compressor 1 compresses the low-pressure refrigerant in the compressor shell 15, and discharges the high-temperature and high-pressure gas refrigerant to the discharge-side pipe 10. The gas refrigerant discharged from the compressor 1 contains the refrigerating machine oil 50 in the compressor shell 15.

[0044] The high-temperature and high-pressure gas refrigerant discharged from the compressor 1 flows through the discharge-side pipe 10 of the compressor 1, passes through the first four-way valve 5, and is condensed by the load-side heat exchanger 2 that serves as a condenser (cooler in the case of supercritical refrigerant, e.g., CO₂) into liquid refrigerant. The liquid refrigerant flows out from the load-side heat exchanger 2. After that, the liquid refrigerant flowing out from the load-side heat exchanger 2 passes through the second four-way valve 6 and flows into the expansion unit inlet 43 in the expander 3 through the inlet pipe 35. The liquid refrigerant flowing into the expansion unit inlet 43 is expanded by the expansion unit 31 into low-pressure two-phase refrigerant, and flows out from the expansion unit outlet 44 into the outlet pipe 36. At this time, the power generator 32 coupled to the rotation shaft 33 is rotated by the driving force generated by the expansion unit 31.

[0045] The low-pressure two-phase refrigerant flowing out from the expansion unit 31 passes through the second four-way valve 6, and flows into the heat source-side heat exchanger 4 that serves as an evaporator. The low-pressure two-phase refrigerant flowing into the heat source-side heat exchanger 4 exchanges heat with a heat source-side medium (outside air) and receives heat to be evaporated into low-pressure gas refrigerant. The low-pressure gas refrigerant flows out from the heat source-side heat exchanger 4. The low-pressure gas refrigerant flowing out from the heat source-side heat exchanger 4 passes through the first four-way valve 5 and further through the low-pressure pipe 22, and flows into the expander shell 34 from the inlet 41 of the expander 3.

[0046] At least part of the refrigerating machine oil 50 contained in the gas refrigerant flowing into the expander shell 34 is separated in the expander shell 34, and the separated refrigerating machine oil 50 is stored in the expander shell 34. The gas refrigerant and the remaining refrigerating machine oil 50 contained in the gas refrigerant flow out from the outlet 42 toward the low pressure-side pipe 21 of the compressor 1. The gas refrigerant flowing out from the outlet 42 of the expander 3 is sucked into the compressor 1 through the low pressure-side pipe 21 of the compressor 1.

[0047] In this way, the entire low-pressure gas refrigerant flowing out from the evaporator flows into the ex-

pander shell 34, and the refrigerating machine oil 50 contained in the gas refrigerant is separated in the expander shell 34 and is stored in the expander shell 34. The refrigerating machine oil 50 stored in the expander shell 34 is supplied to each of the electric motor unit 17 and the compression unit 18 via the rotation shaft 33 to be used for lubrication.

<Flow of Refrigerant during Cooling Operation>

[0048] Differences from the heating operation are mainly described.

[0049] During the cooling operation, the first four-way valve 5 and the second four-way valve 6 are switched to states indicated by the solid lines in Fig. 1.

[0050] The gas refrigerant discharged from the compressor 1 flows through the discharge-side pipe 10 of the compressor 1 and further through the first four-way valve 5, and is condensed by the heat source-side heat exchanger 4 that serves as a condenser (cooler in the case of supercritical refrigerant, e.g., CO₂) into liquid refrigerant. The liquid refrigerant flows out from the heat source-side heat exchanger 4. After that, the liquid refrigerant flowing out from the heat source-side heat exchanger 4 passes through the second four-way valve 6 and the inlet pipe 35, is expanded into low-pressure two-phase refrigerant by the expansion unit 31, and flows out therefrom.

[0051] The low-pressure two-phase refrigerant flowing out from the expansion unit 31 passes through the second four-way valve 6, and flows into the load-side heat exchanger 2 that serves as an evaporator. The low-pressure two-phase refrigerant flowing into the load-side heat exchanger 2 exchanges heat with a load-side medium (air) and receives heat to be evaporated into low-pressure gas refrigerant. The low-pressure gas refrigerant flows out from the load-side heat exchanger 2. The low-pressure gas refrigerant flowing out from the load-side heat exchanger 2 passes through the first four-way valve 5 and further through the low-pressure pipe 22, and flows into the expander shell 34 from the inlet 41 of the expander 3. The gas refrigerant flowing out from the outlet 42 of the expander 3 is sucked into the compressor 1 through the low pressure-side pipe 21 of the compressor 1.

[0052] When the refrigerating machine oil 50 stored in the expander shell 34 is increased and the oil level of the refrigerating machine oil 50 reaches the outlet 42 of the expander shell 34, an oil quantity of the refrigerating machine oil 50 contained in the gas refrigerant flowing out from the expander shell 34 is approximately the same as an oil quantity of the refrigerating machine oil 50 flowing into the expander shell 34.

[0053] The refrigerating machine oil 50 stored in the expander shell 34 is consumed by being supplied to the expansion unit 31 and the power generator 32. For example, part of the refrigerating machine oil 50 supplied to the expansion unit 31 is mixed into the refrigerant in the expansion unit 31, and flows into the compressor 1

through the refrigerant passage. Therefore, an oil quantity of the refrigerating machine oil 50 stored in the expander shell 34 may be reduced.

[0054] As described above, in Embodiment 1, the expander 3 includes the expander shell 34 that defines the outer shell, the expansion unit 31 arranged in the expander shell 34 and configured to expand the refrigerant flowing out from the condenser to generate the driving force, and configured for causing the expanded refrigerant to flow into the evaporator, and the power generator 32 arranged in the expander shell 34 and configured to rotate by the driving force generated by the expansion unit 31.

[0055] Therefore, power generated when the refrigerant is expanded can be recovered as electric power.

[0056] Further, in Embodiment 1, the inlet 41 configured for allowing the refrigerant to flow into the expander shell 34 and the outlet 42 configured for allowing the refrigerant flowing into the expander shell 34 from the inlet 41 to flow into the suction-side pipe 21 of the compressor 1 are formed in the expander shell 34. The refrigerating machine oil 50 contained in the refrigerant flowing into the expander shell 34 is stored in the expander shell 34, and the refrigerating machine oil 50 is supplied to at least one of the expansion unit and the power generator.

[0057] Therefore, the refrigerating machine oil 50 stored in the expander shell 34 can be supplied to the expansion unit 31 and the power generator 32, and depletion of the refrigerating machine oil 50 in the expander shell 34 can be suppressed.

[0058] Further, the low-temperature and low-pressure refrigerant flowing out from the evaporator flows into the expander shell 34, and thus, the power generator 32 can be cooled. Therefore, reduction in efficiency of the power generator 32 can be suppressed.

[0059] Further, temperature rise in the expander shell 34 can be suppressed, and thus, heat is less likely to be exchanged between the refrigerant in the expansion unit 31 and the gas refrigerant in the expander shell 34 so that increase in enthalpy of the refrigerant flowing from the expansion unit 31 into the evaporator can be suppressed to alleviate reduction in refrigeration capacity.

[0060] Further, an oil supply pipe as in the technique disclosed in Patent Literature 2 is not arranged, and thus, the refrigerant that dissolves in the refrigerating machine oil 50 does not form bubbles, thereby being capable of suppressing unsatisfactory lubricity. Further, even under a transitional state, e.g., at a startup of the compressor 1, the expansion unit 31 and the power generator 32 can be lubricated with the refrigerating machine oil 50 stored in the expander shell 34.

[0061] Further, the refrigerant flowing out from the expander shell 34 is caused to flow into the suction-side pipe 21 of the compressor 1, and thus, the refrigerating machine oil 50 can be stored in the expander shell 34 irrespective of the internal pressure of the compressor shell 15 (high-pressure shell or low-pressure shell).

Embodiment 2

[0062] In Embodiment 2 of the present invention, differences from Embodiment 1 are mainly described. Like reference numerals are used to designate components that are the same as those in Embodiment 1, and description thereof is omitted.

[0063] Figs. 2 are diagrams for illustrating configurations of an expander 3 of a refrigeration cycle apparatus 100 according to Embodiment 2 of the present invention.

[0064] As illustrated in Fig. 2(a), the outlet 42 of the expander shell 34 is formed by an opening port formed in a side surface of the expander shell 34. The outlet 42 is formed at a position (Lm) higher than an oil level (Ln) of a preset necessary quantity of the refrigerating machine oil 50 to be stored in the expander shell 34. In this case, the preset necessary quantity is a minimum necessary quantity of oil defined by, for example, specifications of the expander 3.

[0065] As illustrated in Fig. 2(b), a pipe that communicates the inside and the outside of the expander shell 34 may be arranged and the outlet 42 may be formed by an opening port at an end portion of the pipe. Also in this case, the outlet 42 is formed at a position (Lm) higher than the oil level (Ln) of the preset necessary quantity of the refrigerating machine oil 50 to be stored in the expander shell 34.

[0066] With the configuration described above, the preset necessary quantity of the refrigerating machine oil 50 can be stored in the expander shell 34. Therefore, the minimum oil quantity necessary for the expander 3 can be secured.

Embodiment 3

[0067] In Embodiment 3 of the present invention, differences from Embodiment 1 are mainly described. Like reference numerals are used to designate components that are the same as those in Embodiment 1, and description thereof is omitted.

[0068] Fig. 3 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 3 of the present invention.

[0069] As illustrated in Fig. 3, the refrigeration cycle apparatus 100 according to Embodiment 3 further includes, in addition to the configuration of Embodiment 1, an oil return pipe 52 configured for causing the refrigerating machine oil 50 in the expander shell 34 to flow into the suction-side pipe 21 of the compressor 1.

[0070] The oil return pipe 52 connects an oil outlet 45 formed in a bottom portion of the expander shell 34 and the suction-side pipe 21 of the compressor 1. Further, an on-off valve 54 configured to open and close the passage is formed in the oil return pipe 52.

[0071] The controller 200 controls opening and closing of the on-off valve 54. When, for example, the oil quantity of the refrigerating machine oil 50 in the compressor shell 15 is smaller than the preset oil quantity, the controller

200 opens the on-off valve 54 and returns part of the refrigerating machine oil 50 in the expander shell 34 into the compressor shell 15.

[0072] The oil quantity in the compressor shell 15 may be determined, for example, by providing an oil level indicator, or by measuring the shell temperature with a temperature sensor, e.g., a thermistor.

[0073] Instead of the on-off valve 54, a flow control valve with a variable opening degree may be arranged. Further, through omission of the on-off valve 54 and adjustment of the pipe diameter and the length of the oil return pipe 52, a small quantity of the refrigerating machine oil 50 may be returned all the time.

[0074] Further, by lowering the level of the outlet 42 of the expander shell 34, the quantity of the refrigerating machine oil 50 stored in the expander shell 34 is reduced and the quantity of the refrigerating machine oil 50 stored in the compressor shell 15 is increased. Therefore, the level of the outlet 42 of the expander shell 34 may be set depending on the minimum necessary quantity of oil in the compressor shell 15.

[0075] With the configuration described above, the refrigerating machine oil 50 in the expander shell 34 can be returned to the compressor 1, and thus, when the quantity of the refrigerating machine oil 50 contained in the refrigerant that is discharged from the compressor 1 (quantity of the oil that is taken out) is large at, for example, a startup, depletion of the refrigerating machine oil 50 in the compressor shell 15 can be suppressed.

[0076] Further, when the refrigerating machine oil 50 in the expander shell 34 is excessively stored, the refrigerating machine oil 50 can be returned into the compressor shell 15.

[0077] Further, even when, for example, the configuration in the expander 3 or other factors impose a limit and the outlet 42 cannot be formed at a desired position, the oil can be returned to the compressor 1 irrespective of the level of the outlet 42 of the expander shell 34.

Embodiment 4

[0078] In Embodiment 4 of the present invention, differences from Embodiment 1 are mainly described. Like reference numerals are used to designate components that are the same as those in Embodiment 1, and description thereof is omitted.

[0079] Fig. 4 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 4 of the present invention.

[0080] As illustrated in Fig. 4, the refrigeration cycle apparatus 100 according to Embodiment 4 further includes, in addition to the configuration of Embodiment 1 described above, a first bypass pipe 23 configured to branch off from the low-pressure pipe 22 to join the suction-side pipe 21 of the compressor 1. Specifically, the first bypass pipe 23 branches off from the passage from the evaporator (the load-side heat exchanger 2 or the heat source-side heat exchanger 4) to the inlet 41 of the

expander shell 34 to join the passage from the outlet 42 of the expander shell 34 to the compressor 1.

[0081] In this case, the refrigerant liquefied by the condenser (the load-side heat exchanger 2 or the heat source-side heat exchanger 4) flows into the expansion unit 31 in the expander 3, and thus, the temperature of the refrigerant flowing through the expansion unit 31 is lower than the temperature of the refrigerant flowing into the expander shell 34. Therefore, the refrigerant in the expansion unit 31 and the refrigerant flowing into the expander shell 34 exchange heat therebetween.

[0082] In Embodiment 4, part of the refrigerant flowing out from the evaporator flows from the pipe 10 into the expander shell 34, and another part thereof flows from the first bypass pipe 23 into the suction-side pipe 21 of the compressor 1.

[0083] Thus, the flow rate of the refrigerant flowing into the expander shell 34 is reduced compared with a case in which the entire refrigerant flowing out from the evaporator flows into the expander shell 34. Accordingly, the heat exchange quantity between the refrigerant in the expansion unit 31 and the refrigerant flowing into the expander shell 34 can be reduced.

[0084] Therefore, increase in enthalpy of the refrigerant flowing into the evaporator can be suppressed to alleviate reduction in refrigeration capacity.

[0085] Further, excess supply of the refrigerating machine oil 50 into the expander shell 34 can be suppressed. Therefore, a situation in which the oil level of the refrigerating machine oil 50 in the expander shell 34 reaches the power generator 32 can be suppressed.

[0086] In the configuration described above, the size of the expander 3 is smaller than the size of the compressor 1, and thus, the quantity of the refrigerating machine oil 50 contained in the refrigerant flowing out from the expander shell 34 (quantity of oil that is taken out) is smaller than the quantity of the refrigerating machine oil 50 contained in the refrigerant that is discharged from the compressor 1. That is, it is sufficient that a quantity of the oil that is smaller than the quantity of the oil that is taken out of the compressor 1 is supplied to the expander 3.

[0087] Therefore, the length and the diameter of the low-pressure pipe 22 or the first bypass pipe 23 are selected so that the flow rate of the refrigerant that passes through the low-pressure pipe 22 may be lower than the flow rate of the refrigerant that passes through the first bypass pipe 23.

[0088] As described above, by supplying the refrigerant and the oil at an appropriate refrigerant flow rate and an appropriate oil flow rate to the expander 3, the heat exchange quantity in the expansion unit 31 can be suppressed, and depletion of the refrigerating machine oil 50 in the expander shell 34 can be suppressed.

[0089] A flow control valve or other components may be arranged to the low-pressure pipe 22 or the first bypass pipe 23 to control the flow rate of the refrigerant flowing into the expander shell 34. For example, the con-

troller 200 may increase the flow rate of the refrigerant flowing into the expander shell 34 to increase the oil quantity of the stored refrigerating machine oil 50 when the oil quantity of the refrigerating machine oil 50 in the expander shell 34 is smaller than the preset oil quantity.

[0090] The oil quantity in the expander shell 34 may be determined, for example, by providing an oil level indicator, or by measuring the shell temperature with a temperature sensor, e.g., a thermistor.

(Modified Example)

[0091] The configuration described above in Embodiment 3 and the configuration described in Embodiment 4 may be combined.

[0092] For example, as illustrated in Fig. 5, the configuration of Embodiment 1 may further additionally include the oil return pipe 52 configured for causing the refrigerating machine oil 50 in the expander shell 34 to flow into the suction-side pipe 21 of the compressor 1, and the first bypass pipe 23 configured to branch off from the passage from the evaporator to the inlet 41 of the expander shell 34 to join the passage from the outlet 42 of the expander shell 34 to the compressor 1. Such a configuration can achieve effects similar to those described above.

Embodiment 5

[0093] In Embodiment 5 of the present invention, differences from Embodiment 1 are mainly described. Like reference numerals are used to designate components that are the same as those in Embodiment 1, and description thereof is omitted.

[0094] Fig. 6 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 5 of the present invention.

[0095] As illustrated in Fig. 6, the refrigeration cycle apparatus 100 according to Embodiment 5 includes, in addition to the configuration of Embodiment 1, a second bypass pipe 61 configured to branch off from the passage (inlet pipe 35) from the condenser to the expansion unit 31 for causing the refrigerant to flow into the inlet 41 of the expander shell 34.

[0096] Further, a decompression unit, e.g., a capillary tube 63 configured to decompress the refrigerant flowing through the second bypass pipe 61, and a heat exchanger 60 configured to exchange heat between the refrigerant branched off to the second bypass pipe 61 to be decompressed and the refrigerant flowing through the inlet pipe 35 (refrigerant flowing from the condenser into the expansion unit) are arranged to the second bypass pipe 61.

[0097] The outlet 42 of the expander shell 34 in Embodiment 5 joins the suction-side pipe 21 of the compressor 1 through an outlet pipe 20. A decompression unit, e.g., a capillary tube 24, which is configured to decompress the refrigerant, is formed in the outlet pipe 20.

[0098] Further, in Embodiment 5, the suction-side pipe 21 of the compressor 1 is connected to the evaporator (the load-side heat exchanger 2 or the heat source-side heat exchanger 4) through the first four-way valve 5.

[0099] With regard to operation of Embodiment 5, differences from Embodiment 1 are mainly described.

[0100] The refrigerant flowing out from the condenser passes through the second four-way valve 6, and flows into the inlet pipe 35. Part of the refrigerant flowing through the inlet pipe 35 flows into the second bypass pipe 61. The refrigerant flowing into the second bypass pipe 61 is decompressed by the capillary tube 63 and the temperature thereof falls. The heat exchanger 60 exchanges heat between the refrigerant that is decompressed by the capillary tube 63 to have the lowered temperature and the high-pressure refrigerant flowing from the inlet pipe 35 into the expansion unit 31 so that the refrigerant decompressed by the capillary tube 63 turns into gas refrigerant.

[0101] The gas refrigerant flows into the inlet 41 of the expander shell 34. Then, after the refrigerating machine oil 50 contained in the refrigerant is separated, the refrigerant flows from the outlet 42 to the outlet pipe 20. Then, after the refrigerant is decompressed by the capillary tube 24, the refrigerant joins the suction-side pipe 21 of the compressor 1.

[0102] There may be employed a configuration in which the refrigerant is decompressed through adjustment of the pipe diameters and the lengths of the second bypass pipe 61 and the outlet pipe 20 without arranging the decompression units, e.g., the capillary tubes 24 and 63.

[0103] Instead of the capillary tube 63, a decompression device with a variable flow rate may be arranged. Arrangement of such a decompression device with a variable flow rate enables keeping appropriate temperature of the refrigerant flowing into the expander shell depending on the operation state, and the power generator 32 can be effectively cooled. Further, occurrence of transient liquid return (liquid backflow) into the expander shell 34 can be prevented to suppress lowering of oil concentration in the expander shell 34.

[0104] With the configuration described above, the refrigerant flowing into the expander shell 34 can be brought into a gas state, and thus, even when, for example, liquid backflow in which the refrigerant in a liquid state flows out from the evaporator occurs, the refrigerant in the liquid state can be prevented from flowing into the expander shell 34. Therefore, the refrigerant in the liquid state can be prevented from being mixed into the refrigerating machine oil 50, and the oil concentration can be prevented from being lowered.

[0105] Further, by setting the pressure of the refrigerant flowing through the second bypass pipe 61, the pressure and the temperature in the expander shell 34 can be set at desired values. Therefore, by lowering the temperature in the expander shell 34, temperature rise of the power generator 32 can be suppressed, and reduction

in efficiency of the power generator 32 can be suppressed.

(Modified Example 1)

[0106] The configuration described above in Embodiment 3 and the configuration described in Embodiment 5 may be combined.

[0107] For example, as illustrated in Fig. 7, the configuration of Embodiment 5 may further additionally include the oil return pipe 52 configured for causing the refrigerating machine oil 50 in the expander shell 34 to flow into the suction-side pipe 21 of the compressor 1. Such a configuration can achieve effects similar to those described above.

[0108] Further, by setting the pressure in the expander shell 34 to be higher than that of the refrigerant passing through the expansion unit 31, there can be attained oil supply using a pressure difference as a method of supplying the refrigerating machine oil 50 stored in the expander shell 34 to the expansion unit 31 and the power generator 32, and the reliability of the expander 3 is improved. Further, the pressure on the suction side of the compressor 1 is lower than the pressure in the expander shell 34, and thus, the refrigerating machine oil 50 in the expander shell 34 can be returned to the compressor 1 without fail by using the pressure difference.

(Modified Example 2)

[0109] As illustrated in Fig. 8, in addition to the configuration described in Embodiment 5, there may be further arranged a third bypass pipe 65 configured to branch off from the passage from the evaporator to the compressor 1 (low-pressure pipe 22) to join the second bypass pipe 61 at a downstream side of the heat exchanger 60.

[0110] With such a configuration, even when the refrigerant, which flows out from the evaporator and then passes through the low-pressure pipe 22, is in a moist state, the refrigerant in the moist state and the refrigerant, which passes through the second bypass pipe 61 and is brought into the gas state by the heat exchanger 60, join together. Thus, the refrigerant in the moist state can be heated and liquid backflow to the expander shell 34 can be suppressed.

Embodiment 6

[0111] With regard to Embodiment 6 of the present invention, differences from Embodiment 5 are mainly described. Like reference numerals are used to designate components that are the same as those in Embodiment 5, and description thereof is omitted.

[0112] Fig. 9 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 6 of the present invention.

[0113] As illustrated in Fig. 9, the refrigeration cycle apparatus 100 according to Embodiment 6 includes, in

addition to the configuration of Embodiment 5, an oil separator 7 configured to separate the refrigerating machine oil 50 contained in the refrigerant that is discharged from the compressor 1, and a fourth bypass pipe 13 configured to join the refrigerating machine oil 50 separated by the oil separator 7 to the refrigerant decompressed by the second bypass pipe 61. In Embodiment 6, the heat exchanger 60 is unnecessary.

[0114] Further, in Embodiment 6, the discharge-side pipe 10 of the compressor 1 is connected to the oil separator 7. Further, the oil separator 7 and the first four-way valve 5 are connected through the gas pipe 11.

[0115] As described in Modified Example 1 of Embodiment 5, the configuration in which the oil return pipe 52 configured to cause the refrigerating machine oil 50 in the expander shell 34 to flow into the suction-side pipe 21 of the compressor 1 is arranged may be employed.

[0116] In the refrigeration cycle apparatus 100 according to Embodiment 6, the high-temperature and high-pressure refrigerant discharged from the compressor 1 flows into the oil separator 7 through the pipe 10. In the oil separator 7, at least part of the refrigerating machine oil 50 contained in the refrigerant is separated. The refrigerating machine oil 50 separated by the oil separator 7 joins the low-pressure liquid refrigerant flowing through the second bypass pipe 61 through the fourth bypass pipe 13. The low-pressure liquid refrigerant flowing through the second bypass pipe 61 joins the high-temperature refrigerating machine oil 50 to be heated and turned into refrigerant in a gas state. The gasified refrigerant and the refrigerating machine oil 50 flow from the inlet 41 into the expander shell 34.

[0117] On the other hand, the gas refrigerant separated by the oil separator 7 passes through the gas pipe 11, and flows into the condenser (the load-side heat exchanger 2 or the heat source-side heat exchanger 4) through the first four-way valve 5.

[0118] With the configuration described above, the refrigerant flowing into the expander shell 34 can be brought into a gas state, and thus, even when, for example, liquid backflow in which the refrigerant in a liquid state flows out from the evaporator occurs, the refrigerant in the liquid state can be prevented from flowing into the expander shell 34. Therefore, the refrigerant in the liquid state can be prevented from being mixed into the refrigerating machine oil 50, and the oil concentration can be prevented from being lowered.

[0119] Further, by setting the pressure of the refrigerant flowing through the second bypass pipe 61, the pressure and the temperature in the expander shell 34 can be set at desired values. Therefore, by lowering the temperature in the expander shell 34, temperature rise of the power generator 32 can be suppressed, and reduction in efficiency of the power generator 32 can be suppressed.

[0120] Further, the low-temperature refrigerant flowing through the second bypass pipe 61 can cool the high-temperature refrigerating machine oil 50, and thus, tem-

perature rise of the power generator 32 can be suppressed.

[0121] Further, the refrigerating machine oil 50 can be supplied from the oil separator 7, and thus, a sufficient quantity of the oil can be supplied into the expander shell 34.

Embodiment 7

[0122] In Embodiment 7 of the present invention, differences from Embodiment 1 are mainly described. Like reference numerals are used to designate components that are the same as those in Embodiment 1, and description thereof is omitted.

[0123] Fig. 10 is a diagram for illustrating a configuration of a refrigeration cycle apparatus 100 according to Embodiment 7 of the present invention.

[0124] As illustrated in Fig. 10, the refrigeration cycle apparatus 100 according to Embodiment 7 further includes, in addition to the configuration of Embodiment 1, a fifth bypass pipe 37 configured to branch off from the inlet pipe 35 to join the outlet pipe 36 and a second expansion valve 38 arranged to the fifth bypass pipe 37 and configured to expand the refrigerant.

[0125] The fifth bypass pipe 37 branches off from the passage (inlet pipe 35) from the condenser to the expansion unit 31 to join the passage (outlet pipe 36) from the expansion unit 31 to the evaporator.

[0126] The second expansion valve 38 is, for example, an electronically controlled expansion valve with a variable opening degree. The controller 200 controls the opening degree of the second expansion valve 38 in accordance with a preset condition.

[0127] There may be employed a configuration in which an on-off valve configured to open and close the passage of the fifth bypass pipe 37 is provided and the opening degree of the second expansion valve 38 is fixed. In this case, the controller 200 controls the on-off valve.

[0128] When the opening degree of the second expansion valve 38 is fully closed, the refrigerant flowing through the inlet pipe 35 does not flow through the fifth bypass pipe 37. In this case, the operation is similar to that in Embodiment 1.

[0129] On the other hand, when the second expansion valve 38 is opened, the refrigerant flowing through the inlet pipe 35 flows through the fifth bypass pipe 37. The refrigerant flowing through the fifth bypass pipe 37 is decompressed by the second expansion valve 38. At this time, the flow rate of the refrigerant flowing to the expansion unit 31 is reduced, and thus, the drive of the expansion unit 31 is stopped. An on-off valve or other components may be arranged to the inlet pipe 35 or the outlet pipe 36 to completely stop the flow of the refrigerant into the expansion unit 31.

[0130] The refrigerant decompressed by the second expansion valve 38 joins the outlet pipe 36, passes through the second four-way valve 6, and flows into the

evaporator.

[0131] Next, control of the second expansion valve 38 by the controller 200 is described.

[0132] When a preset condition is satisfied, the controller 200 opens the second expansion valve 38, causes the refrigerant to flow through the fifth bypass pipe 37, and stops the drive of the expansion unit 31.

[0133] The preset condition in this case is, for example, at least one of the following conditions (1) to (3).

(1) The period of time elapsed since a startup of the compressor 1 is equal to or shorter than a preset period of time.

(2) The quantity of the refrigerating machine oil 50 in the expander shell 34 is equal to or smaller than a preset quantity.

(3) The rotation speed of the expansion unit 31 is equal to or higher than a preset upper limit, or equal to or lower than a preset lower limit.

[0134] With the configuration described above, when the preset condition is satisfied, the drive of the expansion unit 31 can be stopped.

[0135] That is, by stopping the drive of the expansion unit 31 when the period of time elapsed since a startup of the compressor 1 is equal to or shorter than the preset period of time, the drive of the expansion unit 31 can be prevented until the discharge pressure of the compressor 1 is sufficiently increased, and liquid backflow into the compressor 1 and the like can be suppressed.

[0136] Further, by stopping the drive of the expansion unit 31 when the refrigerating machine oil 50 in the expander shell 34 is reduced to the preset quantity or less, breakage of the expander 3 can be prevented.

[0137] Further, by stopping the drive of the expansion unit 31 when the rotation speed of the expansion unit 31 is equal to or higher than the preset upper limit, or equal to or lower than the preset lower limit, the expansion unit 31 can be driven at the rotation speed falling within a desired range.

[0138] The configuration of Embodiment 7 can also be applied to any of Embodiments 1 to 6.

Reference Signs List

[0139]

1 compressor 2 load-side heat exchanger 3 expander 4 heat source-side heat exchanger 5 first four-way valve 6 second four-way valve 7 oil separator 10 pipe 11 gas pipe 13 fourth bypass pipe 15 compressor shell 17 electric motor unit 18 compression unit 20 outlet pipe 21 pipe 22 low-pressure pipe 23 first bypass pipe 24 capillary tube 31 expansion unit 32 power generator 33 rotation shaft 34 expander shell 35 inlet pipe 36 outlet pipe 37 fifth bypass pipe 38 second expansion valve 41 inlet 42 outlet 43 expansion unit inlet 44

expansion unit outlet 45 oil outlet 50 refrigerating machine oil 52 oil return pipe 54 on-off valve 60 heat exchanger 61 second bypass pipe 63 capillary tube 65 third bypass pipe 100 refrigeration cycle apparatus 200 controller

Claims

1. A refrigeration cycle apparatus comprising a refrigerant circuit,
the refrigerant circuit comprising a compressor, a condenser, an expander, and an evaporator, which are connected by pipes so that refrigerant is circulated through the refrigerant circuit,
the expander comprising:

an expander shell defining an outer shell of the expander;
an expansion unit arranged in the expander shell, the expansion unit being configured to expand the refrigerant flowing out from the condenser to generate driving force, and configured for causing the expanded refrigerant to flow into the evaporator; and
a power generator arranged in the expander shell, the power generator being configured to rotate by the driving force generated by the expansion unit,
the expander shell including:

an inlet configured for allowing the refrigerant to flow into; and
an outlet configured for allowing the refrigerant flowed from the inlet to flow into a suction-side pipe of the compressor,

the expander shell being configured such that refrigerating machine oil contained in the refrigerant is stored therein, and is supplied to at least one of the expansion unit and the power generator.
2. The refrigeration cycle apparatus of claim 1, wherein the outlet of the expander shell is formed at a position higher than an oil level of a preset necessary quantity of the refrigerating machine oil to be stored in the expander shell.
3. The refrigeration cycle apparatus of claim 1 or 2, further comprising an oil return pipe configured for causing the refrigerating machine oil in the expander shell to flow into the suction-side pipe of the compressor.
4. The refrigeration cycle apparatus of any one of claims 1 to 3, wherein the refrigerant flowing out from the evaporator flows into the expander shell from the inlet of the expander shell.
5. The refrigeration cycle apparatus of claim 4, further comprising a first bypass pipe configured to branch off from a passage from the evaporator to the inlet of the expander shell and to join a passage from the outlet of the expander shell to the compressor.
6. The refrigeration cycle apparatus of claim 5, wherein a flow rate of the refrigerant flowing into the expander shell from the inlet of the expander shell is lower than a flow rate of the refrigerant passing through the first bypass pipe.
7. The refrigeration cycle apparatus of any one of claims 1 to 3, further comprising:

a second bypass pipe configured to branch off from a passage from the condenser to the expansion unit, to decompress the refrigerant and to cause the refrigerant to flow into the inlet of the expander shell; and
a heat exchanger configured to exchange heat between the refrigerant branched off and decompressed at the second bypass pipe and the refrigerant flowing from the condenser into the expansion unit.
8. The refrigeration cycle apparatus of claim 7, wherein a pressure of the refrigerant in the expander shell is higher than a pressure of the refrigerant flowing out from the expansion unit.
9. The refrigeration cycle apparatus of claim 7 or 8, further comprising a third bypass pipe configured to branch off from a passage from the evaporator to the compressor and to join the second bypass pipe at a downstream side of the heat exchanger.
10. The refrigeration cycle apparatus of any one of claims 1 to 3, further comprising:

a second bypass pipe configured to branch off from a passage from the condenser to the expansion unit, to decompress the refrigerant and to cause the refrigerant to flow into the inlet of the expander shell;
an oil separator configured to separate the refrigerating machine oil contained in the refrigerant discharged from the compressor; and
a fourth bypass pipe configured to join the refrigerating machine oil separated by the oil separator to the refrigerant decompressed at the second bypass pipe.
11. The refrigeration cycle apparatus of any one of claims 1 to 10, further comprising:

a fifth bypass pipe configured to branch off from a passage from the condenser to the expansion

unit and to join a passage from the expansion unit to the evaporator; and
a second expansion valve arranged to the fifth bypass pipe and configured to expand the refrigerant,
wherein, when a preset condition is satisfied, the refrigerant is caused to flow through the fifth bypass pipe.

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12. The refrigeration cycle apparatus of claim 11, wherein the preset condition comprises at least one of:

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a condition that a period of time elapsed since a startup of the compressor is equal to or shorter than a preset period of time;
a condition that a quantity of the refrigerating machine oil in the expander shell is equal to or smaller than a preset quantity; and
a condition that a rotation speed of the expansion unit is equal to or higher than a preset upper limit, or equal to or lower than a preset lower limit.

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FIG. 1

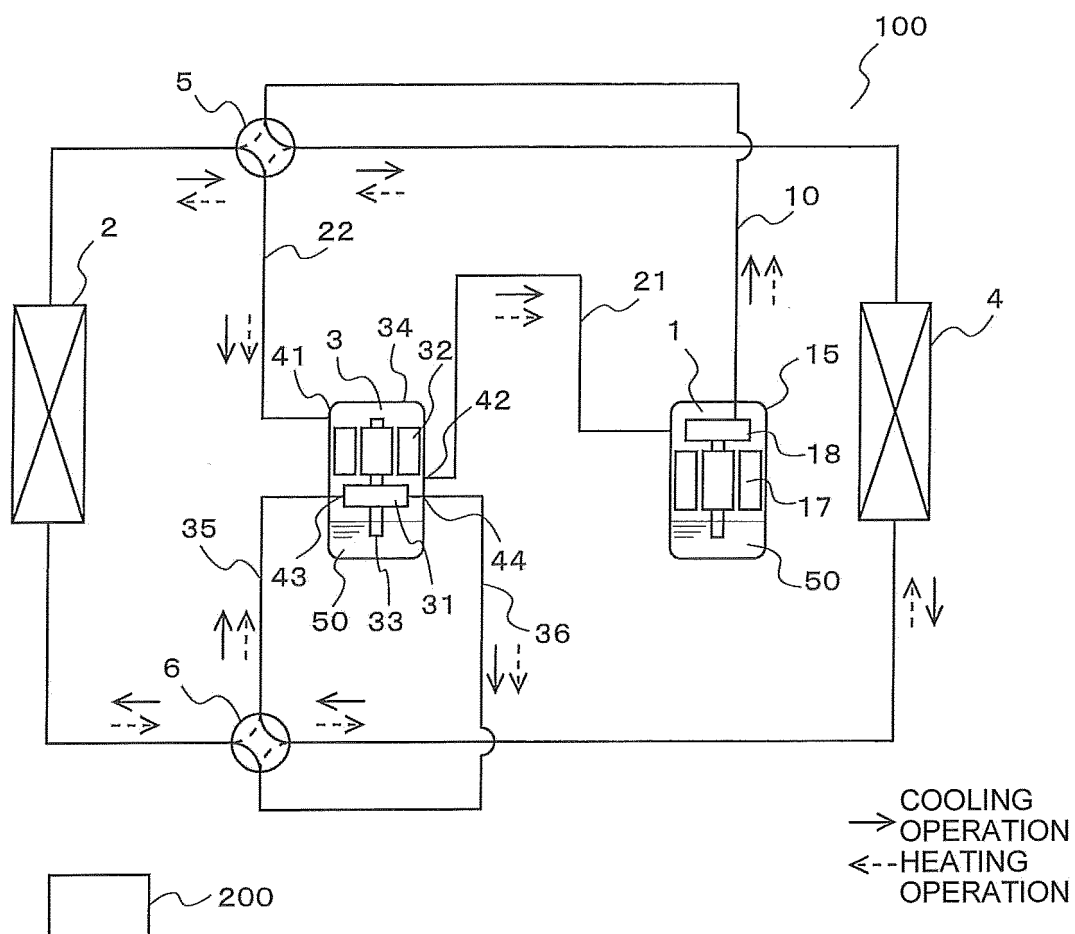


FIG. 2

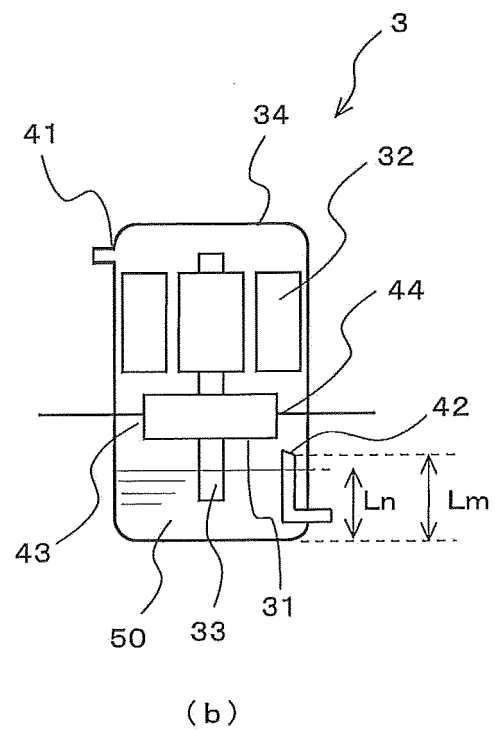
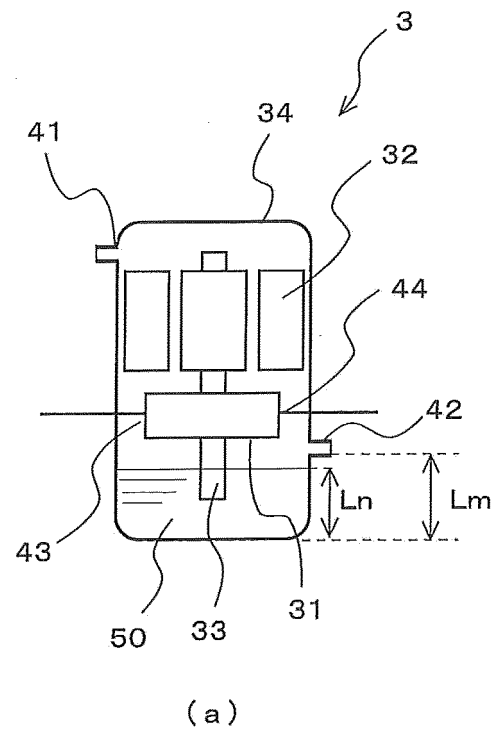


FIG. 3

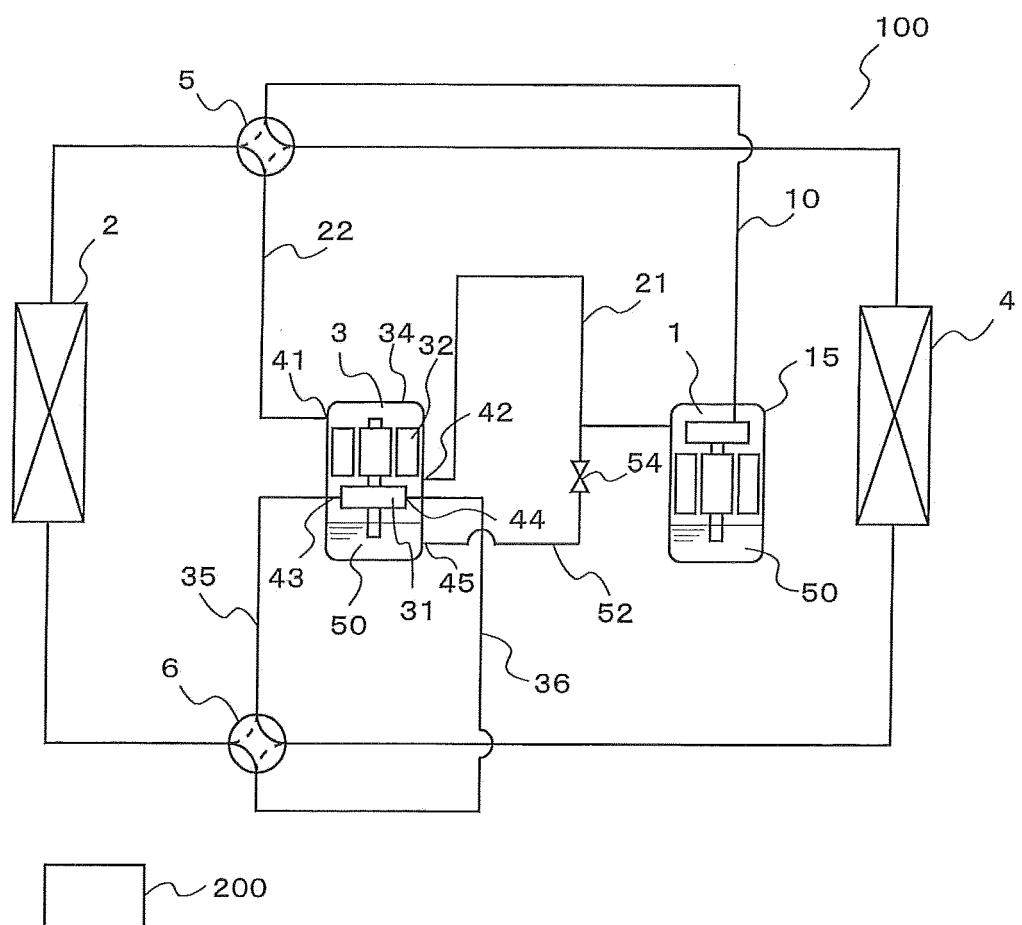


FIG. 4

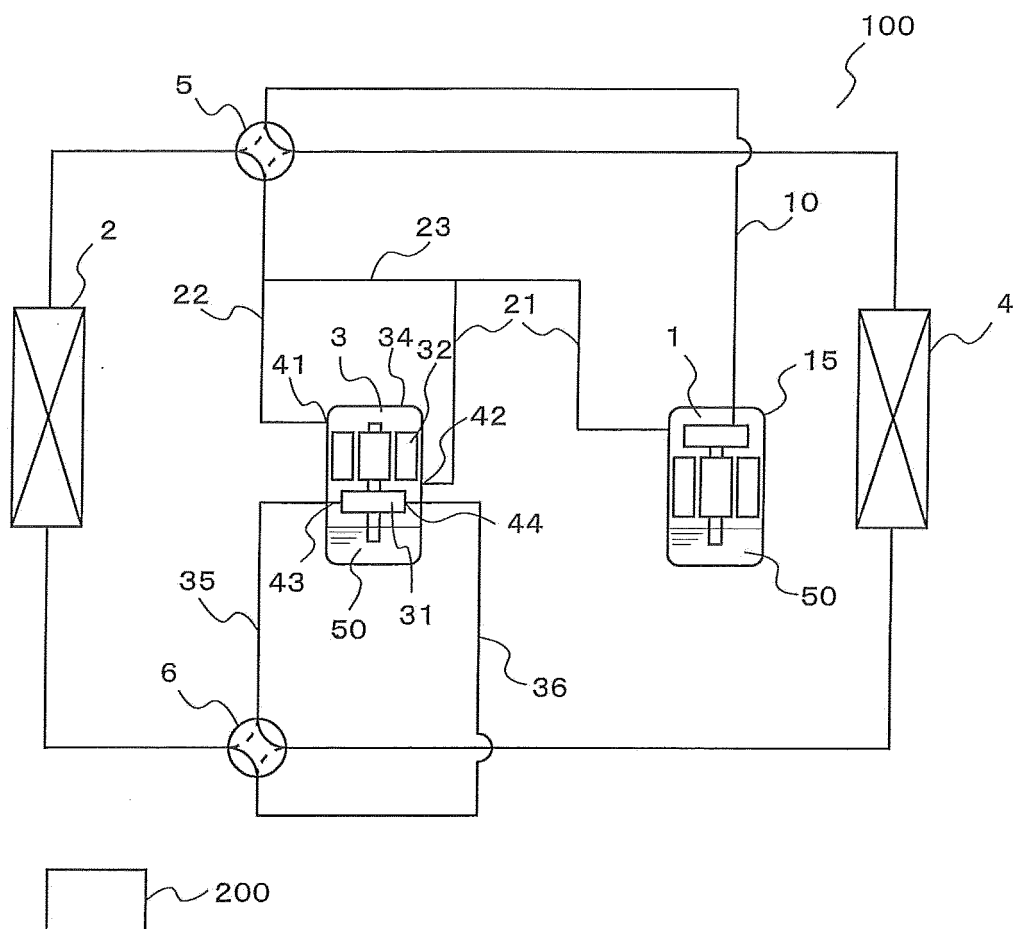


FIG. 5

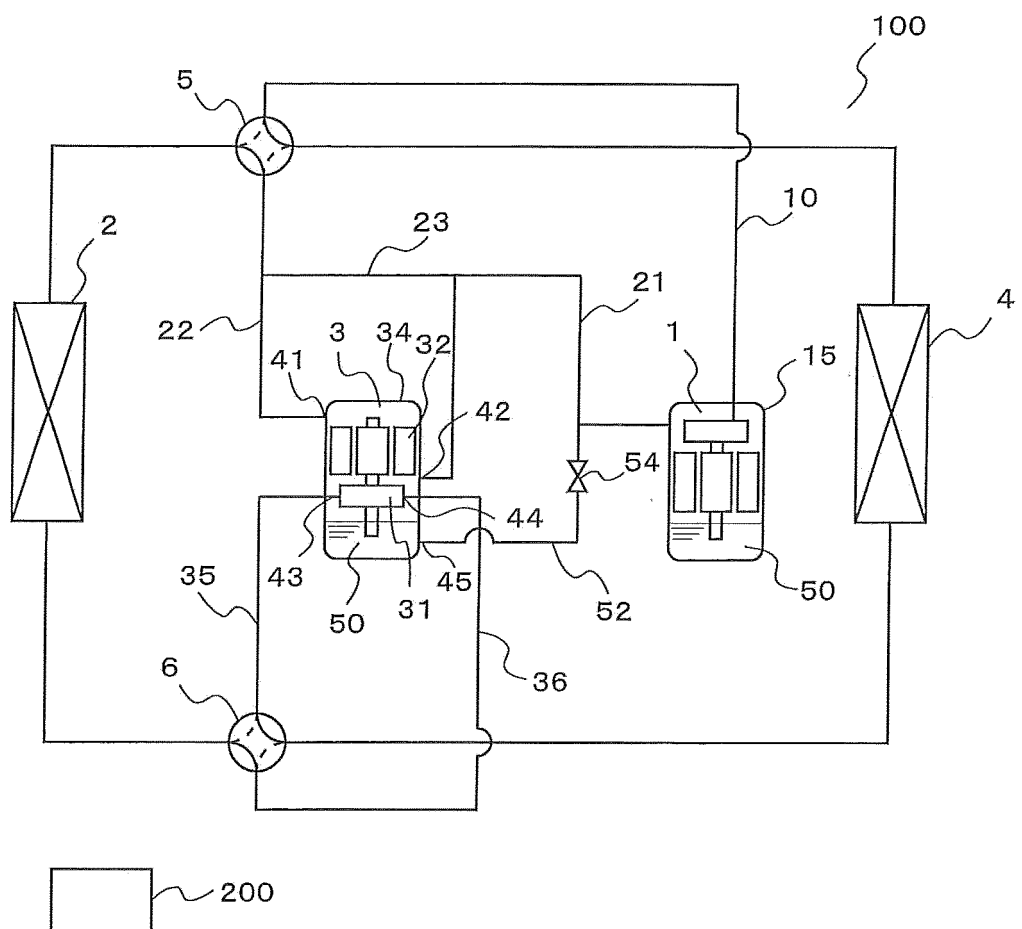


FIG. 6

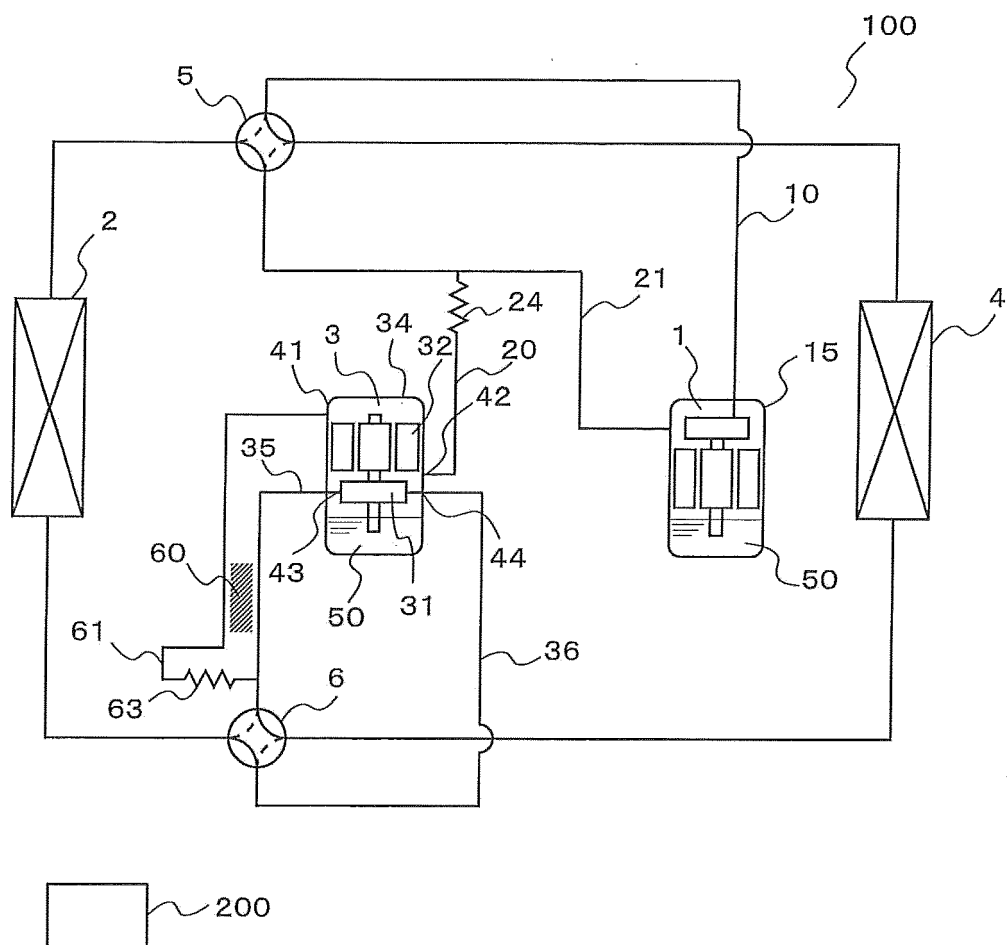


FIG. 7

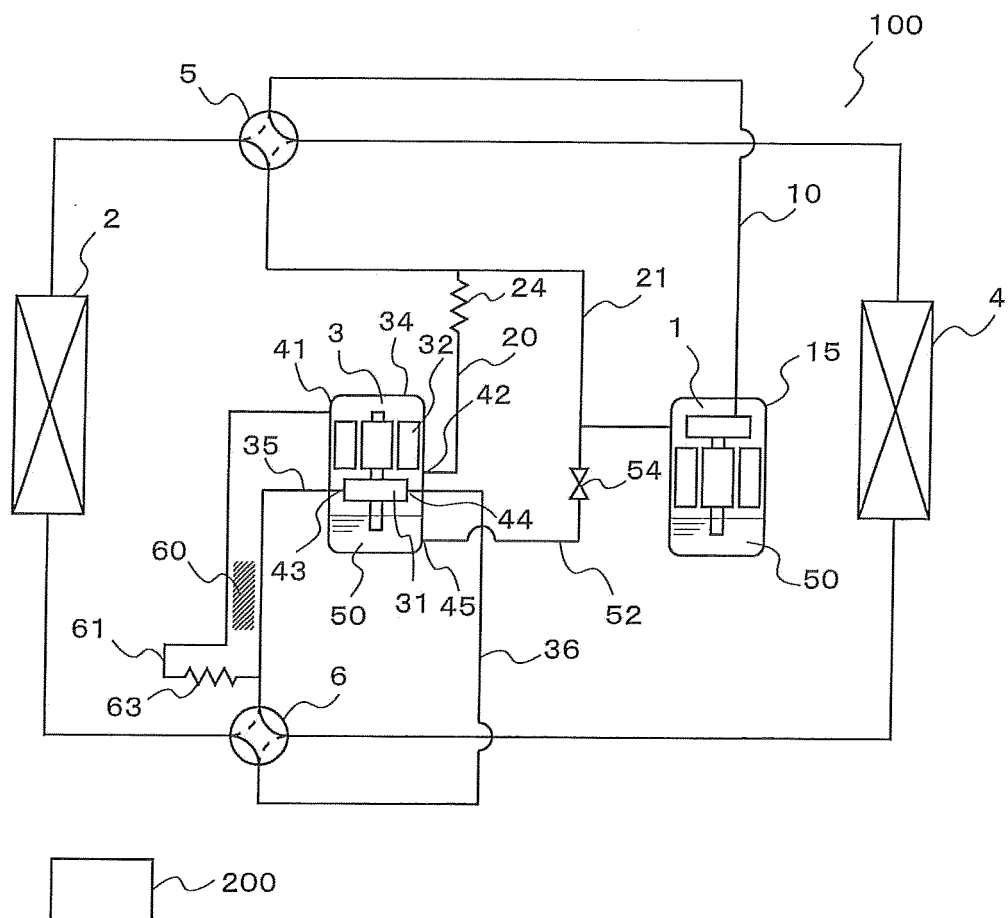


FIG. 8

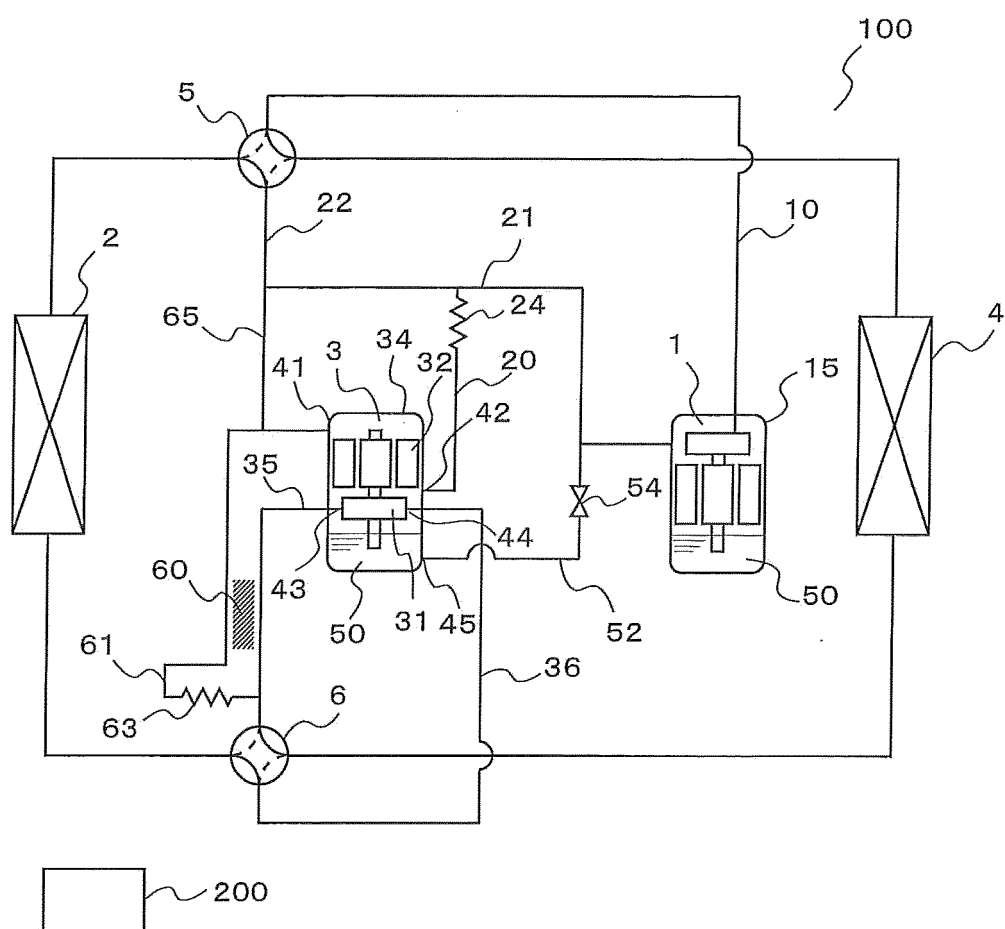


FIG. 9

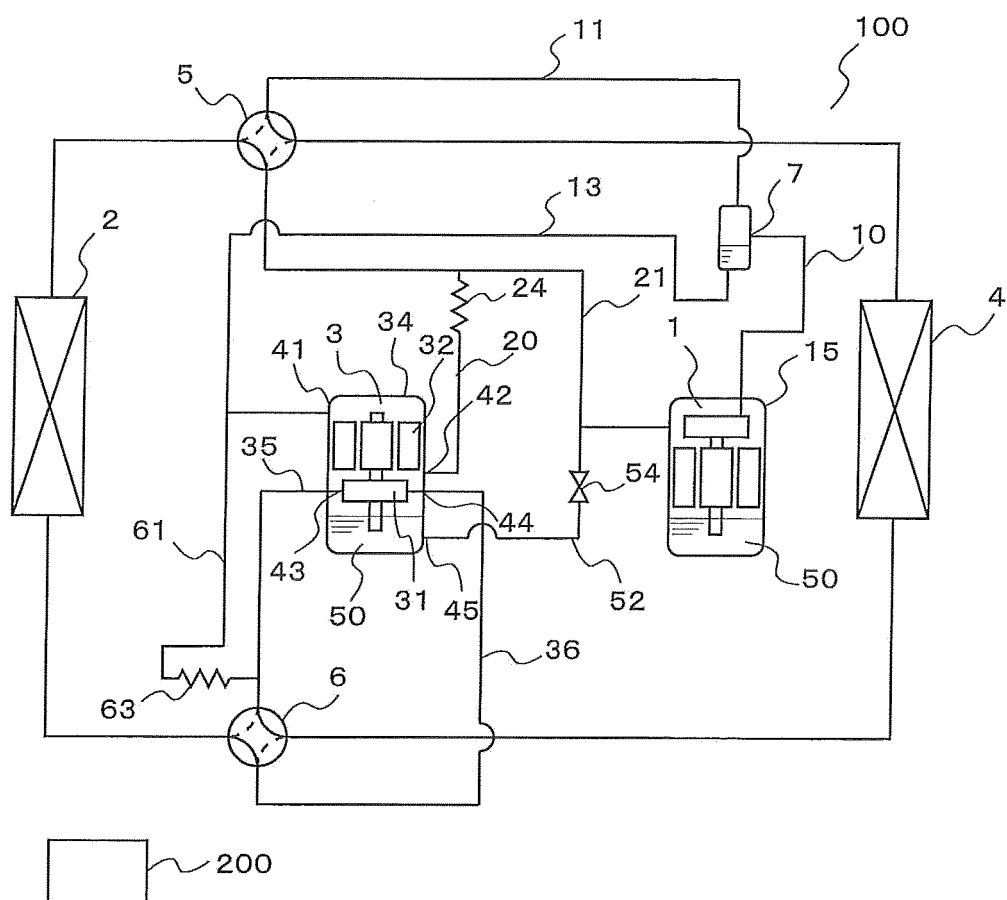
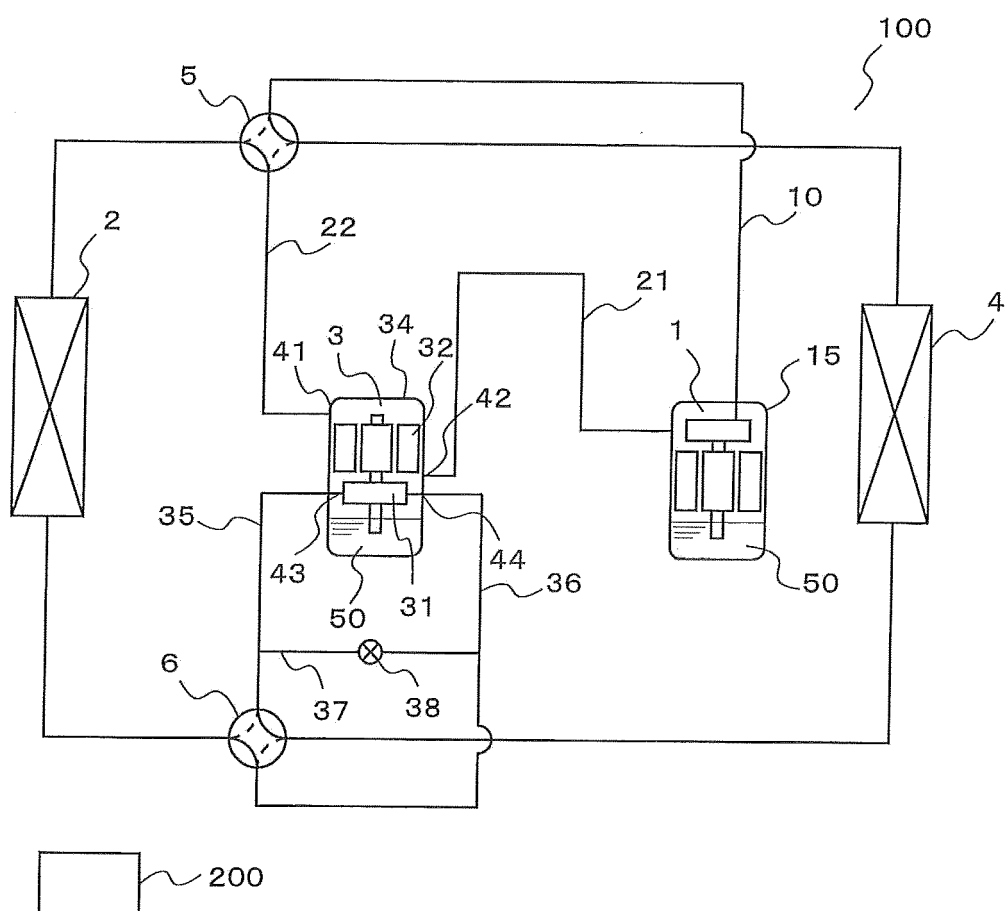


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/050257

A. CLASSIFICATION OF SUBJECT MATTER

F25B11/02(2006.01)i, F25B1/00(2006.01)i, F25B43/02(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)

F25B11/02, F25B1/00, F25B43/02

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2009-204201 A (Panasonic Corp.), 10 September 2009 (10.09.2009), entire text; all drawings (particularly, paragraphs [0018] to [0019], [0026], [0036], [0049]; fig. 3) (Family: none)	1-6, 11-12 7-10
Y A	JP 2011-214778 A (Daikin Industries, Ltd.), 27 October 2011 (27.10.2011), entire text; all drawings (particularly, paragraphs [0039] to [0041]; fig. 1, 2) (Family: none)	1-6, 11-12 7-10

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

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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

"&"

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Date of the actual completion of the international search
14 March, 2014 (14.03.14)Date of mailing of the international search report
25 March, 2014 (25.03.14)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/050257

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2007-285674 A (Daikin Industries, Ltd.), 01 November 2007 (01.11.2007), entire text; all drawings (particularly, paragraphs [0045] to [0046]; fig. 1) (Family: none)	1-6, 11-12 7-10
Y A	JP 2013-139890 A (Daikin Industries, Ltd.), 18 July 2013 (18.07.2013), entire text; all drawings (particularly, paragraphs [0055] to [0056]; fig. 1) (Family: none)	1-6, 11-12 7-10
Y	WO 2012/029203 A1 (Mitsubishi Electric Corp.), 08 March 2012 (08.03.2012), entire text; all drawings (particularly, paragraphs [0033], [0037]; fig. 1 to 3) (Family: none)	4-6
Y	WO 2007/023599 A1 (Mitsubishi Electric Corp.), 01 March 2007 (01.03.2007), entire text; all drawings (particularly, paragraphs [0017] to [0018], [0021] to [0022]; fig. 1) & JP 4516127 B & US 2009/0064709 A1 & EP 1939547 A1 & CN 101180505 A	11-12
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A	JP 2012-42110 A (Panasonic Corp.), 01 March 2012 (01.03.2012), entire text; all drawings (particularly, fig. 1, 5, 7, 9 to 10) (Family: none)	1-12

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

REFERENCES CITED IN THE DESCRIPTION

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