



(11) **EP 3 809 064 A1**

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

(43) Date of publication:
21.04.2021 Bulletin 2021/16

(51) Int Cl.:
F25B 43/00 (2006.01) F25B 1/00 (2006.01)

(21) Application number: **18922598.0**

(86) International application number:
PCT/JP2018/022956

(22) Date of filing: **15.06.2018**

(87) International publication number:
WO 2019/239587 (19.12.2019 Gazette 2019/51)

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

(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

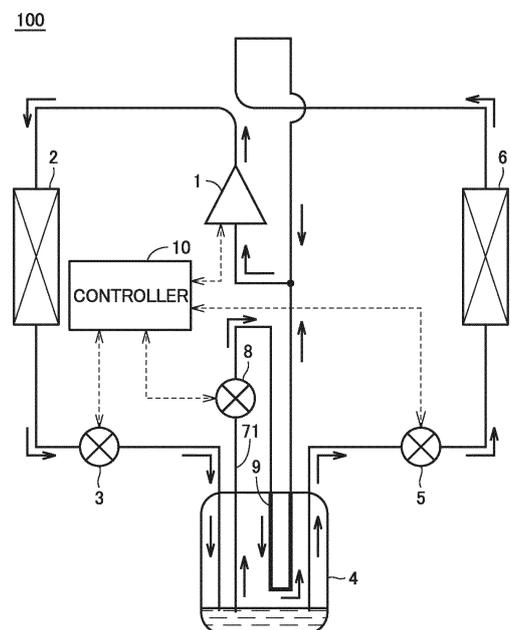
(72) Inventor: **ISHIYAMA, Hiroki**
Tokyo 100-8310 (JP)

(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
An der Frauenkirche 20
01067 Dresden (DE)

(54) **REFRIGERATION CYCLE DEVICE**

(57) In a refrigeration cycle apparatus (100), refrigerant circulates through a compressor (1), a first heat exchanger (2), a first expansion valve (3), a refrigerant container (4), a second expansion valve (5) and a second heat exchanger (6) in this order. The refrigeration cycle apparatus (100) includes: a third expansion valve (8); and a specific flow path (71). The specific flow path (71) allows the third expansion valve (8) to communicate with the refrigerant container (4). The third expansion valve (8) communicates with a suction port of the compressor (1) through the refrigerant container (4). An amount per unit time of the refrigerant passing through the specific flow path (71) when a specific condition is satisfied is larger than the amount per unit time of the refrigerant passing through the specific flow path (71) when the specific condition is not satisfied. The specific condition is a condition that an amount of the refrigerant in the refrigerant container (4) is smaller than a reference amount.

FIG.1



EP 3 809 064 A1

Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] A refrigeration cycle apparatus in which refrigerant stored in a refrigerant container is bypassed to a suction port of a compressor has been conventionally known. For example, Japanese Patent No. 5865561 (PTL 1) discloses a refrigeration cycle apparatus including a bypass circuit that guides at least a part of liquid refrigerant stored in a refrigerant container to the suction side of a compressor through an expansion valve and a refrigerant heat exchanger. By bypassing a part of the refrigerant stored in the refrigerant container, a flow rate of the refrigerant flowing through the low pressure side decreases, and thus, a pressure loss on the low pressure side can be suppressed and the efficiency of the refrigeration cycle apparatus can be improved.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent No. 5865561

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In the refrigeration cycle apparatus disclosed in PTL 1, when an amount of the refrigerant in the refrigerant container decreases and the refrigerant in a gas-liquid two-phase state (wet vapor) flows out of the refrigerant container, a pressure on the low pressure side of the refrigeration cycle apparatus may decrease, which may lead to a reduction in efficiency of the refrigeration cycle apparatus. When the amount of the refrigerant in the refrigerant container increases and a degree of dryness (ratio of the gas refrigerant to the refrigerant) of the refrigerant around the refrigerant heat exchanger decreases, the heat transfer performance (heat exchange efficiency) of the refrigerant heat exchanger may decrease, which may lead to a reduction in efficiency of the refrigeration cycle apparatus. However, the refrigeration cycle apparatus disclosed in PTL 1 does not take into consideration the fact that the efficiency of the refrigeration cycle apparatus is reduced depending on the amount of the refrigerant in the refrigerant container.

[0005] The present invention has been made to solve the above-described problem, and an object of the present invention is to suppress a reduction in efficiency of a refrigeration cycle apparatus.

SOLUTION TO PROBLEM

[0006] In a refrigeration cycle apparatus according to an aspect of the present invention, refrigerant circulates through a compressor, a first heat exchanger, a first expansion valve, a refrigerant container, a second expansion valve and a second heat exchanger in this order. The refrigeration cycle apparatus includes: a third expansion valve; and a specific flow path. The specific flow path allows the third expansion valve to communicate with the refrigerant container. The third expansion valve communicates with a suction port of the compressor through the refrigerant container. An amount per unit time of the refrigerant passing through the specific flow path when a specific condition is satisfied is larger than the amount per unit time of the refrigerant passing through the specific flow path when the specific condition is not satisfied. The specific condition is a condition that an amount of the refrigerant in the refrigerant container is smaller than a reference amount.

[0007] In a refrigeration cycle apparatus according to another aspect of the present invention, refrigerant circulates through a compressor, a first heat exchanger, a first expansion valve, a refrigerant container, a second expansion valve and a second heat exchanger in this order. The refrigeration cycle apparatus includes: a third expansion valve; a specific flow path; and a third heat exchanger. The specific flow path allows the third expansion valve to communicate with the refrigerant container. The third heat exchanger is connected between the third expansion valve and a suction port of the compressor. The third heat exchanger is arranged in the refrigerant container. When a specific condition is satisfied, an amount of the refrigerant flowing into the refrigerant container is smaller than an amount of the refrigerant flowing out of the refrigerant container. The specific condition is a condition that an amount of the refrigerant in the refrigerant container is larger than a reference amount. Heat exchange efficiency of the third heat exchanger when the specific condition is satisfied is lower than the heat exchange efficiency when the amount of the refrigerant in the refrigerant container is the reference amount.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] In the refrigeration cycle apparatus according to an aspect of the present invention, the specific condition is a condition that the amount of the refrigerant in the refrigerant container is smaller than the reference amount, and the amount per unit time of the refrigerant passing through the specific flow path when the specific condition is satisfied is larger than the amount per unit time of the refrigerant passing through the specific flow path when the specific condition is not satisfied. Thus, a reduction in efficiency of the refrigeration cycle apparatus can be suppressed.

[0009] In the refrigeration cycle apparatus according to another aspect of the present invention, the specific

condition is a condition that the amount of the refrigerant in the refrigerant container is larger than the reference amount, and the heat exchange efficiency of the third heat exchanger when the specific condition is satisfied is lower than the heat exchange efficiency when the amount of the refrigerant in the refrigerant container is the reference amount, and when the specific condition is satisfied, the amount of the refrigerant flowing into the refrigerant container is smaller than the amount of the refrigerant flowing out of the refrigerant container. Thus, a reduction in efficiency of the refrigeration cycle apparatus can be suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a first embodiment.

Fig. 2 shows a process flow of expansion valve control performed by a controller in Fig. 1.

Fig. 3 is a flowchart showing a specific process flow of an amount-of-refrigerant adjustment process in Fig. 2.

Fig. 4 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a second embodiment.

Fig. 5 is a flowchart showing a flow of an amount-of-refrigerant adjustment process performed by a controller in Fig. 4.

Fig. 6 shows an example configuration of an on/off unit in Fig. 4.

Fig. 7 shows another example configuration of the on/off unit in Fig. 4.

Fig. 8 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a third embodiment.

Fig. 9 is a flowchart showing a flow of an amount-of-refrigerant adjustment process performed by a controller in Fig. 8.

Fig. 10 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a fourth embodiment.

Fig. 11 is a graph showing a relationship between a height of a liquid level of liquid refrigerant stored in a refrigerant container and the heat exchange efficiency of an internal heat exchanger.

Fig. 12 is a flowchart showing a flow of an amount-of-refrigerant adjustment process performed by a controller in Fig. 10.

Fig. 13 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a fifth embodiment.

Fig. 14 is a flowchart showing a flow of an amount-of-refrigerant adjustment process performed by a controller in Fig. 13.

DESCRIPTION OF EMBODIMENTS

[0011] Embodiments of the present invention will be described in detail hereinafter with reference to the drawings, in which the same or corresponding portions are denoted by the same reference characters and description thereof will not be repeated in principle.

First Embodiment

[0012] Fig. 1 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 100 according to a first embodiment. As shown in Fig. 1, refrigeration cycle apparatus 100 includes a compressor 1, a condenser 2 (first heat exchanger), an expansion valve 3 (first expansion valve), a refrigerant container 4, an expansion valve 5 (second expansion valve), an evaporator 6 (second heat exchanger), a pipe 71 (specific flow path), an expansion valve 8 (third expansion valve), an internal heat exchanger 9 (third heat exchanger), and a controller 10. In refrigeration cycle apparatus 100, refrigerant circulates through compressor 1, condenser 2, expansion valve 3, refrigerant container 4, expansion valve 5, and evaporator 6 in this order.

[0013] Refrigerant container 4 receives the refrigerant from expansion valve 3 and stores the liquid refrigerant in a bottom portion thereof. Pipe 71 allows expansion valve 8 to communicate with refrigerant container 4. Internal heat exchanger 9 is connected between expansion valve 8 and a suction port of compressor 1, and is arranged in refrigerant container 4.

[0014] Controller 10 controls a driving frequency of compressor 1, thereby controlling an amount of the refrigerant discharged per unit time by compressor 1. Controller 10 adjusts degrees of opening of expansion valves 3, 5 and 8.

[0015] Fig. 2 shows a process flow of expansion valve control performed by controller 10 in Fig. 1. The process shown in Fig. 2 is invoked by a not-shown main routine that performs integrated control of refrigeration cycle apparatus 100. In the following description, the steps will be simply described as "S".

[0016] As shown in Fig. 2, in S100, controller 10 performs normal control on expansion valves 3, 5 and 8 and the process proceeds to S200. The normal control includes, for example, degree-of-superheat control for maintaining a degree of superheat of the refrigerant flowing out of evaporator 6 within a certain range. In S200, controller 10 performs an amount-of-refrigerant adjustment process for adjusting an amount of the refrigerant in refrigerant container 4, and then, returns the process to the main routine.

[0017] In refrigeration cycle apparatus 100, when the amount of the refrigerant in refrigerant container 4 decreases and wet vapor flows out of refrigerant container 4, the amount of the refrigerant on the low pressure side (portion from expansion valve 5 to the suction port of compressor 1) decreases, and thus, a pressure on the

low pressure side of refrigeration cycle apparatus 100 decreases. Therefore, a difference between a pressure on the high pressure side (portion from a discharge port of compressor 1 to expansion valve 3) of refrigeration cycle apparatus 100 and the pressure on the low pressure side of refrigeration cycle apparatus 100 becomes large, which may lead to a reduction in efficiency of refrigeration cycle apparatus 100.

[0018] When the degree of opening of expansion valve 5 is increased in order to increase the amount of the refrigerant on the low pressure side by increasing the amount of the refrigerant (amount of the circulating refrigerant) circulating through refrigeration cycle apparatus 100, an amount per unit time of the refrigerant flowing from refrigerant container 4 to expansion valve 5 cannot be increased by controlling the degree of opening of expansion valve 5, after the degree of opening enters a full open state. In such a case, a reduction in efficiency of refrigeration cycle apparatus 100 cannot be suppressed by controlling the degree of opening of expansion valve 5. In addition, when the degree of opening of expansion valve 5 is in the full open state, the amount of the refrigerant flowing out of refrigerant container 4 can hardly be increased, and thus, a decrease in amount of the refrigerant in refrigerant container 4 is almost at a standstill.

[0019] Accordingly, in refrigeration cycle apparatus 100, when the amount of the refrigerant in refrigerant container 4 is smaller than a reference amount, the degree of opening of expansion valve 8 is increased to thereby increase an amount per unit time of the refrigerant passing through pipe 71. Since an amount of the refrigerant flowing from refrigerant container 4 to expansion valve 8 increases, this amount of the refrigerant is added to an amount of the refrigerant taken into compressor 1. As a result, the amount of the circulating refrigerant increases and a reduction in efficiency of refrigeration cycle apparatus 100 can be suppressed. In refrigeration cycle apparatus 100, whether or not a condition (specific condition) that the amount of the refrigerant in refrigerant container 4 is smaller than the reference amount is satisfied is determined based on whether or not a condition that the degree of opening of expansion valve 5 is not smaller than a reference degree of opening (e.g., full open) is satisfied.

[0020] Fig. 3 is a flowchart showing a specific process flow of the amount-of-refrigerant adjustment process (S200) in Fig. 2. As shown in Fig. 3, in S211, controller 10 determines whether or not the degree of opening of expansion valve 5 is not smaller than the reference degree of opening. When the degree of opening of expansion valve 5 is not smaller than the reference degree of opening (YES in S211), controller 10 increases the degree of opening of expansion valve 8 by a certain amount and returns the process to the main routine in S212. When the degree of opening of expansion valve 5 is smaller than the reference degree of opening (NO in S211), controller 10 returns the process to the main routine.

[0021] As described above, in the refrigeration cycle apparatus according to the first embodiment, a reduction in efficiency of the refrigeration cycle apparatus can be suppressed.

Second Embodiment

[0022] In the first embodiment, description has been given of the configuration in which the amount per unit time of the refrigerant passing through the specific flow path is increased by increasing the degree of opening of the third expansion valve. In a second embodiment, description will be given of a configuration in which the amount per unit time of the refrigerant passing through the specific flow path is increased by bypassing the refrigerant from the specific flow path to the suction port of the compressor.

[0023] Fig. 4 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 200 according to the second embodiment. The configuration of refrigeration cycle apparatus 200 in Fig. 4 is different from the configuration of refrigeration cycle apparatus 100 in Fig. 1 in that an on/off unit 80 is added and controller 10 is replaced with a controller 20. Since the remaining configuration is the same, description will not be repeated. In the second embodiment, Figs. 1 and 3 in the first embodiment are replaced with Figs. 4 and 5, respectively.

[0024] As shown in Fig. 4, on/off unit 80 is connected between pipe 71 and the suction port of compressor 1. Controller 20 switches between opening and closing of on/off unit 80. When on/off unit 80 is open, the refrigerant flowing into pipe 71 is bypassed to the suction port of compressor 1 through on/off unit 80.

[0025] In refrigeration cycle apparatus 200, it is unnecessary to increase the amount per unit time of the refrigerant passing through pipe 71 by increasing a diameter of expansion valve 8, and thus, expansion valve 8 can be reduced in size. The reduction in size of expansion valve 8 makes it possible to control the degree of opening of expansion valve 8 in accordance with a relatively low resolution, and thus, the controllability of expansion valve 8 can be improved.

[0026] Fig. 5 is a flowchart showing a flow of an amount-of-refrigerant adjustment process performed by controller 20 in Fig. 4. As shown in Fig. 5, in S221, controller 20 determines whether or not the degree of opening of expansion valve 5 is not smaller than the reference degree of opening. When the degree of opening of expansion valve 5 is not smaller than the reference degree of opening (YES in S221), controller 20 opens on/off unit 80 and returns the process to the main routine in S222. When the degree of opening of expansion valve 5 is smaller than the reference degree of opening (NO in S221), controller 20 closes on/off unit 80 and returns the process to the main routine in S223.

[0027] Fig. 6 shows an example configuration of on/off unit 80 in Fig. 4. As shown in Fig. 6, on/off unit 80 includes an on-off valve 81. On-off valve 81 is connected between

pipe 71 and the suction port of compressor 1. When on/off unit 80 is configured as shown in Fig. 6, controller 20 opens on-off valve 81 in S222 in Fig. 5, and closes on-off valve 81 in S223 in Fig. 5.

[0028] Fig. 7 shows another example configuration of on/off unit 80 in Fig. 4. As shown in Fig. 7, on/off unit 80 includes a three-way valve 82. Three-way valve 82 includes ports P1 to P3 that communicate with one another. Port P1 communicates with expansion valve 8. Port P2 communicates with refrigerant container 4. Port P3 communicates with the suction port of compressor 1. Ports P1 and P2 are opened. Port P3 is switched between opening and closing. When on/off unit 80 is configured as shown in Fig. 7, controller 20 opens port P3 in S222 in Fig. 5, and closes port P3 in S223 in Fig. 5.

[0029] As described above, in the refrigeration cycle apparatus according to the second embodiment, a reduction in efficiency of the refrigeration cycle apparatus can be suppressed. In addition, the controllability of the third expansion valve can be improved.

Third Embodiment

[0030] In the first and second embodiments, description has been given of the configuration in which a reduction in efficiency of the refrigeration cycle apparatus caused by a decrease in amount of the refrigerant in the refrigerant container and a corresponding outflow of wet vapor from the refrigerant container is suppressed. In a third embodiment, description will be given of a configuration in which a reduction in efficiency of the refrigeration cycle apparatus caused by an increase in amount of the refrigerant in the refrigerant container and a corresponding reduction in heat exchange efficiency of the third heat exchanger is suppressed.

[0031] Fig. 8 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 300 according to the third embodiment. The configuration of refrigeration cycle apparatus 300 is different from the configuration of refrigeration cycle apparatus 100 in Fig. 1 in that a pressure sensor 91 is added and controller 10 is replaced with a controller 30. Since the remaining configuration is the same, description will not be repeated. In the third embodiment, Figs. 1 and 3 in the first embodiment are replaced with Figs. 8 and 9, respectively.

[0032] As shown in Fig. 8, pressure sensor 91 detects a pressure (condensation pressure) of the refrigerant in condenser 2 and outputs a detection signal indicating the condensation pressure to controller 30. Using the detection signal from pressure sensor 91, controller 30 controls the degree of opening of expansion valve 3 and adjusts the amount of the refrigerant in refrigerant container 4.

[0033] As the amount of the refrigerant in refrigerant container 4 increases, a liquid level of the liquid refrigerant stored in refrigerant container 4 becomes higher. When a degree of dryness around internal heat exchanger 9 decreases, internal heat exchanger 9 is immersed in the liquid refrigerant and the heat exchange efficiency

of internal heat exchanger 9 is reduced. As a result, the efficiency of refrigeration cycle apparatus 300 may be reduced. In order to suppress the reduction in heat exchange efficiency of internal heat exchanger 9, it is necessary to adjust the amount of the refrigerant in refrigerant container 4.

[0034] When the amount of the refrigerant in refrigeration cycle apparatus 300 is constant, a distribution of the refrigerant in refrigeration cycle apparatus 300 is concentrated on the low pressure side as an amount of the refrigerant in condenser 2 becomes smaller, and thus, the amount of the refrigerant in refrigerant container 4 becomes larger. In addition, as the amount of the refrigerant in condenser 2 becomes smaller, the condensation pressure becomes lower. Therefore, as the condensation pressure becomes lower, the amount of the refrigerant in refrigerant container 4 becomes larger.

[0035] Accordingly, in refrigeration cycle apparatus 300, when the amount of the refrigerant in refrigerant container 4 is larger than the reference amount, and the liquid level rises and the heat exchange efficiency of internal heat exchanger 9 is lower than a desired level, the degree of opening of expansion valve 8 is decreased by a certain amount. Since an amount per unit time of the refrigerant flowing from expansion valve 3 to refrigerant container 4 decreases and a height of the liquid level of the liquid refrigerant stored in refrigerant container 4 becomes lower, a reduction in heat exchange efficiency of internal heat exchanger 9 can be suppressed. As a result, a reduction in efficiency of refrigeration cycle apparatus 300 can be suppressed. In addition, the suppression of the reduction in heat exchange efficiency can lead to a reduction in size of internal heat exchanger 9, and thus, refrigeration cycle apparatus 300 can be reduced in size. In refrigeration cycle apparatus 300, whether or not a condition (specific condition) that the amount of the refrigerant in refrigerant container 4 is larger than the reference amount is satisfied is determined based on whether or not a condition that the condensation pressure is lower than a reference pressure is satisfied.

[0036] Fig. 9 is a flowchart showing a flow of an amount-of-refrigerant adjustment process performed by controller 30 in Fig. 8. As shown in Fig. 9, in S231, controller 30 determines whether or not the condensation pressure is lower than the reference pressure. When the condensation pressure is lower than the reference pressure (YES in S231), controller 30 decreases the degree of opening of expansion valve 3 by a certain amount and returns the process to the main routine in S232. When the condensation pressure is not lower than the reference pressure (NO in S231), controller 30 increases the degree of opening of expansion valve 3 by a certain amount and returns the process to the main routine in S233.

[0037] As described above, in the refrigeration cycle apparatus according to the third embodiment, when the amount of the refrigerant in the refrigerant container increases and the heat exchange efficiency of the third heat exchanger is lower than a desired level, a reduction

in efficiency of the refrigeration cycle apparatus can be suppressed. In addition, in the refrigeration cycle apparatus according to the third embodiment, the refrigeration cycle apparatus can be reduced in size.

Fourth Embodiment

[0038] In the first and second embodiments, description has been given of the case of using the degree of opening of the second expansion valve as an indicator indicating the amount of the refrigerant in refrigerant container 4. In the third embodiment, description has been given of the case of using the condensation pressure as an indicator indicating the amount of the refrigerant in refrigerant container 4. In a fourth embodiment, description will be given of the case of using the height of the liquid level of the liquid refrigerant in refrigerant container 4 as an indicator indicating the amount of the refrigerant in refrigerant container 4.

[0039] Fig. 10 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 400 according to the fourth embodiment. The configuration of refrigeration cycle apparatus 400 is different from the configuration of refrigeration cycle apparatus 100 in Fig. 1 in that a liquid level sensor 92 is added and controller 10 is replaced with a controller 40. Since the remaining configuration is the same, description will not be repeated. In the fourth embodiment, Figs. 1 and 3 in the first embodiment are replaced with Figs. 10 and 12, respectively.

[0040] As shown in Fig. 10, liquid level sensor 92 detects a height of a liquid level of the liquid refrigerant in refrigerant container 4 and outputs a detection signal indicating the liquid level height to controller 40. Using the detection signal from liquid level sensor 92, controller 30 controls the degree of opening of expansion valve 8 and adjusts the amount of the refrigerant in refrigerant container 4.

[0041] Fig. 11 is a graph showing a relationship between the liquid level height of the liquid refrigerant stored in refrigerant container 4 and the heat exchange efficiency of internal heat exchanger 9. In Fig. 11, a liquid level height H1 represents a maximum value of a liquid level height that can maintain a difference between a pressure on the high pressure side and a pressure on the low pressure side at an appropriate level, and represents a liquid level height when the condensation pressure is higher than the reference pressure, for example. A liquid level height H2 is lower than liquid level height H1, and represents a liquid level height when the heat exchange efficiency of internal heat exchanger 9 is maximized.

[0042] As shown in Fig. 11, as the height of the liquid level of the liquid refrigerant stored in refrigerant container 4 becomes higher, an end of pipe 71 in refrigerant container 4 comes closer to the liquid level and the degree of dryness of the refrigerant flowing into pipe 71 decreases. The liquid refrigerant flows into pipe 71, and the heat exchange efficiency of internal heat exchanger

9 becomes higher as compared with the case in which the wet vapor flows into pipe 71. However, when the height of the liquid level in refrigerant container 4 further increases and the degree of dryness of the refrigerant around internal heat exchanger 9 further decreases, internal heat exchanger 9 is immersed in the liquid refrigerant and the heat exchange efficiency of internal heat exchanger 9 is reduced.

[0043] Accordingly, in refrigeration cycle apparatus 400, a reduction in heat exchange efficiency of internal heat exchanger 9 is suppressed by controlling the degree of opening of expansion valve 8 to suppress a deviation of the liquid level height of the liquid refrigerant stored in refrigerant container 4 from the range of H2 to H1. As a result, a reduction in efficiency of refrigeration cycle apparatus 400 can be suppressed. In addition, the suppression of the reduction in heat exchange efficiency can lead to a reduction in size of internal heat exchanger 9, and thus, refrigeration cycle apparatus 400 can be reduced in size. Furthermore, a change in liquid level height of the liquid refrigerant stored in refrigerant container 4 is within the certain range, and thus, vibration of the liquid refrigerant in refrigerant container 4 is suppressed and noise of refrigeration cycle apparatus 400 is suppressed. As a result, the user comfort can be improved.

[0044] Fig. 12 is a flowchart showing a flow of an amount-of-refrigerant adjustment process performed by controller 40 in Fig. 10. As shown in Fig. 12, in S241, controller 40 determines whether or not the height of the liquid level of the liquid refrigerant in refrigerant container 4 is not lower than reference height H1 (first reference height). When the height of the liquid level of the liquid refrigerant in refrigerant container 4 is not lower than reference height H1 (YES in S241), controller 40 increases the degree of opening of expansion valve 8 by a certain amount and returns the process to the main routine in S242.

[0045] When the height of the liquid level of the liquid refrigerant in refrigerant container 4 is lower than reference height H1 (NO in S241), controller 40 determines whether or not the height of the liquid level of the liquid refrigerant in refrigerant container 4 is not lower than reference height H2 (second reference height) in S243. When the height of the liquid level of the liquid refrigerant in refrigerant container 4 is not lower than reference height H2 (YES in S243), controller 40 decreases the degree of opening of expansion valve 8 by a certain amount and returns the process to the main routine in S244. When the height of the liquid level of the liquid refrigerant in refrigerant container 4 is lower than reference height H2 (NO in S243), controller 40 increases the degree of opening of expansion valve 8 by a certain amount and returns the process to the main routine in S245.

[0046] As described above, in the refrigeration cycle apparatus according to the fourth embodiment, a reduction in efficiency of the refrigeration cycle apparatus can be suppressed. In addition, in the refrigeration cycle ap-

paratus according to the fourth embodiment, the refrigeration cycle apparatus can be reduced in size, and further, noise can be suppressed and the user comfort can be improved.

Fifth Embodiment

[0047] In the fourth embodiment, description has been given of the configuration in which the amount per unit time of the refrigerant passing through the specific flow path is increased by increasing the degree of opening of the third expansion valve. In a fifth embodiment, description will be given of a configuration in which the amount per unit time of the refrigerant passing through the specific flow path is increased by bypassing the refrigerant from the specific flow path to the suction port of the compressor, in addition to increasing the degree of opening of the third expansion valve.

[0048] Fig. 13 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 500 according to the fifth embodiment. The configuration of refrigeration cycle apparatus 500 is different from the configuration of refrigeration cycle apparatus 400 in Fig. 10 in that an on/off unit 80A is added and controller 40 is replaced with a controller 50. Since the remaining configuration is the same, description will not be repeated. In the fifth embodiment, Figs. 10 and 12 in the fourth embodiment are replaced with Figs. 13 and 14, respectively.

[0049] As shown in Fig. 13, on/off unit 80A is connected between pipe 71 and the suction port of compressor 1. Controller 50 switches between opening and closing of on/off unit 80A. A specific configuration of on/off unit 80A is the same as that of on/off unit 80 in Fig. 6 or 7.

[0050] In refrigeration cycle apparatus 500, it is unnecessary to increase the amount per unit time of the refrigerant passing through pipe 71 by increasing a diameter of expansion valve 8, and thus, expansion valve 8 can be reduced in size. The reduction in size of expansion valve 8 makes it possible to control the degree of opening of expansion valve 8 in accordance with a relatively low resolution, and thus, the controllability of expansion valve 8 can be improved.

[0051] Fig. 14 is a flowchart showing a flow of an amount-of-refrigerant adjustment process performed by controller 50 in Fig. 13. As shown in Fig. 14, in S251, controller 50 determines whether or not the height of the liquid level of the liquid refrigerant in refrigerant container 4 is not lower than reference height H1. When the height of the liquid level of the liquid refrigerant in refrigerant container 4 is not lower than reference height H1 (YES in S251), controller 50 increases the degree of opening of expansion valve 8 by a certain amount and the process proceeds to S253 in S252. In S253, controller 50 closes on/off unit 80A and returns the process to the main routine.

[0052] When the height of the liquid level of the liquid refrigerant in refrigerant container 4 is lower than refer-

ence height H1 (NO in S251), controller 50 determines whether or not the height of the liquid level of the liquid refrigerant in refrigerant container 4 is not lower than reference height H2 in S254. When the height of the liquid level of the liquid refrigerant in refrigerant container 4 is not lower than reference height H2 (YES in S254), controller 50 decreases the degree of opening of expansion valve 8 by a certain amount and the process proceeds to S256 in S255. In S256, controller 50 closes on/off unit 80A and returns the process to the main routine. When the height of the liquid level of the liquid refrigerant in refrigerant container 4 is lower than reference height H2 (NO in S254), controller 50 opens on/off unit 80A and returns the process to the main routine in S257.

[0053] As described above, in the refrigeration cycle apparatus according to the fifth embodiment, a reduction in efficiency of the refrigeration cycle apparatus can be suppressed. In addition, in the refrigeration cycle apparatus according to the fifth embodiment, noise can be suppressed and the user comfort can be improved, and further, the controllability of the third expansion valve can be improved.

[0054] It is intended that the embodiments disclosed herein are to be carried out in any appropriate combination with no contradiction. It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0055] 1 compressor; 2 condenser; 3, 5, 8 expansion valve; 4 refrigerant container; 6 evaporator; 10, 20, 30, 40, 50 controller; 71 pipe; 80, 80A on/off unit; 81 on-off valve; 82 three-way valve; 91 pressure sensor; 92 liquid level sensor; 100, 200, 300, 400, 500 refrigeration cycle apparatus; P1 to P3 port.

Claims

1. A refrigeration cycle apparatus in which refrigerant circulates through a compressor, a first heat exchanger, a first expansion valve, a refrigerant container, a second expansion valve and a second heat exchanger in this order, the refrigeration cycle apparatus comprising:

a third expansion valve; and
a specific flow path allowing the third expansion valve to communicate with the refrigerant container,
the third expansion valve communicating with a suction port of the compressor through the refrigerant container,

an amount per unit time of the refrigerant passing through the specific flow path when a specific condition is satisfied being larger than the amount per unit time of the refrigerant passing through the specific flow path when the specific condition is not satisfied,
 the specific condition being a condition that an amount of the refrigerant in the refrigerant container is smaller than a reference amount.

- 2. The refrigeration cycle apparatus according to claim 1, wherein the specific condition includes a condition that a degree of opening of the second expansion valve is not smaller than a reference degree of opening.
- 3. The refrigeration cycle apparatus according to claim 1, wherein the specific condition includes a condition that a height of a liquid level of the refrigerant in a liquid state stored in the refrigerant container is lower than a reference height.
- 4. The refrigeration cycle apparatus according to any one of claims 1 to 3, wherein a degree of opening of the third expansion valve when the specific condition is satisfied is larger than the degree of opening of the third expansion valve when the specific condition is not satisfied.
- 5. The refrigeration cycle apparatus according to any one of claims 1 to 3, further comprising an on/off unit connected between the specific flow path and the suction port, wherein the on/off unit is opened when the specific condition is satisfied, and the on/off unit is closed when the specific condition is not satisfied.
- 6. The refrigeration cycle apparatus according to any one of claims 1 to 5, further comprising a third heat exchanger connected between the third expansion valve and the suction port, and arranged in the refrigerant container.
- 7. A refrigeration cycle apparatus in which refrigerant circulates through a compressor, a first heat exchanger, a first expansion valve, a refrigerant container, a second expansion valve and a second heat exchanger in this order, the refrigeration cycle apparatus comprising:

a third expansion valve;
 a specific flow path allowing the third expansion valve to communicate with the refrigerant container; and
 a third heat exchanger connected between the third expansion valve and a suction port of the compressor, and arranged in the refrigerant

container,
 when a specific condition is satisfied, an amount of the refrigerant flowing into the refrigerant container being smaller than an amount of the refrigerant flowing out of the refrigerant container, the specific condition being a condition that an amount of the refrigerant in the refrigerant container is larger than a reference amount,
 heat exchange efficiency of the third heat exchanger when the specific condition is satisfied being lower than the heat exchange efficiency when the amount of the refrigerant in the refrigerant container is the reference amount.

5
 10
 15
 20
 25
 30
 35
 40
 45
 50

- 8. The refrigeration cycle apparatus according to claim 7, wherein the specific condition includes a condition that a pressure of the first heat exchanger is lower than a reference pressure, and a degree of opening of the first expansion valve when the specific condition is satisfied is smaller than the degree of opening of the first expansion valve when the specific condition is not satisfied.
- 9. The refrigeration cycle apparatus according to claim 7, wherein the specific condition includes a condition that a height of a liquid level of the refrigerant in a liquid state stored in the refrigerant container is higher than a first reference height, an amount per unit time of the refrigerant passing through the specific flow path when the specific condition is satisfied or when the height is lower than a second reference height is larger than the amount per unit time of the refrigerant passing through the specific flow path when the height is higher than the second reference height and lower than the first reference height, and the second reference height is lower than the first reference height.
- 10. The refrigeration cycle apparatus according to claim 9, wherein a degree of opening of the third expansion valve when the height is higher than the first reference height or when the height is lower than the second reference height is larger than the degree of opening of the third expansion valve when the height is higher than the second reference height and lower than the first reference height.
- 11. The refrigeration cycle apparatus according to claim 9, further comprising an on/off unit connected between the specific flow path and the suction port, wherein a degree of opening of the third expansion valve when the height is higher than the first reference height is larger than the degree of opening of the

third expansion valve when the height is higher than the second reference height and lower than the first reference height,

the on/off unit is opened when the height is lower than the second reference height, and

the on/off unit is closed when the height is higher than the second reference height and lower than the first reference height.

5

10

15

20

25

30

35

40

45

50

55

FIG.1

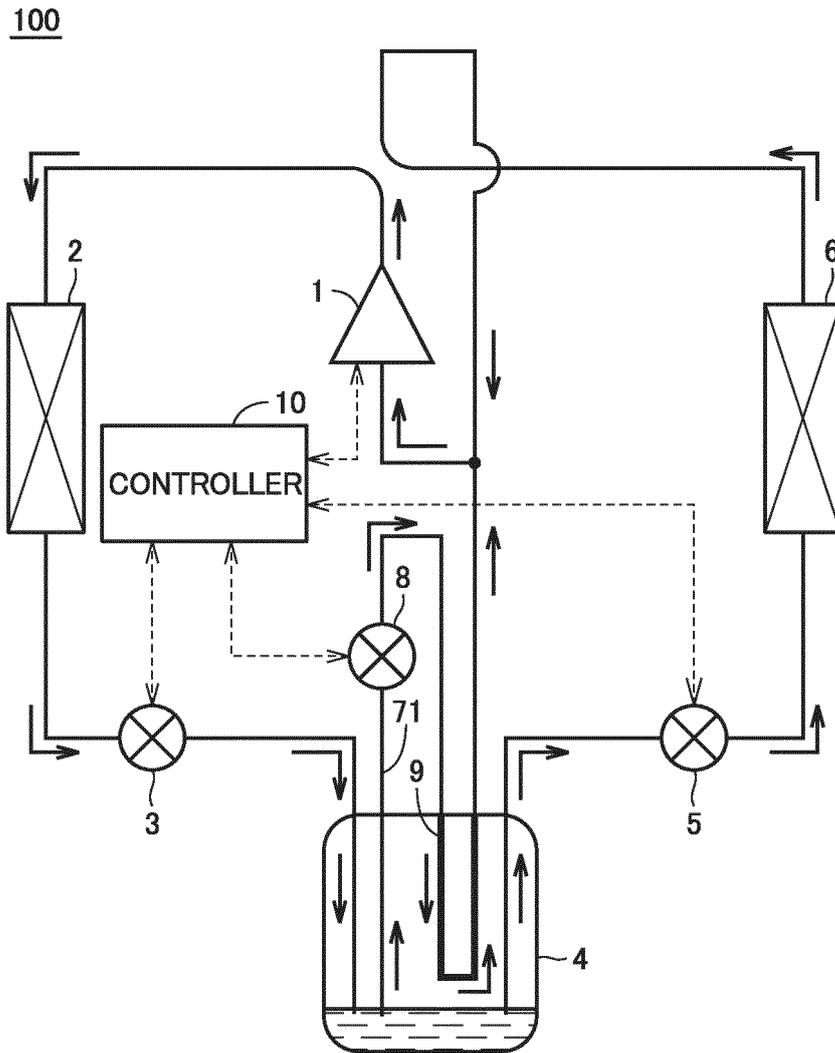


FIG.2

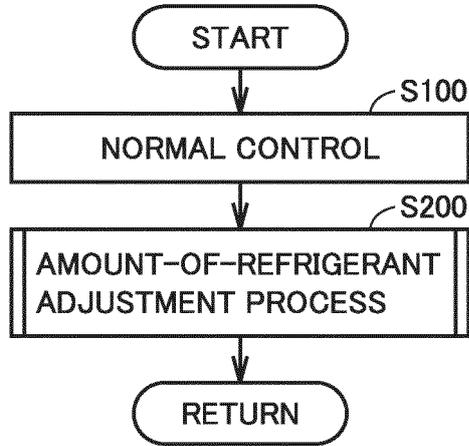


FIG.3

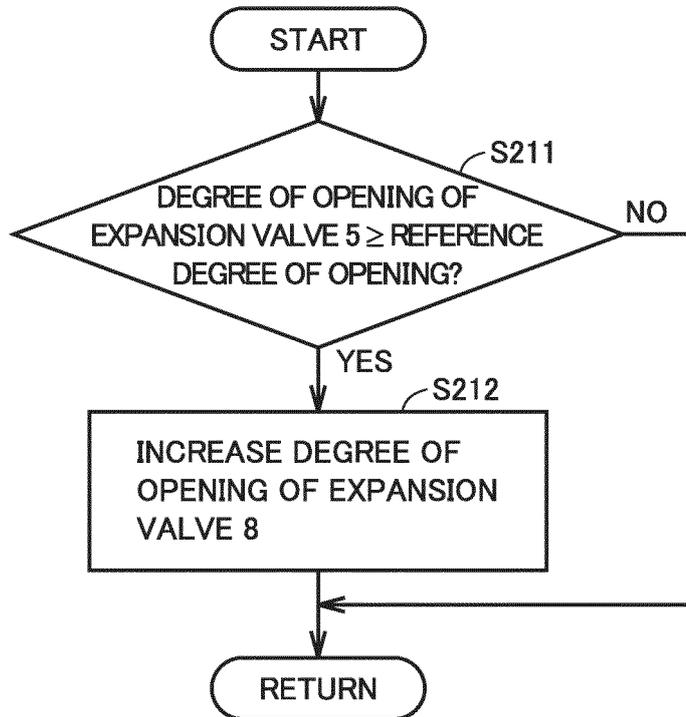


FIG.4

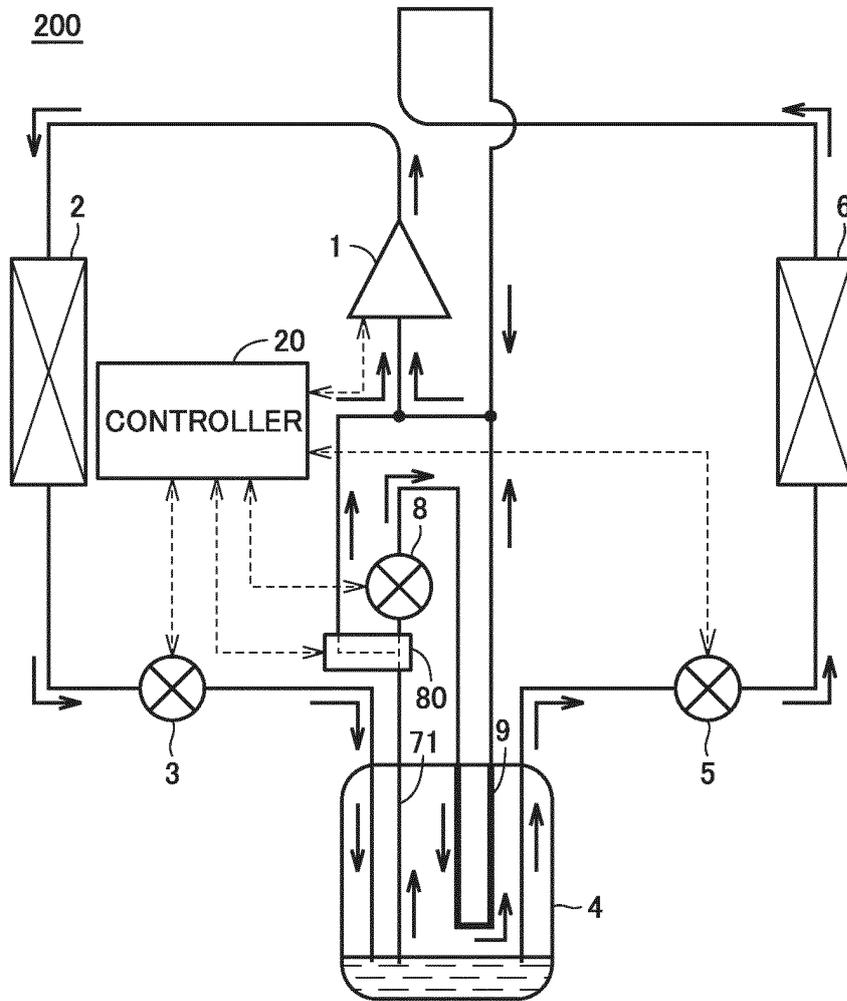


FIG.5

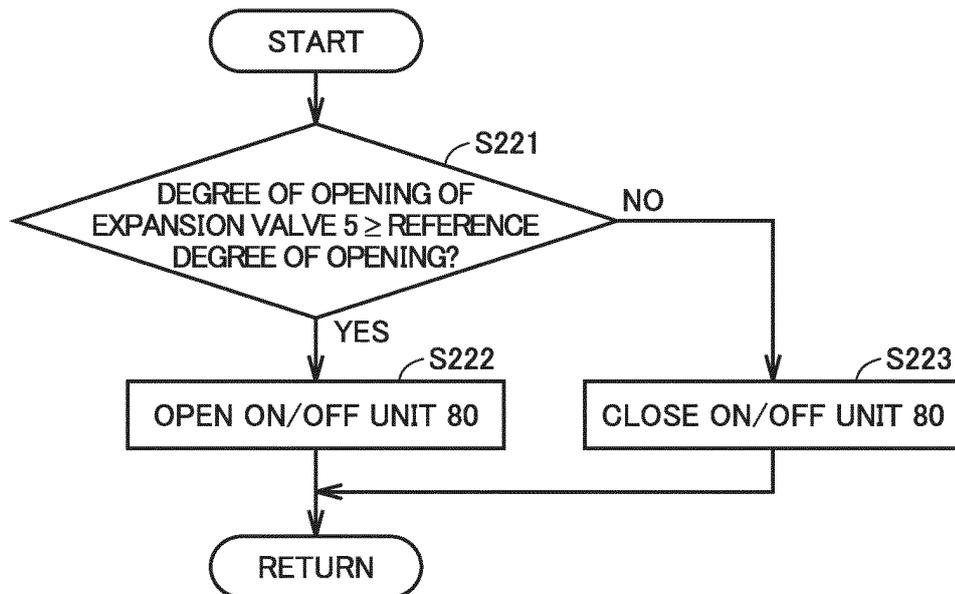


FIG.6

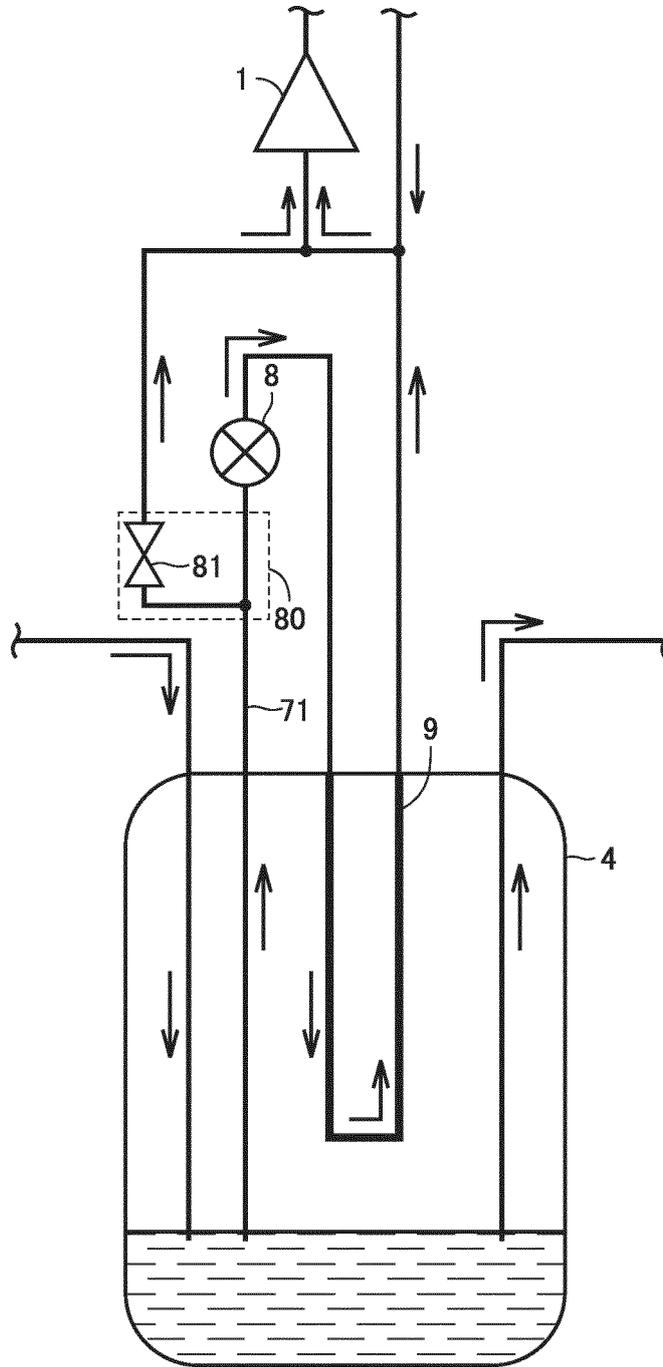


FIG. 7

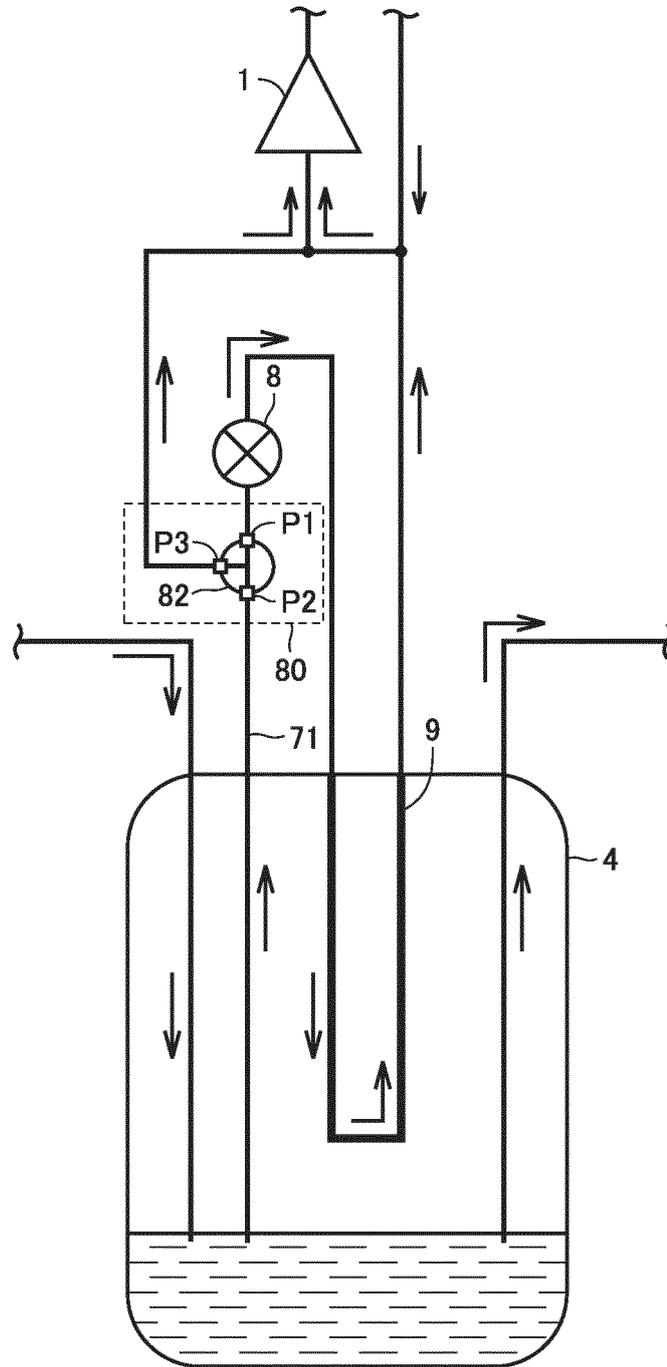


FIG.8

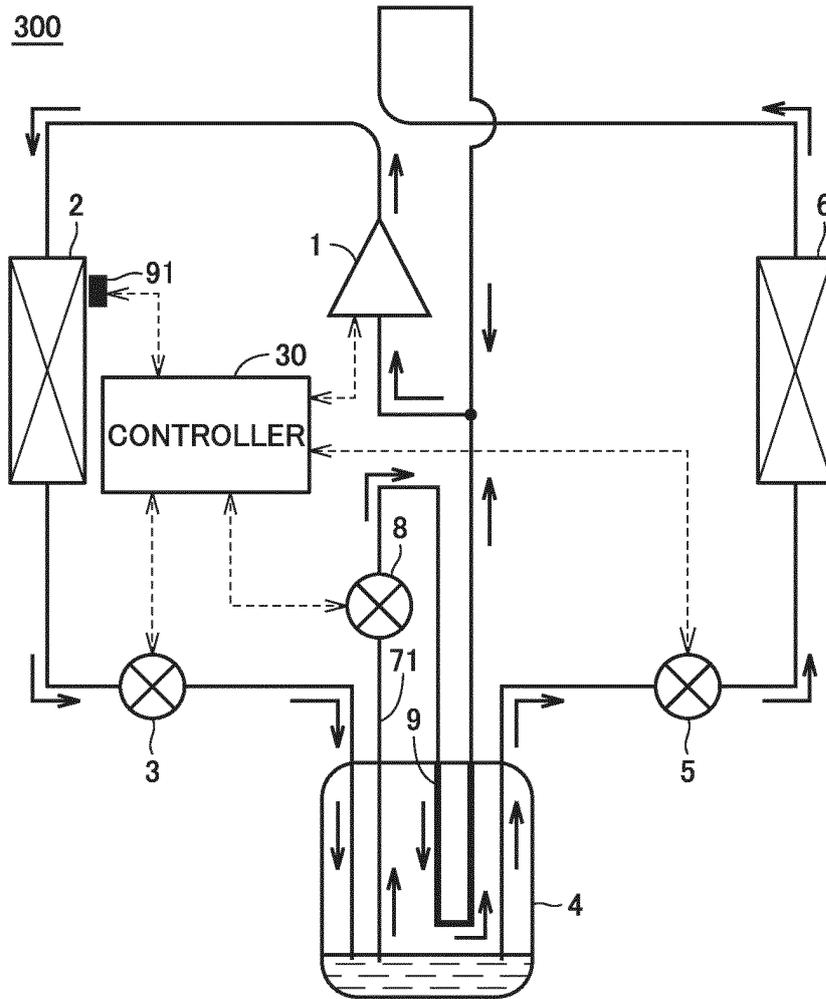


FIG.9

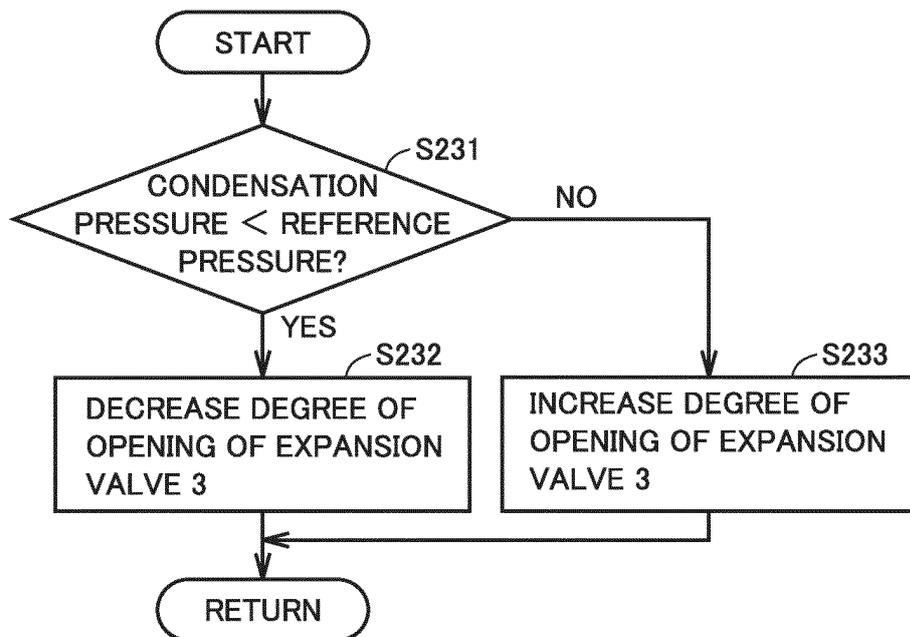


FIG.10

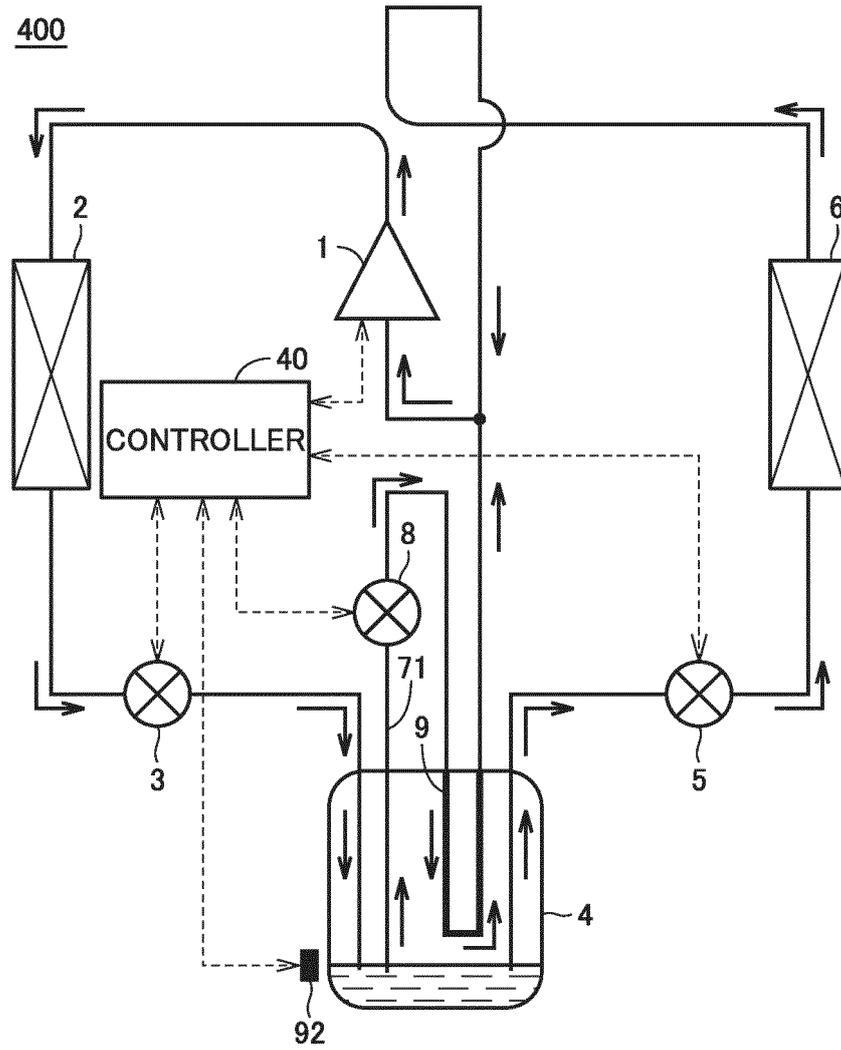


FIG.11

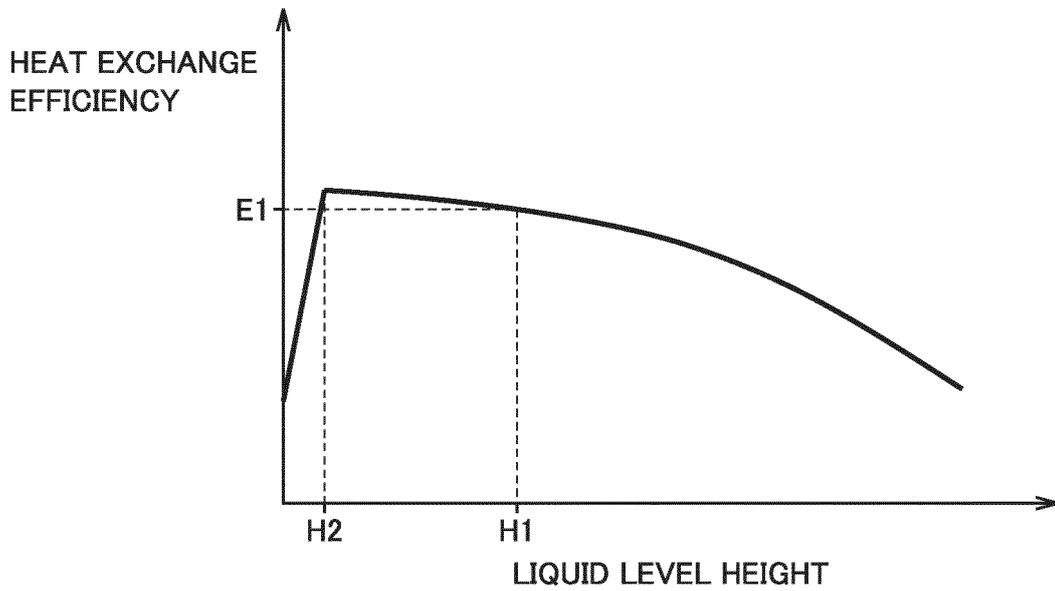


FIG.12

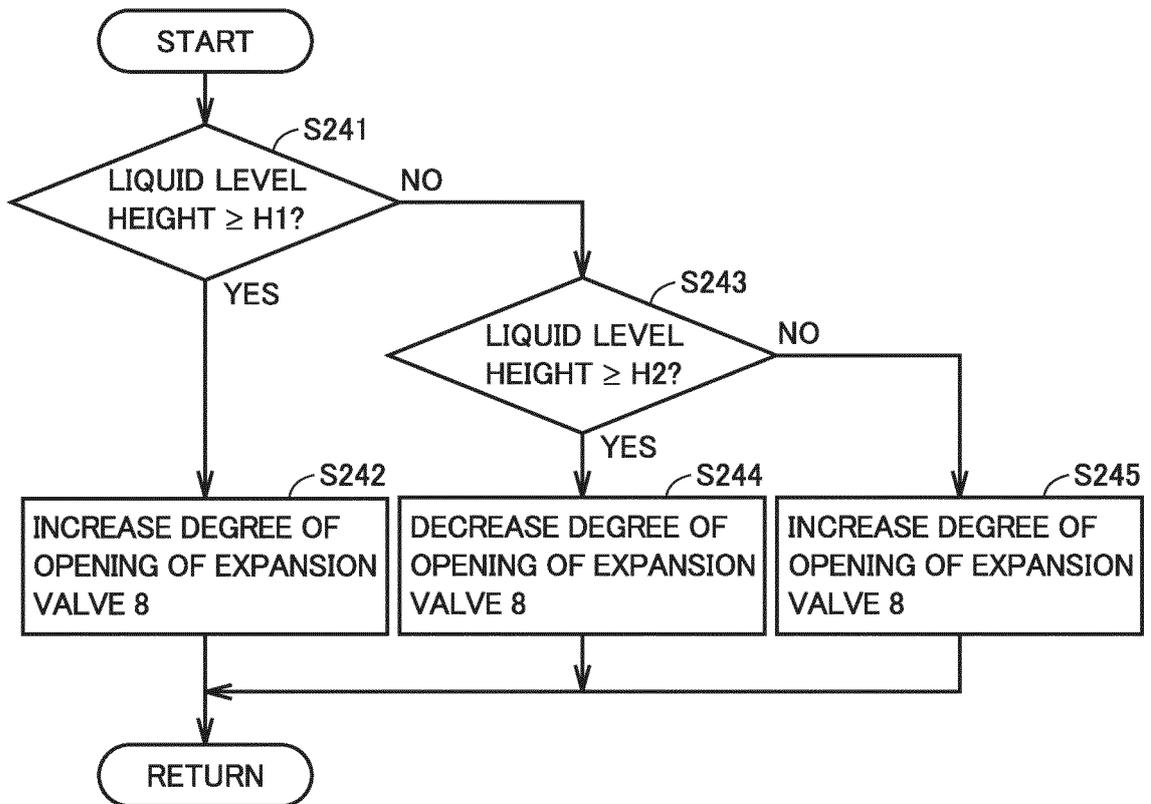


FIG.13

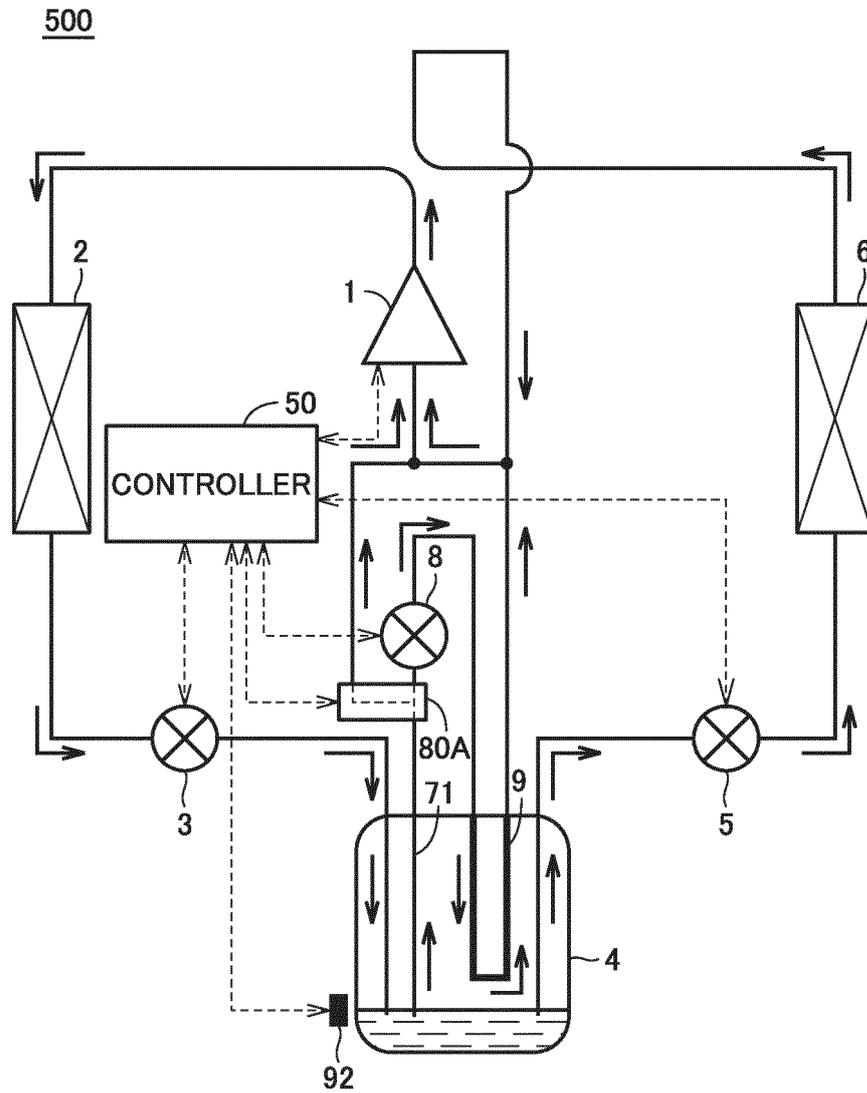
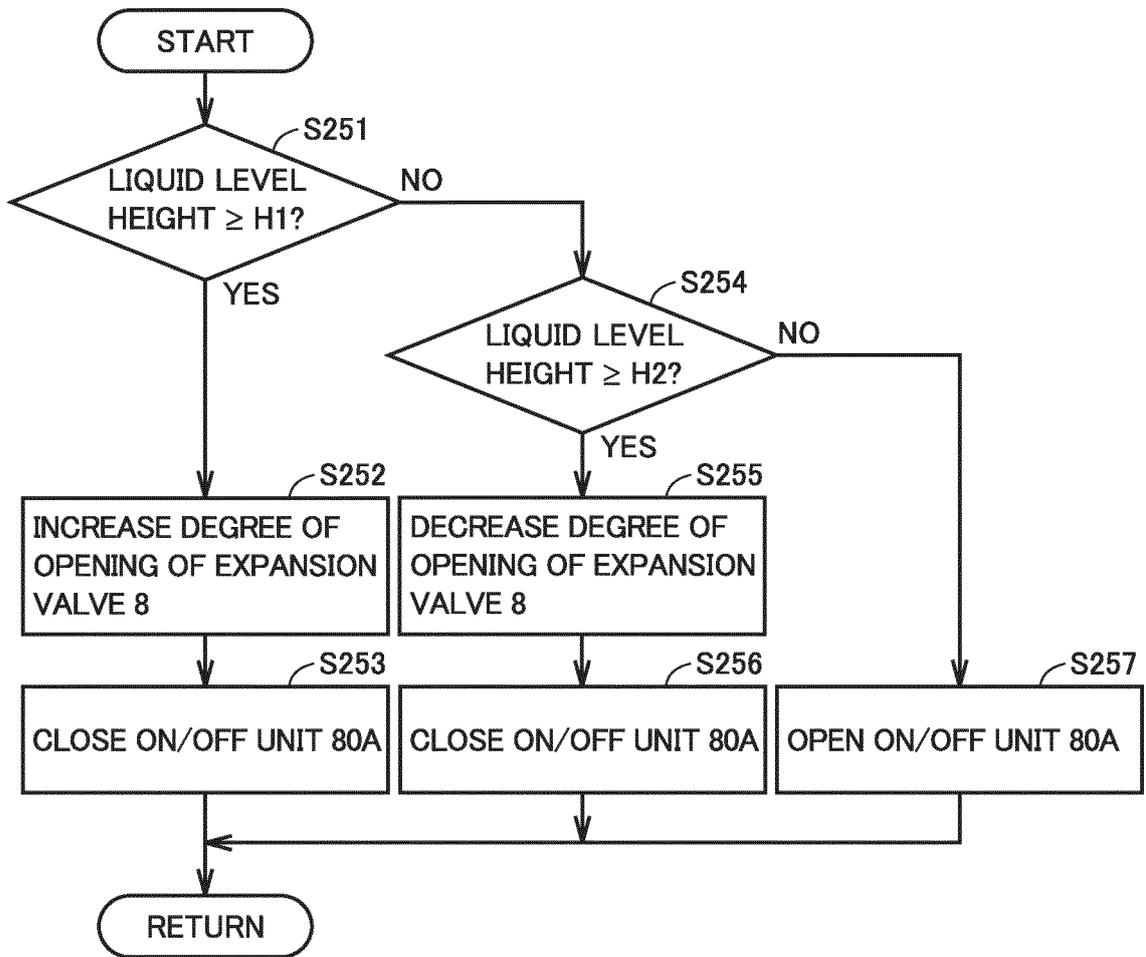


FIG.14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/022956

5

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F25B43/00 (2006.01) i, F25B1/00 (2006.01) i

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

10

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl. F25B43/00, F25B1/00

15

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

20

C. DOCUMENTS CONSIDERED TO BE RELEVANT

25

30

35

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2015/198475 A1 (MITSUBISHI ELECTRIC CORP.) 30 December 2015, fig. 1 & US 2017/0167762 A1, fig. 1 & EP 3163217 A1 & CN 106415153 A	1-11
A	US 2013/0145791 A1 (HILL PHOENIX, INC.) 13 June 2013, fig. 1 (Family: none)	1-11
A	US 2009/0019878 A1 (GUPTE, Neelkanth S.) 22 January 2009, fig. 1, 2 & JP 2008-530511 A & WO 2006/091190 A1 & CN 101124441 A & AU 2005327954 A & MX 2007010002 A	1-11

40

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

45

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

50

Date of the actual completion of the international search
09.08.2018Date of mailing of the international search report
21.08.2018

55

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/022956

5
10
15
20
25
30
35
40
45
50
55

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 127887/1978 (Laid-open No. 44178/1980) (TOKYO SHIBAURA ELECTRIC CO., LTD.) 22 March 1980, fig. 1 (Family: none)	1-11

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 5865561 B [0002] [0003]