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(54) **REFRIGERATION CYCLE EQUIPMENT**

(57) A refrigeration cycle equipment includes: a compressor (1); a four-way valve (2); an outdoor heat exchanger (3); an expansion valve (4); an indoor heat exchanger (5); a refrigerant pipe line which sequentially connects a compressor (1), a four-way valve (2), an outdoor heat exchanger (3), an expansion valve (4), and an indoor heat exchanger (5); a bypass pipe line (8) connecting a refrigerant pipe line between the outdoor heat exchanger (3) and the expansion valve (4) and a refrigerant pipe line between a suction port of the compressor (1) and the four-way valve (2); an open/close valve (9)

provided for the bypass pipe line (8); an outdoor temperature sensor (17) provided for the outdoor heat exchanger (3) to detect an outdoor temperature; and a control unit (20) controlling the compressor (1), the four-way valve (2), the expansion valve (4), and the open/close valve mechanism (9). The control unit (20) controls the open/close valve mechanism (9) of the bypass pipe line (8) to be opened at a time when the outdoor temperature is detected to be more than a predetermined temperature in a defrosting operation of the refrigeration cycle equipment.

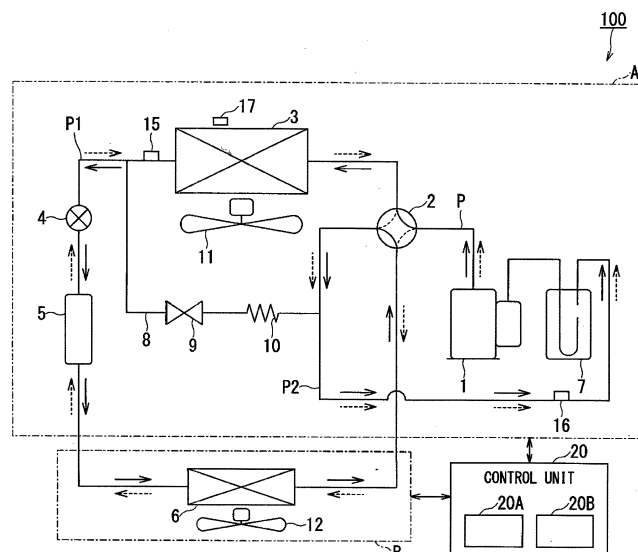


FIG. 1

Description

BACKGROUND OF THE INVENTION

Technical Field

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

Related Art

[0002] Conventionally, there is known a refrigeration cycle equipment or system in which a refrigerant (cooling medium) discharged from a compressor flows through an outdoor heat exchanger, an indoor heat exchanger, an expansion valve and a four-way valve, and the refrigeration cycle equipment provided with these components is switched so as to perform heating operation or cooling operation by changing a flow direction of the refrigerant by operating the four-way valve.

[0003] In the heating operation of the refrigeration cycle equipment, when a temperature of the outdoor heat exchanger is lowered, frost adheres to a number of fins provided for the outdoor heat exchanger, and hence, the heat-exchanging performance of the outdoor heat exchanger is degraded. Because of such reason, when a fact that a predetermined amount of frost adheres to the outdoor heat exchanger is detected, a control unit of the refrigeration cycle equipment controls the four-way valve to switch the direction of the refrigerant flow for a cooling operation and perform a defrosting operation (reverse-defrost) to dissolve the forest adhering to the fins of the outdoor heat exchanger.

[0004] During the defrosting operation, since the heating operation is interrupted, it is desirable to make short a time required for the defrosting operation.

[0005] In order to solve such defect, prior art provides an equipment for effectively performing the defrosting operation by connecting a refrigerant pipe between the outdoor heat exchanger and the expansion valve and a refrigerant pipe between a suction (intake) side of the compressor and the four-way valve by using a bypass pipe to raise an suction pressure of the compressor by sucking highly heated refrigerant through the bypass pipe during the defrosting operation, thereby increasing the temperature of the refrigerant discharged from the compressor (as disclosed, for example, in Japanese Patent Laid-open No. HEI 9-159329 (Patent Document 1)).

[0006] On the other hand, in recent years, it is desired to provide a refrigeration cycle equipment or system capable of performing a heating operation under an extremely cold environment of an outdoor temperature of less than -15°C , for example, which requires an improvement of expansion of usable condition of the refrigeration cycle equipment suitable under a further low temperature condition.

[0007] However, if the defrosting operation is performed under the extremely cold environment by using

the bypass pipe in a manner as disclosed in the Patent Document 1, a large amount of liquid refrigerant is sucked into the compressor, which may cause damage to the compressor operation.

SUMMARY OF THE INVENTION

[0008] The present invention was conceived in consideration of the circumstances mentioned above and to provide a refrigeration cycle equipment capable of performing a heating operation even in an extremely cold environment.

[0009] The above object can be achieved according to the present invention by providing a refrigeration cycle equipment which includes: a compressor; a four-way valve; an outdoor heat exchanger; an expansion valve; an indoor heat exchanger; a refrigerant pipe line which sequentially connects a compressor, a four-way valve, an outdoor heat exchanger, an expansion valve, and an indoor heat exchanger; a bypass pipe line connecting a refrigerant pipe line between the outdoor heat exchanger and the expansion valve and a refrigerant pipe line between a suction port of the compressor and the four-way valve; an open/close valve provided for the bypass pipe line; an outdoor temperature sensor provided for the outdoor heat exchanger to detect an outdoor temperature; and a control unit controlling the compressor, the four-way valve, the expansion valve, and the open/close valve. The control unit controls the open/close valve of the bypass pipe line to be opened at a time when the outdoor temperature is detected to be more than a predetermined temperature in a defrosting operation of the refrigeration cycle equipment.

Effect of the Invention

[0010] According to the present invention of the structure mentioned above, the control unit performs the controlling of the open/close valve provided for the bypass line to be opened at a time when the outdoor temperature is detected to be more than a predetermined temperature in a defrosting operation of the refrigeration cycle equipment, and accordingly, the heating operation can be performed even in an extremely cold environment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] In the accompanying drawings:

Fig. 1 is a block diagram illustrating a configuration of a refrigeration cycle equipment according to an embodiment of the present invention;

Fig. 2 is a flowchart explaining a heating operation start control in the refrigeration cycle equipment shown in Fig. 1; and

Fig. 3 is a flowchart explaining a defrosting operation control in the refrigeration cycle equipment shown in Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] Hereunder, one embodiment of the present invention will be explained with reference to the accompanying drawings.

[0013] It is further to be noted that an air conditioner is explained hereunder as one preferred embodiment of the refrigeration cycle equipment according to the present invention.

[0014] As shown in Fig. 1, an air conditioner, i.e., refrigeration cycle equipment, 100 according to the present embodiment is provided with a heat-pump type refrigeration cycle constructed by a compressor 1, a four-way valve 2, an outdoor heat exchanger 3, an expansion valve 4, a receiver tank 5, an indoor heat exchanger 6, and an accumulator 7 which are connected in this order via a refrigerant pipe P. A refrigerant of R32 fills this refrigeration cycle.

[0015] In the above configuration, the outdoor heat exchanger 3 and the expansion valve 4 are connected with each other by a refrigerant pipe P1, and the four-way valve 2 and the accumulator 7 are connected with each other by a refrigerant pipe P2, and these refrigerant pipes P1 and P2 are connected by a bypass pipe line 8. The bypass pipe line 8 is provided, on an intermediate portion, with an open/close valve (open/close mechanism) 9 for opening or closing the bypass pipe line 8 and with a capillary tube (decompression device) 10 for controlling a flow rate of the refrigerant.

[0016] In a cooling operation period, as shown with solid arrows, the refrigerant discharged from the compressor 1 flows into the indoor heat exchanger (evaporator) 6 via the four-way valve 2, the outdoor heat exchanger (condenser) 3, the expansion valve 4, and the receiver tank 5, and the refrigerant flowing out of the indoor heat exchanger 6 is sucked into the compressor 1 via the four-way valve 2 and the accumulator 7.

[0017] On the other hand, in a heating operation period, as shown with broken arrows, the four-way valve 2 is switched in flow direction, and the refrigerant discharged from the compressor 1 flows into the indoor heat exchanger (condenser) 6, and the refrigerant flowing out of the indoor heat exchanger 6 is sucked into the compressor 1 via the receiver tank 5, the expansion valve 4, the outdoor heat exchanger (evaporator) 3, the four-way valve 2, and the accumulator 7.

[0018] The outdoor heat exchanger 3 and the indoor heat exchanger 6 are fin-tube heat exchangers, each provided with a plurality of heat-transfer fins arranged in parallel at a predetermined pitch and adapted to pass the heat-exchanged air through a gap between adjacent fins, and a heat transfer tube provided so as to penetrate these heat-transfer fins to thereby introduce the refrigerant inside the heat exchanger.

[0019] An outdoor fan 11 is disposed near the outdoor heat exchanger 3, and an indoor fan 12 is also disposed near the indoor heat exchanger 6.

[0020] The expansion valve 4 is so-called a pulse mo-

tor valve in an opening degree of which continuously changes in response to pulse numbers of a driving pulse signal to be inputted.

[0021] The receiver tank 5 is a refrigerant amount regulating container for storing surplus refrigerant generated in the refrigeration cycle, and the accumulator 7 is a gas/liquid separator for separating the refrigerant into refrigerant gas and refrigerant liquid.

[0022] A refrigerant temperature sensor 15 is provided on an inlet side (in the heating operation period) of the outdoor heat exchanger 3. A refrigerant temperature sensor 16 is also provided to the pipe line P2 between the four-way valve 2 and the accumulator 7, and an outdoor temperature sensor 17 on the outdoor air suction side near the outdoor heat exchanger 3.

[0023] The refrigerant temperature sensor 15 detects a temperature TE of the refrigerant flowing into the outdoor heat exchanger 3 at the heating operation period. The refrigerant temperature sensor 16 detects a temperature TS of the refrigerant sucking into the compressor 1. The outdoor temperature sensor 17 detects a temperature To of an outdoor air near the outdoor heat exchanger 3.

[0024] An inverter, not shown, is connected to a motor of the compressor 1, and the inverter converts a voltage of an AC (alternate current) source into a DC (direct current) voltage, which is converted into an AC voltage having a predetermined frequency F, which is then outputted. The motor of the compressor 1 is driven with a rotating speed (revolution number) in response to this frequency F.

[0025] With reference to Fig. 1, the compressor 1, the four-way valve 2, the outdoor heat exchanger 3, the expansion valve 4, the receiver tank 5, the accumulator 7, the bypass pipe line 8, the open/close valve 9, capillary tube 10, the outdoor fan 11, and the inverter are accommodated in the outdoor unit A, and on the other hand, the indoor heat exchanger 6 and the indoor fan 12 are accommodated in the indoor unit B. The control unit 20 is connected to the outdoor unit A and the indoor unit B.

[0026] The control unit 20 is composed of a micro-computer and a peripheral circuit thereof and includes following means (elements or sections) (1) and (2) for mainly acting the following functions.

(1) A first control section 20A is adapted to compare a temperature To detected by the temperature sensor 17 with a first set value Tos1 at the heating operation starting time of the refrigeration cycle equipment so as to select whether a normal heating operation is to be performed or a cooling cycle operation is to be performed till a predetermined time ts passes beforehand the normal heating operation.

(2) A second control section 20B is adapted to compare a temperature To detected by the temperature sensor 17 with a second set value Tos2 at the defrosting operation starting time of the refrigeration cycle equipment so as to select whether a defrosting

operation is to be performed by opening the open/close valve 9 or the defrosting operation is to be performed with the open/close valve 9 being closed.

[0027] Next, a control mode performed by the control unit 20 will be explained with reference to the flowcharts of Figs. 2 and 3.

[0028] First, with reference to the flowchart of Fig. 2, when the refrigeration cycle equipment 100 operates to start the heating operation ("YES" in step S1), the control unit 20 (first control section 20A) compares the detected temperature (outdoor temperature) To detected by the outdoor temperature sensor 17 with the first set value Tos1 (step S2). In this comparison, when the outdoor temperature To is more than the set value Tos1 (for example, -5°C) ("YES" in step S2), the control unit 20 starts the normal heating operation (step S3) and ends the heating operation start control.

[0029] On the other hand, when the outdoor temperature To is less than the set value Tos1 (for example, -5°C) ("NO" in step S2), the control unit 20 operates to set the four-way valve 2 to a position in the cooling operation and starts the cooling cycle operation (step S4).

[0030] The control unit 20 then starts time counting t (step S5). In this operation, if the time count t does not reach the predetermined time ts ("NO" in step S6), the control unit 20 maintains the time count t (step S5). On the contrary, if the time count t reaches the predetermined time ts ("YES" in step S6), the control unit 20 stops the operation of the compressor 1 and switches the position of the four-way valve 2 to the position for the heating operation (step S7). Thereafter, the control unit 20 starts the normal heating operation (step S3) and ends the heating operation start control.

[0031] Further, under an environment in which the outdoor temperature is low, the refrigerant is liable to stagnate in components incorporated in the outdoor unit A such as the compressor 1, the outdoor heat exchanger 3, the accumulator 7. Under such stagnated condition of the refrigerant, the outdoor temperature is low and the refrigerant pressure is also low. At this instance, when the compressor 1 is started to operate in the heating operation mode, the suction pressure becomes liable to be negative, and the supply of the refrigerant machine oil to a sliding portion of the compressor is blocked, which may result in damage of the compressor 1.

[0032] Then, as described above, if the outdoor temperature To is a low outdoor temperature less than the first set value Tos1, the cooling operation is performed till a predetermined time elapses so as to preheat the inside of the refrigeration cycle. By performing the cooling cycle operation, the outdoor heat exchanger 3 is heated, and when the operation mode is switched to the heating operation mode, the suction pressure of the compressor 1 is not liable to become negative, and hence, the damage of the compressor 1 by the negative pressure can be prevented.

[0033] Further, the control unit 20 stops the operation of the indoor fan 12 as like as the defrosting operation in the cooling cycle operation before the heating operation start, so as not to flow cold wind into a room.

5 **[0034]** Next, the defrosting operation control performed by the control unit 20 will be explained with reference to the flowchart of Fig. 3.

[0035] The refrigeration cycle equipment 100 starts the heating operation, and a condition for defrosting operation is satisfied ("YES" in step S11), the control unit 20 (second control section 20B) compares the detected temperature (outdoor temperature) To detected by the outdoor temperature sensor 17 with the second set value Tos2 (step S12). In such operation, the control unit 20 judges whether the defrosting operation is to be performed or not in consideration of the refrigerant temperature TE detected by the refrigerant temperature sensor 15, the refrigerant temperature TS detected by the refrigerant temperature sensor 16, and the outdoor temperature To detected by the outdoor temperature sensor 17.

[0036] In this judgement, if the outdoor temperature To is more than the set value Tos2 (for example, -15°C) ("YES" in step S12), the control unit 20 operates to open the open/close valve 9 of the bypass pipe line 8 (step S13) and starts the defrosting operation (step S14). At the defrosting operation, the control unit 20 changes the position of the four-way valve 2 to take the cooling operation position from the heating operation position.

[0037] When the refrigeration cycle equipment 100 starts the defrosting operation, and continues the defrosting operation ("NO" in step S15) till the defrosting operation end condition is satisfied, and if the defrosting operation end condition is satisfied ("YES" in step S15), the control unit 20 judges the open/close condition of the open/close valve 9 of the bypass pipe line 8 (step S16).

[0038] In this operation, if the open/close valve 9 is opened, ("YES" in step S16), the valve 9 is closed (step 17). On the other hand, the open/close valve 9 is closed in the step S16, the operation proceeds to the next step S18 to end the defrosting operation control.

[0039] As mentioned hereinabove, during the defrosting operation, by opening the open/close valve 9 of the bypass pipe line 8, a part of the high temperature refrigerant flowing out of the outdoor heat exchanger 3 is sucked into the compressor by by-passing the expansion valve 4 and the indoor heat exchanger 6. According to this operation, the sucking pressure of the compressor 1 increases and the temperature of the refrigerant becomes high, and as a result, the temperature of the refrigerant discharged from the compressor 1 becomes high, which effectively results in the reduction of the time required for the defrosting.

[0040] However, if the defrosting operation is performed by opening the open/close valve 9 of the bypass pipe line 8 under an extremely cold environment of, for example, an outdoor temperature of less than -15°C, the amount of liquid refrigerant to be by-passed increases, which leads to excessively compressed state by the liq-

uid, which may cause damage to the compressor.

[0041] Against such defect, according to the present invention, under the extremely cold environment in which the outdoor temperature T_o becomes less than the second set value T_{os2} , it is controlled that the open/close valve 9 of the bypass pipe line 8 is closed in the defrosting operation, thereby effectively preventing the excessively compressed state by liquid in the compressor 1 from causing.

[0042] As described above, according to the present embodiment, since the open/close operation of the open/close valve 9 of the bypass pipe line 8 can be controlled by the control unit 20 including the first and second control sections 20A and 20B, there is provided the refrigeration cycle equipment which can perform the heating operation even under an extremely cold environment.

[0043] It is further to be noted that the present invention is not limited to the described embodiment, and many other changes and modifications or alternations may be made without departing from the spirit of the present invention and the scope of the appended claims.

[0044] It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

Claims

1. A refrigeration cycle equipment comprising: a compressor (1); a four-way valve (2); an outdoor heat exchanger (3); an expansion valve (4); an indoor heat exchanger (5); a refrigerant pipe line which sequentially connects the compressor (1), the four-way valve (2), the outdoor heat exchanger (3), the expansion valve (4), and the indoor heat exchanger (5); a bypass pipe line (8) connecting the refrigerant pipe line between the outdoor heat exchanger (3) and the expansion valve (4) and the refrigerant pipe line between a suction port of the compressor (1) and the four-way valve (2); an open/close valve mechanism (9) provided for the bypass pipe line (8); an outdoor temperature sensor (17) provided for the outdoor heat exchanger (3) to detect an outdoor temperature; and a control unit (20) controlling the compressor (1), the four-way valve (2), the expansion valve (4), and the open/close valve mechanism (9), wherein the control unit (20) is configured to control the open/close valve mechanism (9) of the bypass pipe line (8) to be opened at a time when the outdoor

temperature is detected to be more than a predetermined temperature in a defrosting operation of the refrigeration cycle equipment.

2. The refrigerant cycle equipment according to claim 1, wherein the control unit (20) includes a first control section (20A) configured to control a heating operation start timing, and a second control section (20B) is configured to control a defrosting operation.

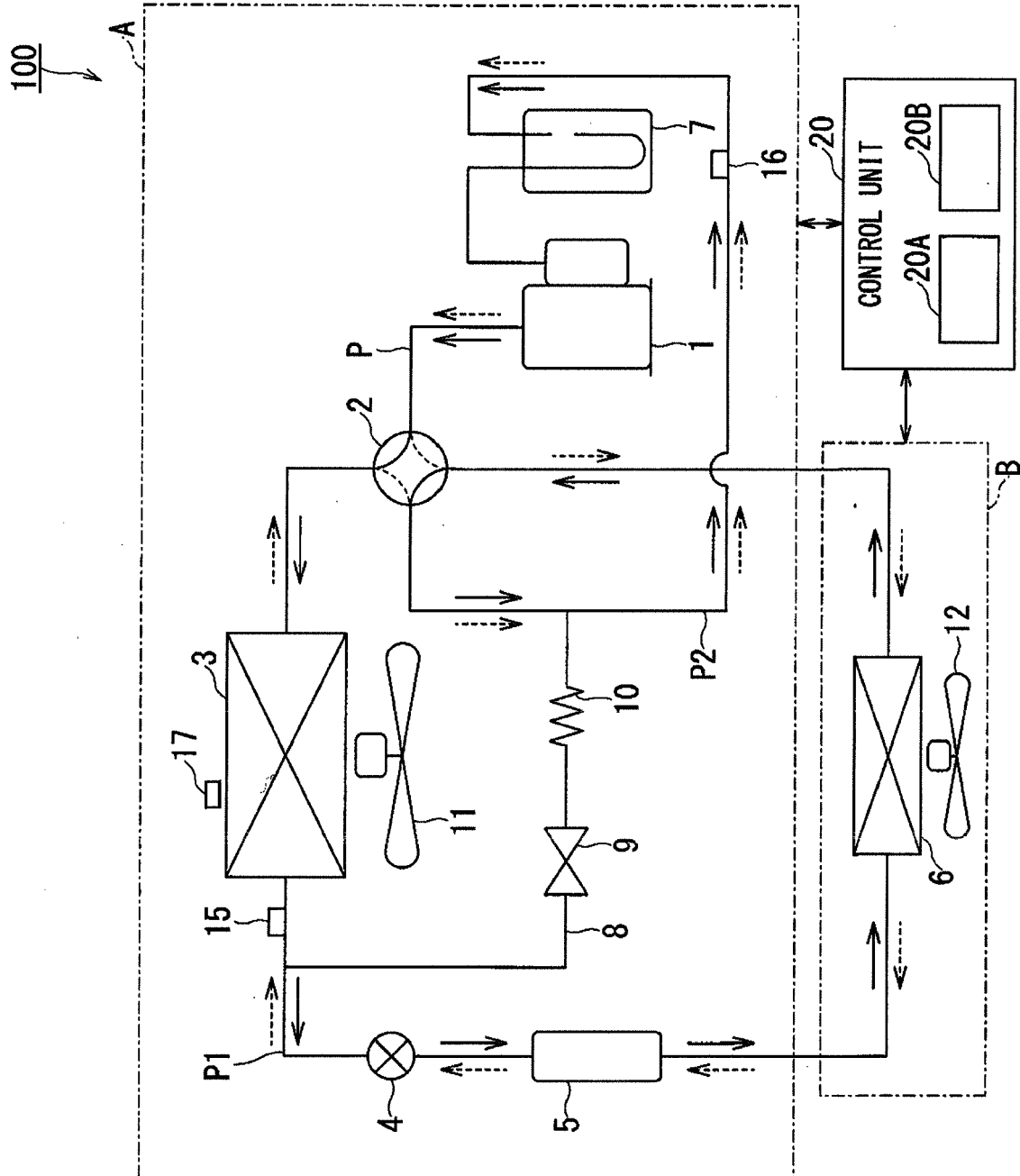


FIG. 1

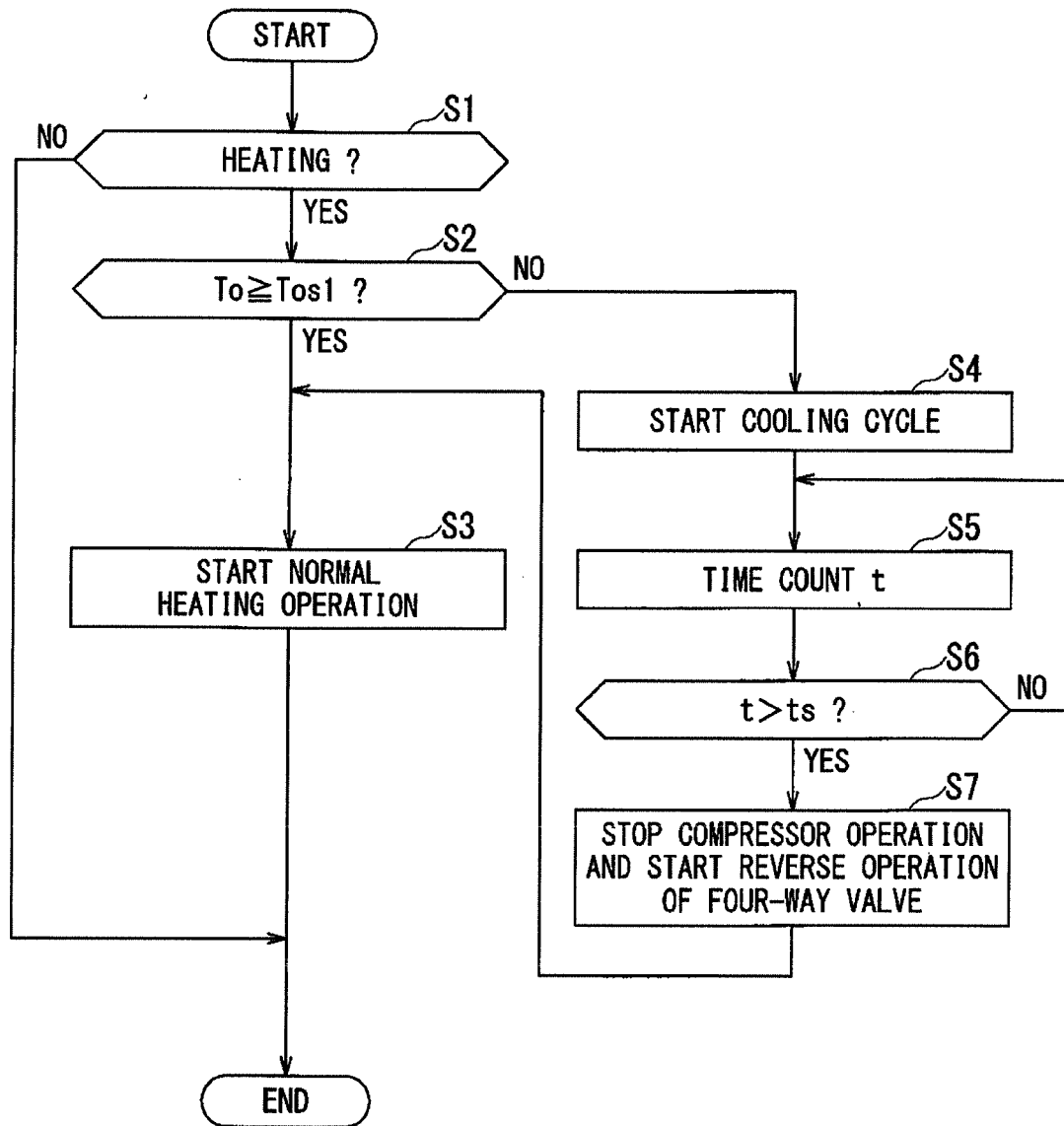


FIG. 2

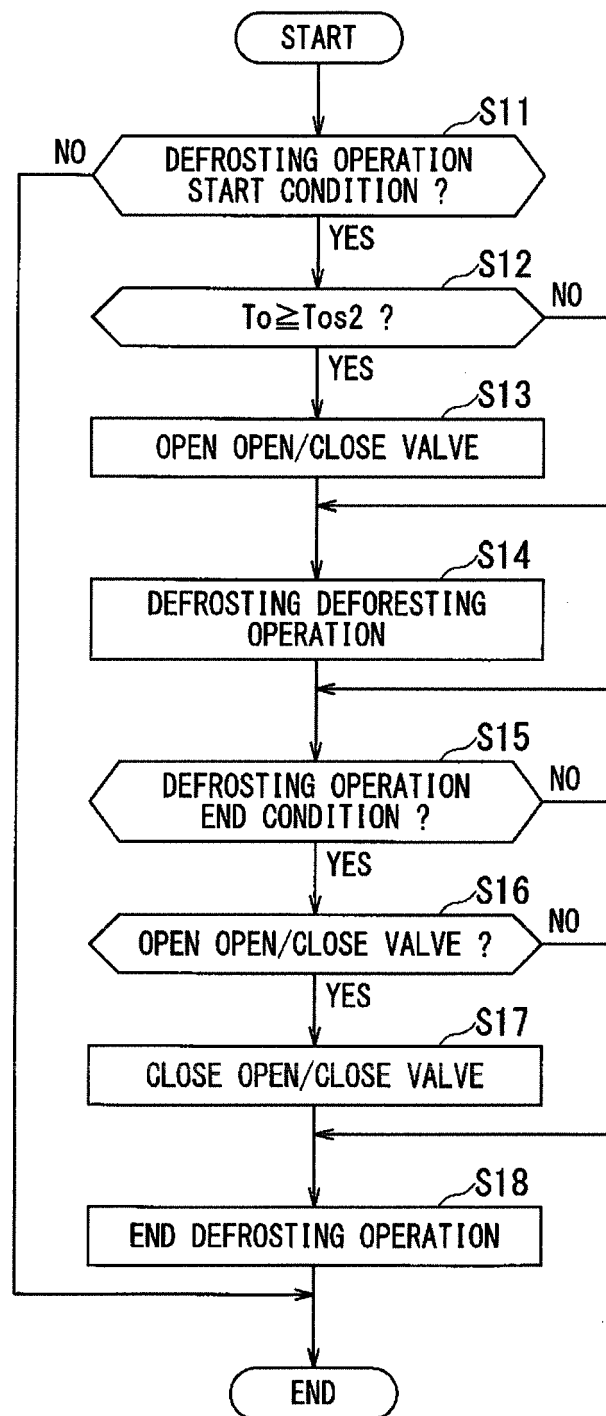


FIG. 3



EUROPEAN SEARCH REPORT

Application Number
EP 16 16 1482

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 1 August 2016	Examiner Szilagyi, Barnabas
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 16 16 1482

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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