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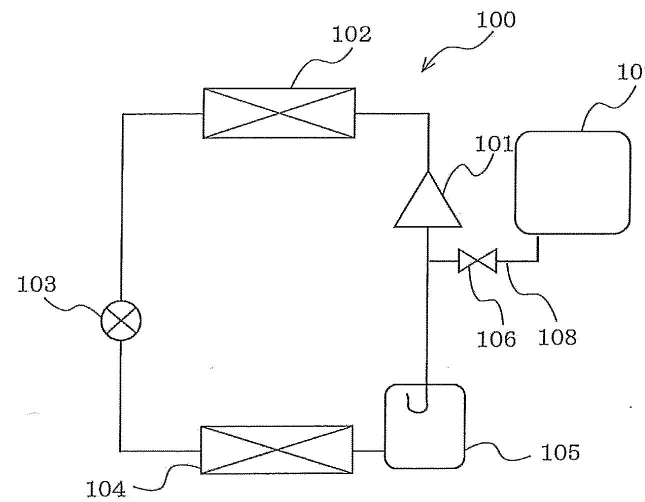
(54) **REFRIGERATION DEVICE**

(57) A refrigeration apparatus including a refrigeration cycle 100 including a compressor 101, a condenser 102, an expansion valve 103, and an evaporator 104 sequentially connected by pipes so that refrigerant circulates therein, an expansion tank 107 to collect the refrigerant and decreases a pressure of the refrigeration cycle 100, an oil return pipe 108 to return the refrigerant collected in the expansion tank 107 and oil stagnating in the expansion tank 107 to the refrigeration cycle 100, and a regulating valve 106 disposed in the oil return pipe 108 and configured to open and close to control a flow of the refrigerant, wherein the oil return pipe 108 connects a suction side of the compressor 101 and a lower part of the expansion tank 107.

FIG. 1



EP 2 998 665 A1

Description

Technical Field

[0001] The present invention relates to a refrigeration apparatus that prevents oil from stagnating in an expansion tank.

Background Art

[0002] In a conventional refrigeration apparatus, an expansion tank is connected between a suction side of a low temperature-side evaporator and an accumulator (see, for example, Patent Literature 1).
[0003] Further, a capillary tube and a check valve are disposed between an expansion tank and a refrigeration cycle (see, for example, Patent Literature 2).

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Patent No. 3270706
Patent Literature 2: Japanese Examined Utility Model Registration Application Publication No. S60-15083

Summary of Invention

Technical Problem

[0005] In a method of installation of the expansion tank of the above conventional refrigeration apparatus, oil may leak into the expansion tank and stagnates in it. When oil stagnates in the expansion tank, oil in the refrigeration cycle becomes insufficient, which may lead to a damage of the compressor in the worst case.
[0006] The present invention has been made to overcome the above problem, and an object of the invention is to provide a refrigeration apparatus which enables immediate oil return even if oil leaks into the expansion tank. Solution to Problem
[0007] A refrigeration apparatus includes a refrigeration cycle including a compressor, a condenser, an expansion valve, and an evaporator sequentially connected by pipes so that refrigerant circulates therein; an expansion tank to collect the refrigerant and decrease a pressure of the refrigeration cycle; an oil return pipe to return the refrigerant collected in the expansion tank and return oil stagnating in the expansion tank to the refrigeration cycle; and a regulating valve disposed in the oil return pipe and configured to open and close to control a flow of the refrigerant, wherein the oil return pipe connects a suction side of the compressor and a lower part of the expansion tank.

Advantageous Effects of Invention

[0008] According to a refrigeration apparatus of the present invention, since the oil return pipe is connected in the lower part of the expansion tank, immediate oil return is possible even if oil leaks into the expansion tank. Accordingly, shortage of oil in the refrigeration cycle and damage to the compressor can be prevented.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram of a refrigeration apparatus according to Embodiment 1 of the present invention.
[Fig. 2] Fig. 2 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 1 of the present invention.
[Fig. 3] Fig. 3 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 2 of the present invention.
[Fig. 4] Fig. 4 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 3 of the present invention.
[Fig. 5] Fig. 5 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 4 of the present invention.
[Fig. 6] Fig. 6 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 5 of the present invention.
[Fig. 7] Fig. 7 is a refrigerant circuit diagram of a refrigeration apparatus according to Embodiment 7 of the present invention.
[Fig. 8] Fig. 8 is a refrigerant circuit diagram of a refrigeration apparatus according to Embodiment 8 of the present invention.

Description of Embodiments

[0010] With reference to the drawings, Embodiments of the present invention will be described hereafter. Embodiments described below are merely exemplary, not intended to limit the scope of the present invention. The relationships of dimensions between components shown in the accompanying drawings may be different from those of actual ones.

Embodiment 1

[0011] Fig. 1 is a refrigerant circuit diagram of a refrigeration apparatus according to Embodiment 1 of the present invention.
[0012] A refrigeration cycle 100 of the refrigeration apparatus according to Embodiment 1 of the present invention includes a compressor 101, a condenser 102, an expansion valve 103, an evaporator 104, and a gas-liquid separator 105, which are sequentially connected by

pipes so that refrigerant circulates therein.

[0013] Further, in the refrigeration cycle 100, an expansion tank 107 is connected between a suction side of the compressor 101 and the gas-liquid separator 105 via an oil return pipe 108, and the oil return pipe 108 is provided with a solenoid valve (regulating valve) 106.

[0014] The compressor 101 suctions refrigerant and compresses the refrigerant to have a high temperature and a high pressure.

[0015] The condenser 102 evaporates and gasifies or condenses and liquefies refrigerant by exchanging heat between air, for example, supplied from a blower, and refrigerant. The blower is not shown in the drawings.

[0016] The expansion valve 103 depressurizes and expands refrigerant.

[0017] The evaporator 104 condenses and liquefies or evaporates and gasifies refrigerant by exchanging heat between air, for example, supplied from a blower, and refrigerant. The blower is not shown in the drawings.

[0018] The gas-liquid separator 105 has a function of separating the refrigerant introduced thereinto a gas refrigerant and a liquid refrigerant.

[0019] The solenoid valve (regulating valve) 106 is opened and closed to control a flow of refrigerant.

[0020] The expansion tank 107 is configured to collect refrigerant to thereby prevent the pressure of the refrigeration cycle 100 from excessing an allowable pressure even when refrigerant in the refrigeration cycle 100 is completely gasified. When the refrigeration apparatus is in an operable state, the refrigerant can be cooled to a lower temperature by using other cooling heat source (for example, coolant water), thereby decreasing the pressure of the refrigeration cycle 100. However, for example in an electrical outage, the refrigeration apparatus is inoperable and other cooling heat source is also inoperable. Therefore, the expansion tank 107 is used in case of emergency such as electrical outage as an alternative means for reducing the pressure of the refrigeration cycle 100 so that it does not excess the allowable pressure.

[0021] The oil return pipe 108 allows the refrigerant collected in the expansion tank 107 and the oil stagnating in the expansion tank 107 to be returned to the refrigeration cycle 100.

[0022] Next, an operation of the refrigeration apparatus according to Embodiment 1 will be described.

[0023] High-temperature, high-pressure gas refrigerant which is discharged from the compressor 101 flows into the condenser 102, and is condensed and liquefied by exchanging heat with, for example, outside air, and becomes high-pressure liquid refrigerant. The high-pressure liquid refrigerant is decompressed in the expansion valve 103, becomes low-pressure gas-liquid two-phase refrigerant, and flows into the evaporator 104. The low-pressure gas-liquid two-phase refrigerant which has flowed into the evaporator 104 is heated, for example, by air in a refrigeration storage (while cooling the air in the refrigeration storage), evaporates and becomes low-pressure gas refrigerant. Then, the low-pressure gas refrigerant flowing out of the evaporator 104 flows into the compressor 101, and is compressed again.

[0024] Even if the refrigerant flowing out of the evaporator 104 is in a low-pressure two-phase gas-liquid state, the liquid refrigerant can be stored in the gas-liquid separator 105, while only the gas refrigerant can be allowed to flow into the compressor 101, because the gas-liquid separator 105 is disposed on the suction side of the compressor 101.

[0025] Next, an operation of collecting the refrigerant into the expansion tank 107 of the refrigeration apparatus according to Embodiment 1 will be described.

[0026] First, the solenoid valve (regulating valve) 106 is set to be open when power is not supplied to the refrigeration apparatus. Accordingly, the solenoid valve (regulating valve) 106 is open during electrical outage since power is not supplied to the refrigeration apparatus. As a result, the volume of the refrigerant flow path increases by the amount of the oil return pipe 108 and the expansion tank 107 (the volume of the refrigeration cycle 100 temporarily increases). The refrigerant in the refrigeration cycle 100 flows into the expansion tank 107, thereby reducing the pressure of the refrigeration cycle 100.

[0027] Further, the solenoid valve (regulating valve) 106 is set to close when power is supplied to the refrigeration apparatus. Accordingly, the solenoid valve (regulating valve) 106 closes on recovery from power outage, since power is supplied to the refrigeration apparatus. Since refrigerant is expected to stagnate in the expansion tank 107, the solenoid valve (regulating valve) 106 is set to close after the refrigerant in the expansion tank 107 is collected (when a predetermined period of time had elapsed after the recovery from power outage).

[0028] According to the above operation, the pressure of the refrigeration cycle 100 can be reduced even when the pressure of the refrigeration cycle 100 increases in case of emergency such as electrical outage.

[0029] Fig. 2 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 1 of the present invention.

[0030] In Embodiment 1 the oil return pipe 108 is connected at a lower part of the expansion tank 107, as illustrated in Fig. 2. Since this configuration can increase a level of oil from the oil return pipe 108, an increased oil return rate is also attained. In addition to that, since oil has a specific gravity larger than that of refrigerant and tends to be stored in a lower part of the expansion tank 107, the oil stored in the lower part can be collected by the oil return pipe 108 provided in the lower part of the expansion tank 107. As a result, oil return from the expansion tank 107 can be immediately and reliably performed, stagnation of oil in the expansion tank 107 can be prevented, and damaging to the compressor can be avoided.

[0031] Further, a position of connection between the refrigeration cycle 100 and the expansion tank 107 is at a low-pressure side (suction side) of the compressor 101 so as to generate a pressure difference between the refrigeration cycle 100 and the expansion tank 107 and facilitate immediate oil return from the expansion tank 107 to the refrigeration cycle 100.

Embodiment 2

[0032] Fig. 3 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 2 of the present invention.

[0033] In Embodiment 2 described below, redundancy is avoided by omitting descriptions for the same elements as those of Embodiment 1. Reference numbers in the one hundreds in Embodiment 1 are modified to those in the two hundreds in Embodiment 2.

[0034] According to Embodiment 2, as shown in Fig. 3, the position of connection between a refrigeration cycle 200 and an expansion tank 107 is at a gas-liquid separator 205.

[0035] With this configuration, gas refrigerant separated by the gas-liquid separator 205 can be collected into the expansion tank 207. Accordingly, the amount of oil leaking into the expansion tank 207 decreases, thereby avoiding stagnation of oil in the expansion tank 207. Further, refrigerant can be prevented from returning into the compressor 201 caused by refrigerant flowing back to the gas-liquid separator 205 from the expansion tank 207 can be prevented.

Embodiment 3

[0036] Fig. 4 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 3 of the present invention.

[0037] In Embodiment 3 described below, redundancy is avoided by omitting the description for the same elements as those of Embodiments 1 and 2. Reference numbers in the one hundreds in Embodiment 1 are modified to those in the three hundreds in Embodiment 3.

[0038] According to Embodiment 3, in addition to Embodiment 2, an oil return pipe 308 which connects a gas-liquid separator 305 and an expansion tank 307 is provided with a trap 309 with a hole 309a formed in a lower part as shown in Fig. 4.

[0039] With this configuration, oil can be further prevented from leaking into the expansion tank 307 by allowing oil to stagnate in the trap 309 and to be discharged from the hole 309a formed in the lower part when oil leaks into the oil return pipe 308.

Embodiment 4

[0040] Fig. 5 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 4 of the present invention.

[0041] In Embodiment 4 described below, redundancy is avoided by omitting the description for the same elements as those of Embodiments 1 to 3. Reference numbers in the one hundreds in Embodiment 1 are modified to those in the four hundreds in Embodiment 4.

[0042] According to Embodiment 4, in addition to Embodiment 3, an oil return pipe 408 which connects a gas-liquid separator 405 and an expansion tank 407 is provided with a check valve 410 parallel to a solenoid valve (regulating valve) 406 as shown in Fig. 5. Further, the oil return pipe 408 has a diameter on a side on which the solenoid valve (regulating valve) 406 is disposed, that is, from which oil leaks into the expansion tank 407, the diameter being smaller than a diameter of the oil return pipe 408 on a side on which the check valve 410 is disposed, that is, the side from which oil is returned from the expansion tank 407.

[0043] With this configuration, oil can be further prevented from leaking into the expansion tank 407 and the amount of oil return can be increased, thereby allowing for immediate oil return.

Embodiment 5

[0044] Fig. 6 is an enlarged view of an essential part of a refrigerant circuit of the refrigeration apparatus according to Embodiment 5 of the present invention.

[0045] In Embodiment 5 described below, redundancy is avoided by omitting the description for the same elements as those of Embodiments 1 to 4. Reference numbers in the one hundreds in Embodiment 1 are modified to those in the five hundreds in Embodiment 5.

[0046] According to Embodiment 5, in addition to Embodiment 4, an evaporation pressure regulating valve (EPR) 506 is provided instead of a solenoid valve (regulating valve) as shown in Fig. 6.

[0047] With this configuration, control of the solenoid valve (regulating valve) can be simplified since the evaporation pressure regulating valve 506 is a valve that does not open until a predetermined pressure difference is generated on both sides of the evaporation pressure regulating valve 506.

Embodiment 6

[0048] In Embodiment 6 described below, redundancy is avoided by omitting the description for the same elements as those of Embodiments 1 to 5.

[0049] According to Embodiment 6, although not shown in the figure, an oil return pipe is connected to a lower part of an expansion tank similar to Embodiment 1 in Embodiments 2 to 5.

[0050] With this configuration, an effect of Embodiment 1 can also be obtained in addition to an effect of Embodiments 2 to 5.

Embodiment 7

[0051] Fig. 7 is a refrigerant circuit diagram of the refrigeration apparatus according to Embodiment 7 of the present invention.

[0052] In Embodiment 7 described below, redundancy is avoided by omitting the description for the same elements as those of Embodiments 1 to 6. Reference numbers in the one hundreds in Embodiment 1 are modified to those in the six hundreds in Embodiment 7.

[0053] According to Embodiment 7, a refrigeration cycle 600 of the refrigeration apparatus is a two-stage refrigeration cycle which is composed of a high temperature-side refrigeration cycle 600a and a low temperature-side refrigeration cycle 600b.

[0054] The high temperature-side refrigeration cycle 600a includes a high temperature-side compressor 601 a, a condenser 602, a high temperature-side expansion valve 603a, and a high temperature-side flow path of a cascade heat exchanger 611, which are sequentially connected by pipes so that refrigerant circulates therein.

[0055] The low temperature-side refrigeration cycle 600b includes a low temperature-side compressor 601 b, a low temperature-side flow path of the cascade heat exchanger 611, a low temperature-side expansion valve 603b, an evaporator 604, and a gas-liquid separator 605, which are sequentially connected by pipes so that refrigerant which becomes a supercritical state within a range of a designed temperature (for example, such as carbon dioxide or R23) circulates therein.

[0056] Further, an expansion tank 607 is connected by an oil return pipe 608 between a suction side of the low temperature-side compressor 601 b of the low temperature-side refrigeration cycle 600b and the gas-liquid separator 605, and the oil return pipe 608 is provided with a solenoid valve (regulating valve) 606.

[0057] Next, an operation of the refrigeration apparatus according to Embodiment 7 will be described.

[0058] High-temperature, high-pressure gas refrigerant which is discharged from the high temperature-side compressor 601 a of the high temperature-side refrigeration cycle 600a flows into the condenser 602, and is condensed and liquefied by exchanging heat with, for example, outside air, and becomes high-pressure liquid refrigerant. The high-pressure liquid refrigerant is decompressed in the high temperature-side expansion valve 603a, becomes low-pressure gas-liquid two-phase refrigerant, and flows into the high temperature-side flow path of the cascade heat exchanger 611. The low-pressure gas-liquid two-phase refrigerant on the high temperature-side is heated by refrigerant which flows in the low temperature-side flow path in the cascade heat exchanger 611, evaporates and becomes low-pressure gas refrigerant, and then, flows into the high temperature-side compressor 601 a and is compressed again.

[0059] On the other hand, in the low temperature-side refrigeration cycle 600b, high-temperature, high-pressure gas refrigerant which is discharged from the low temperature-side compressor 601 b flows into the low temperature-side flow path of the cascade heat exchanger 611, and is condensed and liquefied by refrigerant which flows in the high temperature-side flow path, and becomes high-pressure liquid refrigerant. The high-pressure liquid refrigerant flows into the low temperature-side expansion valve 603b. The high-pressure liquid refrigerant which has flowed into the low temperature-side expansion valve 603b is decompressed, becomes a low-pressure gas-liquid two-phase refrigerant, and flows into the evaporator 604. The low-pressure gas-liquid two-phase refrigerant which has flowed into the evaporator 604 is heated, for example, by air in a refrigeration storage (while cooling the air in the refrigeration storage), evaporates and becomes low-pressure gas refrigerant. Then, the low-pressure gas refrigerant flowing out of the evaporator 31 flows into the low temperature-side compressor 601b, and is compressed again.

[0060] Even if the refrigerant flowing out of the evaporator 604 is in a low-pressure two-phase gas-liquid state, the liquid refrigerant can be stored in the gas-liquid separator 605, while only the gas refrigerant can be allowed to flow into the low temperature-side compressor 601 b, since the gas-liquid separator 605 is disposed on the suction side of the low temperature-side compressor 601 b.

[0061] As described above, the amount of refrigerant that becomes a supercritical state within a range of a designed temperature of the low temperature-side can be reduced compared with a case of an air cooling type unitary refrigeration cycle by adopting a two-stage refrigeration cycle which uses a refrigerant that becomes a supercritical state within a range of a designed temperature as the low temperature-side refrigeration cycle 600b. Accordingly, an absolute value of the amount of oil stagnation in the expansion tank 607 can be reduced compared with a case of an air cooling type unitary refrigeration cycle.

[0062] The reason that the two-stage refrigeration cycle can reduce the amount of refrigerant that becomes a supercritical state compared with the air cooling type unitary refrigeration cycle is that the two-stage refrigeration cycle uses the cascade heat exchanger 611 for a heat exchanger on the low temperature-side and the high temperature-side, which enables reduction of the amount of refrigerant compared with a unitary cycle which uses an air cooling type condenser.

[0063] Accordingly, since an oil filling amount can be reduced (a smaller amount of refrigerant is necessary in a cascade heat exchanger (plate type heat exchanger) 611 compared with an air cooling type condenser) and an absolute amount of refrigerant can be reduced, oil stagnation in the expansion tank 607 can be avoided even if it leaks into the expansion tank 607.

[0064] As a refrigerant which circulates in the high temperature-side refrigeration cycle 600a, for example, tetrafluoropropene such as 2, 3, 3, 3-tetrafluoropropene (HFO-1234yf), or a mixed refrigerant which contains tetrafluoropropene may be used.

Embodiment 8

[0065] Fig. 8 is a refrigerant circuit diagram of the refrigeration apparatus according to Embodiment 8 of the present invention.

[0066] In Embodiment 8 described below, redundancy is avoided by omitting the description for the same elements as those of Embodiments 1 to 7. Reference numbers in the one hundreds in Embodiment 1 are modified to those in the seven hundreds in Embodiment 8.

[0067] According to Embodiment 8, in addition to Embodiment 7, low temperature-side expansion valves 703b1, 703b2 are connected in series in a low temperature-side refrigeration cycle 700b as shown in Fig. 8.

[0068] Since the low temperature-side expansion valves 703b1, 703b2 are provided as a two-stage configuration, refrigerant which can exist in a liquid single-phase state in a pipe in conventional configurations can be in a two-phase gas-liquid state in the present configuration. The refrigerant in a two-phase gas-liquid state has a density lower than that in a liquid single-phase state, thereby reducing the refrigerant amount in the whole cycle. Accordingly, oil stagnation in the expansion tank 707 can be further prevented.

[0069] Embodiments 1 to 8 can be appropriately combined, for example, Embodiments 1 and 7, or Embodiments 2 and 8.

Reference Signs List

[0070] 100 refrigeration cycle 101 compressor 102 condenser 103 expansion valve 104 evaporator 105 gas-liquid separator 106 solenoid valve (regulating valve) 107 expansion tank 108 oil return pipe 200 refrigeration cycle 201 compressor 205 gas-liquid separator 206 solenoid valve (regulating valve) 207 expansion tank 208 oil return pipe 301 compressor 305 gas-liquid separator 306 solenoid valve (regulating valve) 307 expansion tank 308 oil return pipe 309 trap 309a hole 401 compressor 405 gas-liquid separator 406 solenoid valve (regulating valve) 407 expansion tank 408 oil return pipe 409 trap 409a hole 410 check valve 501 compressor 505 gas-liquid separator 506 evaporation pressure regulating valve (EPR) 507 expansion tank 508 oil return pipe 509 trap 509a hole 510 check valve 600 refrigeration cycle 600a high temperature-side refrigeration cycle 600b low temperature-side refrigeration cycle 601 a high temperature-side compressor 601 b low temperature-side compressor 602 condenser 603a high temperature-side expansion valve 603b low temperature-side expansion valve 604 evaporator 605 gas-liquid separator 606 solenoid valve (regulating valve) 607 expansion tank 608 oil return pipe 611 cascade heat exchanger 700 refrigeration cycle 700a high temperature-side refrigeration cycle 700b low temperature-side refrigeration cycle 701 a high temperature-side compressor 701 low temperature-side compressor 702 condenser 703a high temperature-side expansion valve 703b1 low temperature-side expansion valve 703b2 low temperature-side expansion valve 704 evaporator 705 gas-liquid separator 706 solenoid valve (regulating valve) 707 expansion tank 708 oil return pipe 711 cascade heat exchanger

Claims

1. A refrigeration apparatus comprising:

a refrigeration cycle including a compressor, a condenser, an expansion valve, and an evaporator sequentially connected by pipes so that refrigerant circulates therein;
an expansion tank to collect the refrigerant and decrease a pressure of the refrigeration cycle;
an oil return pipe to return the refrigerant collected in the expansion tank and return oil stagnating in the expansion tank to the refrigeration cycle; and
a regulating valve disposed in the oil return pipe and configured to open and close to control a flow of the refrigerant, wherein the oil return pipe connects a suction side of the compressor and a lower part of the expansion tank.

2. A refrigeration apparatus comprising:

a refrigeration cycle composed of a high temperature-side refrigeration cycle including a high temperature-side compressor, a condenser, a high temperature-side expansion valve, and a high temperature-side flow path of a cascade heat exchanger sequentially connected by pipes so that refrigerant circulates therein, and a low temperature-side refrigeration cycle including a low temperature-side compressor, a low temperature-side flow path of the cascade heat exchanger, a low temperature-side expansion valve, and an evaporator sequentially connected by pipes so that refrigerant circulates therein;
an expansion tank that collects the refrigerant which circulates in the low temperature-side refrigeration cycle and decreases a pressure of the refrigeration cycle;
an oil return pipe to return refrigerant, which has circulated in the low temperature-side refrigeration cycle and collected in the expansion tank, and return oil stagnating in the expansion tank to the refrigeration cycle; and
a regulating valve disposed in the oil return pipe and configured to open and close to control a flow of the refrigerant which circulates in the low temperature-side refrigeration cycle, wherein the oil return pipe connects a suction side of the low temperature-side compressor and a lower part of the expansion tank.

3. The refrigeration apparatus of claim 2, wherein the refrigerant circulating in the low temperature-side refrigeration cycle becomes a supercritical state within a range of a designed temperature.

4. The refrigeration apparatus of claim 3, wherein the refrigerant circulating in the low temperature-side refrigeration cycle is carbon dioxide or R23.

5. The refrigeration apparatus of any one of claims 2 to 4, wherein two of the low temperature-side expansion valves are provided in series.

6. The refrigeration apparatus of claim 1, further comprising a gas-liquid separator provided on a suction side of the compressor, wherein the oil return pipe connects the gas-liquid separator and a lower part of the expansion tank.

7. The refrigeration apparatus of any one of claims 2 to 5, further comprising a gas-liquid separator on a suction side of the low temperature-side compressor, wherein the oil return pipe connects the gas-liquid separator and a lower part of the expansion tank.

8. The refrigeration apparatus of claim 6 or 7, wherein the oil return pipe is provided with a trap having a hole formed in a lower part so that oil which leaks into the oil return pipe stagnates in the trap and is discharged from the hole.

9. The refrigeration apparatus of any one of claims 1 to 8, wherein the oil return pipe includes a check valve provided parallel to the regulating valve, the oil return pipe having a diameter on a side on which the regulating valve is provided, the diameter being smaller than a diameter of the oil return pipe on a side on which the check valve is provided.

10. The refrigeration apparatus of any one of claims 1 to 9, wherein the regulating valve is set to open when power is not supplied thereto, and to close when power is supplied thereto, and is set to close after the refrigerant in the expansion tank is collected, or when predetermined period of time has elapsed after recovery from power outage.

11. The refrigeration apparatus of any one of claims 1 to 9, wherein the regulating valve is an evaporation pressure regulating valve configured not to open until a predetermined pressure difference is generated on both sides thereof.

FIG. 1

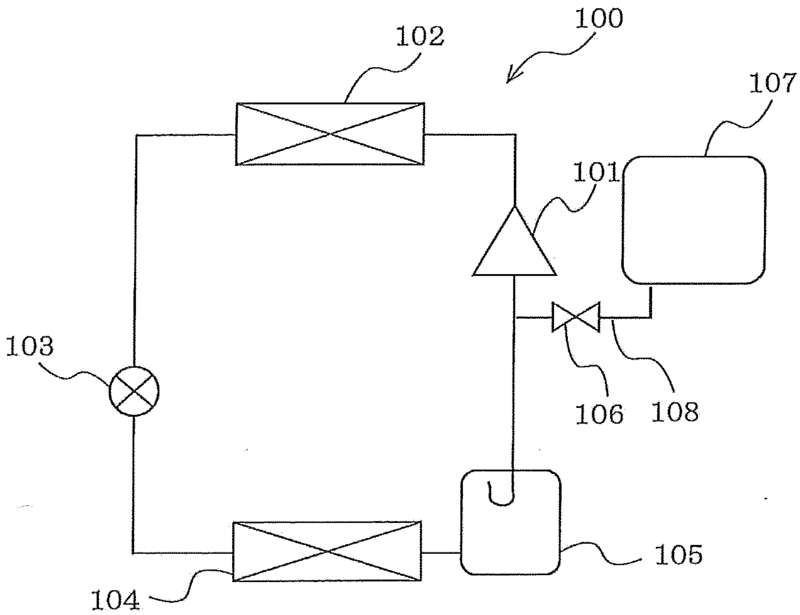


FIG. 2

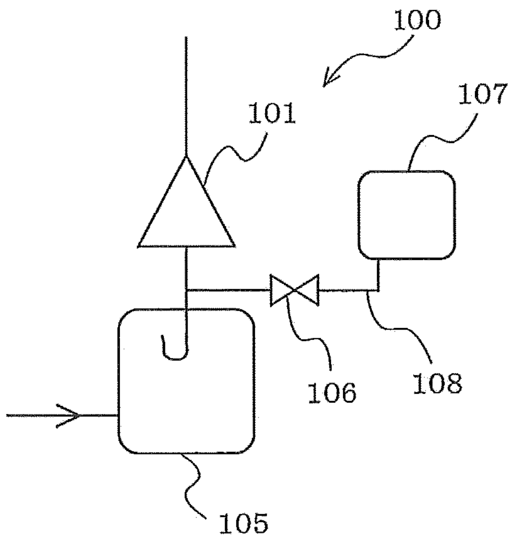


FIG. 3

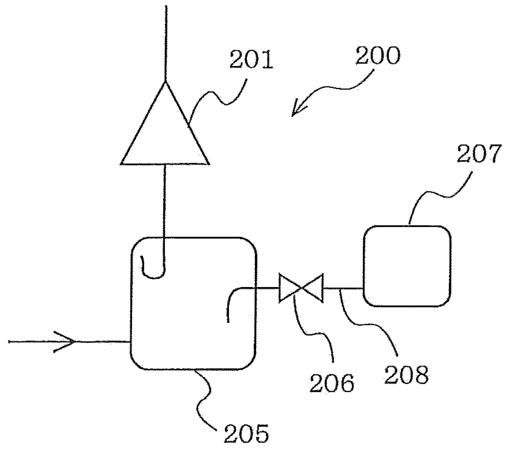


FIG. 4

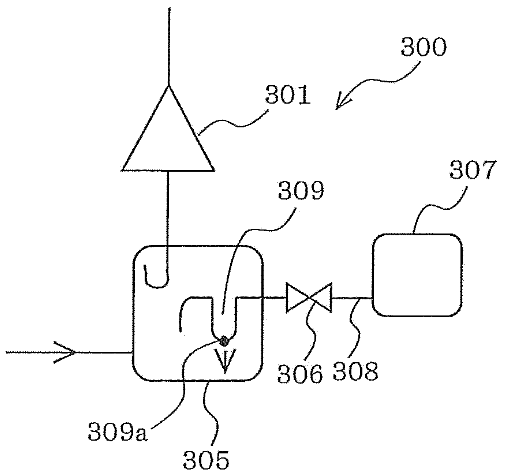


FIG. 5

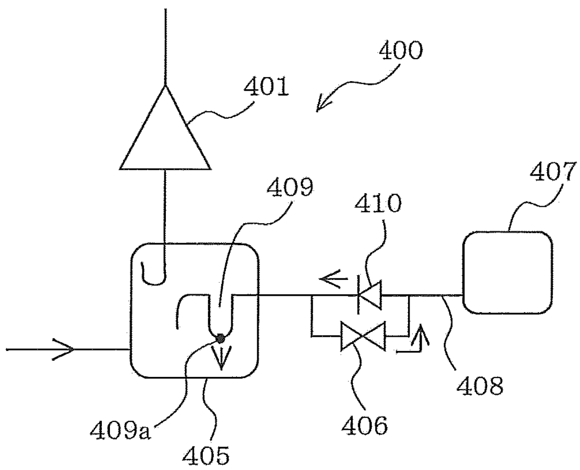


FIG. 6

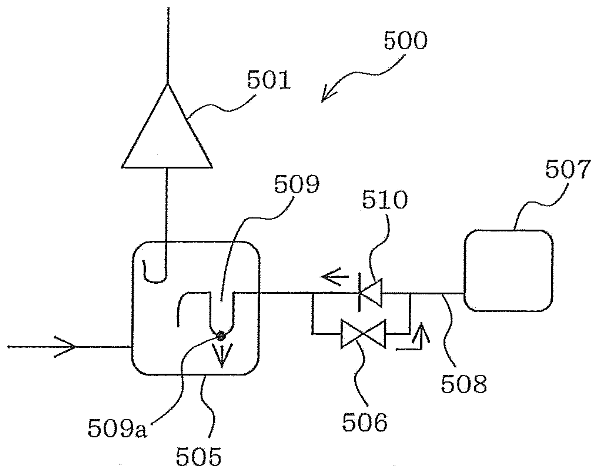

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FIG. 7

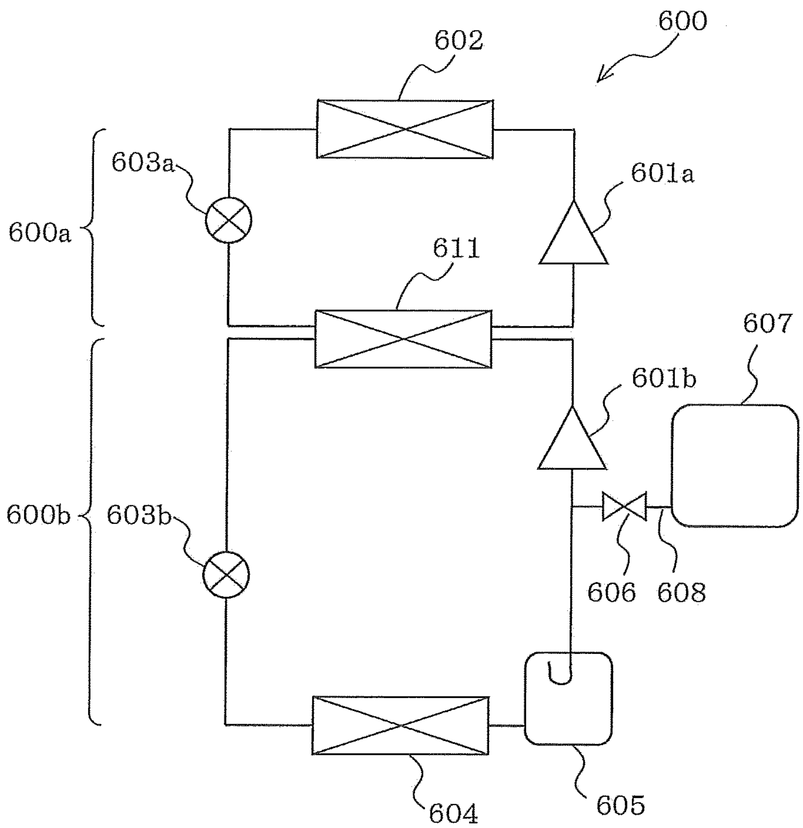
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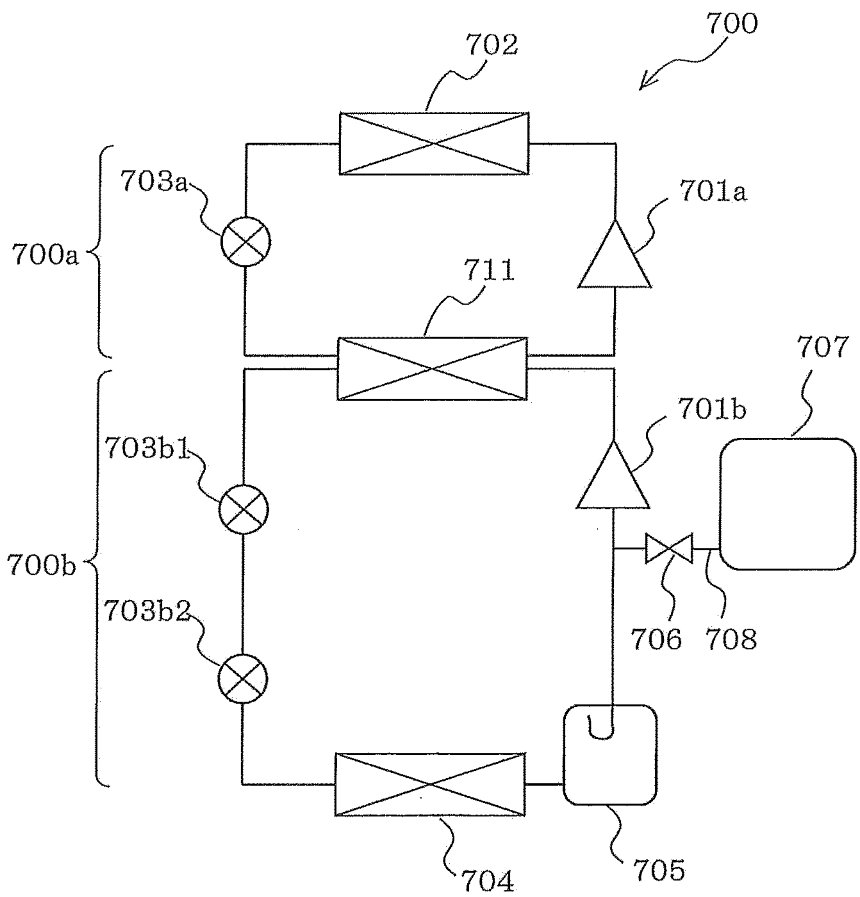
FIG. 8



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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/063693

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i, *F25B7/00*(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)
F25B1/00, F25B7/00, 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	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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 2007-303792 A (Sanyo Electric Co., Ltd.), 22 November 2007 (22.11.2007), paragraphs [0038] to [0073]; fig. 6 & US 2009/0126389 A1 & EP 2019269 A1 & KR 10-2009-0008342 A & CN 101443601 A	1-7,9-11 8
Y A	JP 2009-156531 A (Mitsubishi Electric Corp.), 16 July 2009 (16.07.2009), paragraphs [0009] to [0029], [0070], [0088] (Family: none)	1-7,9-11 8
Y A	JP 2004-308972 A (Mayekawa Mfg., Co., Ltd.), 04 November 2004 (04.11.2004), paragraphs [0017] to [0033]; fig. 1 to 3 (Family: none)	1-7,9-11 8

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

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Date of the actual completion of the international search	Date of mailing of the international search report
08 August, 2013 (08.08.13)	20 August, 2013 (20.08.13)

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/063693

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-287292 A (Sanyo Electric Co., Ltd.), 10 October 2003 (10.10.2003), paragraphs [0011] to [0013]; fig. 1 (Family: none)	6,7
Y	JP 2006-290042 A (Calsonic Kansei Corp.), 26 October 2006 (26.10.2006), paragraph [0046]; fig. 1 (Family: none)	10
Y	JP 2010-7987 A (Hoshizaki Electric Co., Ltd.), 14 January 2010 (14.01.2010), paragraphs [0023] to [0031]; fig. 3 (Family: none)	11
A	JP 2012-112622 A (Mitsubishi Electric Corp.), 14 June 2012 (14.06.2012), entire text; all drawings (Family: none)	1-11
A	JP 2003-279202 A (Mayekawa Mfg., Co., Ltd.), 02 October 2003 (02.10.2003), entire text; all drawings (Family: none)	1-11
A	JP 3-263556 A (Sanyo Electric Co., Ltd.), 25 November 1991 (25.11.1991), entire text; all drawings (Family: none)	1-11
A	JP 2003-185285 A (Ebara Corp.), 03 July 2003 (03.07.2003), paragraph [0009]; fig. 3 (Family: none)	8

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REFERENCES CITED IN THE DESCRIPTION

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