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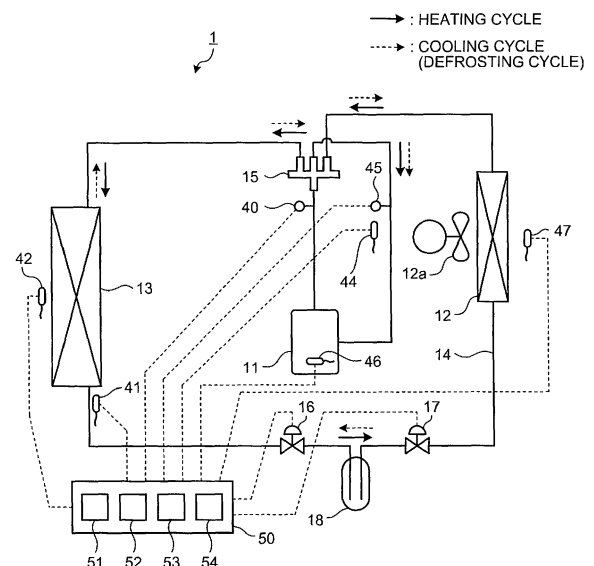
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(54) **AIR CONDITIONER**

(57) An air conditioner 1 includes a refrigerant circuit including a refrigerant compressor 11, a heat source side heat exchanger 12, an electronic expansion valve for heating 17, an electronic expansion valve for cooling 16, and a use side heat exchanger 13 and an expansion valve control unit 50 for controlling a refrigerant superheating degree of an exit of the heat source side heat exchanger by the electronic expansion valve for heating and controlling a refrigerant supercooling degree of an exit of the use side heat exchanger by the electronic expansion valve for cooling at the time of a heating cycle for heating the use side with a refrigerant by the use side heat exchanger. The expansion valve control unit 50 includes a target value correction control unit 53 which gradually lowers a target supercooling degree of the electronic expansion valve for cooling when the opening of the electronic expansion valve for heating is equal to or larger than the set opening and a set opening correction control unit 54 which corrects the set opening of the electronic expansion valve for heating in the target value correction control unit according to the rotation speed of the refrigerant compressor.

FIG.1



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Description

Field

[0001] The present invention relates to an air conditioner.

Background

[0002] Patent Literature 1 discloses a conventional heat pump hot water supplying/air conditioning apparatus which includes a refrigerant circuit including a refrigerant compressor, a heat source side heat exchanger, an electronic expansion valve for heating, an electronic expansion valve for cooling, and a refrigerant / water heat exchanger. At the time of hot water supply for producing warm water by heating water with a refrigerant by the refrigerant /water heat exchanger, the heat pump hot water supplying/air conditioning apparatus controls a refrigerant superheating degree of an exit of the heat source side heat exchanger by the electronic expansion valve for heating and controls a refrigerant supercooling degree of an exit of the refrigerant /water heat exchanger by the electronic expansion valve for cooling. The heat pump hot water supplying/air conditioning apparatus includes a target value correction control unit which controls both electronic expansion valves in a proper operation area by gradually decreasing the target supercooling degree of the electronic expansion valve for cooling when the opening of the electronic expansion valve for heating is equal to or larger than a set opening.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent Application Laid-open No. 2011-252622 A

Summary

Technical Problem

[0004] In the air conditioner described in Patent Literature 1, the set opening of the electronic expansion valve for heating is uniformly kept. For example, at the time of water supply operation, when the refrigerant compressor is operated at the rotation speed higher than the rated capacity operation and lacks the refrigerant in the refrigerant circuit due to the restriction of the electronic expansion valve for cooling, the electronic expansion valve for heating is opened to the set opening or to be larger than the set opening, and the amount of the refrigerant suctioned by the refrigerant compressor is secured. When the state is changed from this state to the state in which the rotation speed of the refrigerant compressor is lower than the rated capacity operation, the electronic expansion valve for heating is restricted. However, because

the electronic expansion valve for heating is opened to the set opening or to be larger than the set opening, it takes time to restrict it to a necessary opening. Therefore, there is a possibility that a liquid back flow occurs, and the stability of the operation is lowered. When the liquid back flow occurs, a liquid refrigerant is suctioned to the refrigerant compressor.

[0005] The present invention has been made to solve the above problems. A purpose of the present invention is to provide an air conditioner which improves a performance by providing an appropriate supercooling degree and improves stability of an operation.

Solution to Problem

[0006] To achieve the purpose described above, an air conditioner of a present invention includes a refrigerant circuit which includes a refrigerant compressor, a heat source side heat exchanger, an electronic expansion valve for heating, an electronic expansion valve for cooling, and a use side heat exchanger, and an expansion valve control unit configured to control a refrigerant superheating degree of an exit of the heat source side heat exchanger by the electronic expansion valve for heating and control a refrigerant supercooling degree of an exit of the use side heat exchanger by the electronic expansion valve for cooling at the time of a heating cycle for heating an use side with a refrigerant by the use side heat exchanger. The expansion valve control unit includes a target value correction control unit which is configured to gradually lower a target supercooling degree of the electronic expansion valve for cooling when an opening of the electronic expansion valve for heating becomes equal to or larger than a set opening; and a set opening correction control unit which is configured to correct the set opening of the electronic expansion valve for heating in the target value correction control unit according to a rotation speed of the refrigerant compressor.

[0007] According to the air conditioner, when the rotation speed of the refrigerant compressor is changed, the set opening of the electronic expansion valve for heating is corrected by correcting the set opening of the electronic expansion valve for heating in the target value correction control unit according to the rotation speed of the refrigerant compressor by the set opening correction control unit. Accordingly, in the air conditioner, when the rotation speed of the refrigerant compressor is changed, generation of the liquid back flow to the refrigerant compressor caused by excessively opening the opening of the electronic expansion valve for heating and generation of shortage of the suctioned refrigerant amount in the refrigerant compressor caused by excessively restricting the opening of the electronic expansion valve for heating can be prevented. In the above air conditioner, the superheating degree and the supercooling degree are independently controlled, and the target supercooling degree of the electronic expansion valve for cooling is changed according to the set opening of the electronic

expansion valve for heating by the target value correction control unit. As a result, the stability of the operation can be improved.

[0008] Further, in the air conditioner of the present invention, the set opening correction control unit is configured to correct the set opening of the electronic expansion valve for heating in the target value correction control unit to be smaller than a rated capacity operation when the rotation speed of the refrigerant compressor is lower than the rated capacity operation and corrects the set opening of the electronic expansion valve for heating in the target value correction control unit to be larger than the rated capacity operation when the rotation speed of the refrigerant compressor is higher than the rated capacity operation.

[0009] According to the air conditioner, when the rotation speed of the refrigerant compressor is lower than the rated capacity operation, the generation of the liquid back flow to the refrigerant compressor can be prevented by correcting the set opening of the electronic expansion valve for heating in the target value correction control unit to be smaller than the rated capacity operation. On the other hand, when the rotation speed of the refrigerant compressor is higher than the rated capacity operation, the shortage of the suctioned refrigerant amount in the refrigerant compressor can be prevented by correcting the set opening of the electronic expansion valve for heating in the target value correction control unit to be larger than the rated capacity operation.

[0010] Further, in the air conditioner of the present invention, the set opening correction control unit is configured to divide the rotation speed value of the refrigerant compressor into a plurality of ranges, and a corrected opening of the set opening is previously set corresponding to each range.

[0011] According to the air conditioner, since the set opening is corrected according to the divided ranges of the rotation speed values of the refrigerant compressor, the correction is not frequently performed, and frequent changes of the opening of the electronic expansion valve for cooling according to the correction of the opening of the electronic expansion valve for heating by the target value correction control unit can be reduced.

[0012] Further, in the air conditioner of the present invention, the set opening correction control unit is configured to previously set the corrected opening of the set opening corresponding to an arbitrary rotation speed value of the refrigerant compressor.

[0013] According to the air conditioner, since the set opening is corrected corresponding to an arbitrary rotation speed value of the refrigerant compressor, the air conditioner can promptly cope with the change of the rotation speed of the refrigerant compressor.

[0014] Further, in the air conditioner of the present invention, the corrected opening set by the set opening correction control unit is within + 10% of the opening of the electronic expansion valve for heating at the time of prescribed performance measurement.

[0015] When the corrected opening according to the rotation speed value of the refrigerant compressor is too large than a proper value, the opening of the electronic expansion valve for heating becomes larger. Therefore, it is difficult to obtain an effect. On the other hand, when the corrected opening according to the rotation speed value of the refrigerant compressor is set to be smaller than or extremely close to the proper value, the correction of the supercooling degree is easily performed. Therefore, the supercooling degree is not provided, and the performance is deteriorated. Therefore, it is preferable to set the corrected opening to be the opening within + 10%, which is slightly larger than the proper opening, of the proper opening in consideration of product variation of a single component of the electronic expansion valve for heating in order to improve usefulness of the control by the set opening correction control unit.

[0016] Further, in the air conditioner of the present invention, the expansion valve control unit is configured to control the opening of the electronic expansion valve for heating so that a refrigerant superheating degree calculated based on a difference between a temperature detected by a temperature sensor in the middle of the heat source side heat exchanger and a temperature detected by a temperature sensor on an exit side of the heat source side heat exchanger becomes a target superheating degree.

[0017] The pressure saturation temperature corresponding to the detected values of the temperature sensor and the low-pressure sensor provided on the exit side of the heat source side heat exchanger at the time of heating may be detected. Also, the temperature detected by the temperature sensor in the middle of the heat source side heat exchanger which can detect a saturation temperature in a pseudo-manner can be used as a substitute.

Advantageous Effects of Invention

[0018] According to the present invention, performances can be improved by providing an appropriate supercooling degree, and operational stability can be improved.

Brief Description of Drawings

[0019]

FIG. 1 is a diagram of a refrigerant system of an air conditioner according to an embodiment of the present invention.

FIG. 2 is a diagram of a control flow by a set opening correction control unit and a target value correction control unit of the air conditioner according to the embodiment of the present invention.

FIG. 3 is a diagram of correction values of the set opening correction control unit of the air conditioner according to the embodiment of the present inven-

tion.

FIG. 4 is a conventional example of an air conditioner.

FIG. 5 is an embodiment of an air conditioner.

Description of Embodiments

[0020] Embodiment according to the present invention will be described in detail below with reference to the drawings. The present invention is not limited to the embodiment. Also, components of the embodiments below include components which can be easily switched by those skilled in the art and components which are substantially same as those of the embodiments.

[0021] FIG. 1 is a diagram of a refrigerant system of an air conditioner according to the present embodiment.

[0022] As illustrated in FIG. 1, an air conditioner 1 can select either one of a cooling cycle or a heating cycle by switching a circulating direction of a refrigerant. In the air conditioner 1, the refrigerant discharged from a refrigerant compressor 11 circulates in a closed-cycle refrigerant circuit 14 including a heat source side heat exchanger (for example, outdoor heat exchanger) 12 and a use side heat exchanger (for example, indoor heat exchanger) 13 and repeats to change its state between gas and liquid. The refrigerant circuit 14 illustrated in FIG. 1 includes a four-way valve 15 on the discharge side of the refrigerant compressor 11. The refrigerant circuit 14 can select either one of the cooling cycle or the heating cycle. In the cooling cycle (defrosting cycle), the circulating direction of the refrigerant is reversed by operating the four-way valve 15 so as to circulate the refrigerant to the use side heat exchanger 13 via the heat source side heat exchanger 12 in a clockwise direction. In the heating cycle, the refrigerant is circulated to the heat source side heat exchanger 12 via the use side heat exchanger 13 in a counterclockwise direction.

[0023] The refrigerant circuit 14 includes an electronic expansion valve for cooling (EEVC) 16, an electronic expansion valve for heating (EEVH) 17, and a receiver 18 as known in addition to the heat source side heat exchanger 12, the use side heat exchanger 13, and the four-way valve 15. The electronic expansion valve for cooling (EEVC) 16 and the electronic expansion valve for heating (EEVH) 17 are connected in series, and the receiver 18 are arranged therebetween. Also, an outside air fan 12a for flowing outer air is provided in the heat source side heat exchanger 12. The outside air fan 12a can appropriately adjust an amount of outside air to be flowed to the heat source side heat exchanger 12 (air blasting quantity).

[0024] The air conditioner 1 may use the refrigerant circuit 14 as an air heat source heat pump and may include a water system for using warm water obtained by heating water by the air heat source heat pump for hot water supply and heating. That is, heat of the refrigerant of the use side heat exchanger 13 is exchanged to heat of the warm water of the water system.

[0025] When the refrigerant circuit 14 selects the heating cycle, a low-temperature and low-pressure gas refrigerant is compressed by the refrigerant compressor 11, and the compressed gas is discharged to the refrigerant circuit 14 as a high-temperature and high-pressure gas refrigerant. As indicated by the solid arrows in FIG. 1, the gas refrigerant is supplied to the use side heat exchanger 13 by the four-way valve 15 and is circulated in the counterclockwise direction. The use side heat exchanger 13 in this case is a heat exchanger for heat-exchanging between the heat of the high-temperature and high-pressure gas refrigerant and surrounding air, and condensation heat radiated by condensation of the refrigerant functions as a condenser for heating air. As a result, the high-temperature and high-pressure gas refrigerant flowing in the refrigerant circuit 14 is condensed to be a high-temperature and high-pressure liquid refrigerant, and the surrounding air becomes warm by absorbing heat from the refrigerant.

[0026] The liquid refrigerant condensed by the use side heat exchanger 13 is introduced into the receiver 18 through the electronic expansion valve for cooling (EEVC) 16 which controls the supercooling degree of the liquid refrigerant. The receiver 18 separates the refrigerant into liquid and gas and adjusts an amount of the circulating refrigerant. The electronic expansion valve for heating (EEVH) 17 which reduces the pressure of the high-temperature and high-pressure liquid refrigerant is arranged on the downstream side of the receiver 18. The refrigerant passes through the electronic expansion valve for heating (EEVH) 17 so that the high-temperature and high-pressure liquid refrigerant is decompressed to be a low-temperature and low-pressure gas-liquid two-phase refrigerant, and the gas-liquid two-phase refrigerant is supplied to the heat source side heat exchanger 12. The gas-liquid two-phase refrigerant introduced into the heat source side heat exchanger 12 which functions as an evaporator absorbs heat from outside air by heat-exchanging with outside air and is evaporated.

[0027] A superheating degree of the refrigerant evaporated by the heat source side heat exchanger 12 is controlled by the electronic expansion valve for heating (EEVH) 17. The low-temperature and low-pressure gas refrigerant evaporated by absorbing the heat from outside air by passing through the heat source side heat exchanger 12 passes through the four-way valve 15 again and is suctioned to the refrigerant compressor 11. The low-temperature and low-pressure gas refrigerant suctioned to the refrigerant compressor 11 is compressed by the refrigerant compressor 11 again to be the high-temperature and high-pressure gas refrigerant. After that, the gas refrigerant circulates the same path and repeats to change its state between gas and liquid. At this time, it has been known that a frost formation phenomenon occurs in which the moisture in the air is frozen on the outer peripheral surface of the heat source side heat exchanger 12 with low temperature.

[0028] The frost prevents heat exchange between the

refrigerant and the outside air by the heat source side heat exchanger 12 and reduces the heat exchange efficiency. Therefore, it is necessary to remove the frost by operating a defrosting operation at an appropriate operation time interval by detecting accumulation of the frost. In the defrosting operation, the circulating direction of the refrigerant is reversed by operating the four-way valve 15 in the refrigerant circuit 14, the operation mode is switched to the cooling cycle (defrosting cycle) for circulating the refrigerant in directions of dashed arrows in FIG. 1. Then, the high-temperature and high-pressure gas refrigerant discharged from the refrigerant compressor 11 is introduced into the heat source side heat exchanger 12, and the frost on the heat source side heat exchanger 12 is melted by radiating heat (condensation heat).

[0029] When the heating operation is performed by the heating cycle in which the use side heat exchanger 13 heats water to produce warm water or to heat the air, the electronic expansion valve for cooling (EEVC) 16 is controlled via an expansion valve control unit 50 so that the supercooling degree of the refrigerant condensed by the use side heat exchanger 13 becomes a target value, and the electronic expansion valve for heating (EEVH) 17 is controlled via the expansion valve control unit 50 so that the superheating degree of the refrigerant evaporated by the heat source side heat exchanger 12 becomes a target value.

[0030] Specifically, the electronic expansion valve for cooling (EEVC) 16 is controlled via an expansion valve for cooling control unit 51 so that a pressure saturation temperature corresponding to values detected by a high-pressure sensor 40 or a refrigerant supercooling degree calculated based on a difference between a temperature detected by a second heat exchange temperature sensor 42 arranged in the middle of the use side heat exchanger 13 and a refrigerant temperature detected by a first heat exchange temperature sensor 41 on the exit side of the use side heat exchanger 13 becomes a target supercooling degree T_{sc} . Also, the electronic expansion valve for heating (EEVH) 17 is controlled via an expansion valve for heating control unit 52 so that a pressure saturation temperature corresponding to a value detected by a temperature sensor 44 and a low-pressure sensor 45 provided on the exit side of the heat source side heat exchanger 12 at the time of heating or a refrigerant superheating degree calculated based on a difference between a temperature detected by a second heat exchange temperature sensor 47 in the middle of the heat source side heat exchanger 12 and a temperature detected by the temperature sensor 44 on the exit side of the heat source side heat exchanger 12 becomes a target superheating degree T_{sh} .

[0031] In the expansion valve control unit 50, a target value correction control unit 53 is provided to control the electronic expansion valve for cooling (EEVC) 16 and the electronic expansion valve for heating (EEVH) 17 in an appropriate operation area by gradually decreasing

the target supercooling degree T_{sc} of the electronic expansion valve for cooling (EEVC) 16 when the opening of the electronic expansion valve for heating (EEVH) 17 is equal to or larger than the set opening. The target value correction control unit 53 prevents the opening of the electronic expansion valve for heating (EEVH) 17 for controlling the superheating degree from being too large than a proper opening when the opening of the electronic expansion valve for cooling (EEVC) 16 becomes too small by the supercooling degree control. The target value correction control unit 53 is operated when the opening of the electronic expansion valve for heating (EEVH) 17 becomes equal to or larger than an opening which has been previously set by the superheating degree control.

[0032] Especially, in the air conditioner 1 in which a piping length of the refrigerant circuit 14 exceeds, for example, 30 m and the capacity of the receiver 18 is limited and the refrigerant amount lacks at the time of the heating operation, when the supercooling degree and the suctioned superheating degree are controlled in a state where the electronic expansion valve for cooling (EEVC) 16 and the electronic expansion valve for heating (EEVH) 17 are completely independent of each other, the air conditioner 1 is often operated in a state where the electronic expansion valve for cooling (EEVC) 16 is tend to be restricted and the electronic expansion valve for heating (EEVH) 17 is tend to be opened. When the rotation speed of the refrigerant compressor 11 is lowered from the above state, a close operation of the electronic expansion valve for heating (EEVH) 17 is too late, and there is a high possibility that the liquid back flow to the refrigerant compressor 11 and the oil shortage occur. In such an air conditioner 1, by correcting the set opening of the electronic expansion valve for heating (EEVH) 17 according to the rotation speed of the refrigerant compressor 11 and setting a threshold, the air conditioner 1 can be operated as properly opening the electronic expansion valve for heating (EEVH) 17 even when the rotation speed is low. Even when the rotation speed of the refrigerant compressor 11 is changed due to load variation after that, a risk of failure of the refrigerant compressor 11 can be reduced by preventing a liquid back flow and oil shortage. Therefore, reliability of the air conditioner 1 is improved. Also, since the operation is performed without stopping the control of the target value correction control unit 53, the performance and efficiency are improved while the reliability is secured.

[0033] The target value correction control unit 53 according to the present embodiment performs correction control when the opening of the electronic expansion valve for heating (EEVH) 17 becomes a set opening corresponding to the rotation speed of the compressor.

[0034] The target value correction control unit 53 sets a correction value ΔT_{sc} of the target supercooling degree T_{sc} . The correction value ΔT_{sc} is set as follows so as to be added or subtracted according to the correction value ΔT_{sc} and the opening of the electronic expansion valve for heating (EEVH) 17.

[Execution Condition]

[0035]

(1) In a case of $\Delta T_{sc} = 0$, a value -1 is added to the value ΔT_{sc} at the time when "EEVH $\geq$ set opening corresponding to the rotation speed of the compressor" is satisfied.

(2) In a case of $\Delta T_{sc} \neq 0$, a sampling time is set to be, for example, five minutes and the opening of the EEVH is confirmed. When the condition "EEVH $\geq$ set opening corresponding to the rotation speed of the compressor" continues for five minutes, a value -1 is further added.

[0036] Regarding the value ΔT_{sc} , the minimum value of integration is determined. In a case where the value reaches the minimum value, further subtraction is not applied even when the execution condition is satisfied.

[Canceling Condition]

[0037] In a case where the sampling time is set to be, for example, five minutes and the condition "EEVH $<$ set opening corresponding to the rotation speed of the compressor" continues for five minutes, a value + 1 is added to the value ΔT_{sc} . This operation is repeated.

[0038] Regarding the value ΔT_{sc} , the maximum value of the integration is assumed to be zero. In a case where the value reaches the maximum value, further addition is not applied even when the canceling condition is satisfied.

[0039] That is, when the opening of the electronic expansion valve for heating (EEVH) 17 exceeds the set opening corresponding to the rotation speed of the compressor, the target value correction control unit 53 corrects the target supercooling degree T_{sc} as described above and corrects and controls the supercooling degree at the exit of the use side heat exchanger 13 by autonomously increasing the opening of the electronic expansion valve for cooling (EEVC) 16.

[0040] Also, in the expansion valve control unit 50, a set opening correction control unit 54 is provided which corrects the set opening of the electronic expansion valve for heating (EEVH) 17 in the target value correction control unit 53 according to the rotation speed of the refrigerant compressor 11 detected by a rotation speed detecting unit 46 of the refrigerant compressor 11. The set opening correction control unit 54 prevents a liquid back flow to the refrigerant compressor 11 when the rotation speed of the refrigerant compressor 11 changes. The set opening correction control unit 54 is operated according to the rotation speed of the refrigerant compressor 11. It is considered that a rotation sensor provided in a rotation shaft of the refrigerant compressor 11 and an inverter output are used as the rotation speed detecting unit 46.

[0041] FIG. 2 is a diagram of a control flow by the set opening correction control unit and the target value cor-

rection control unit of the air conditioner according to the present embodiment. FIG. 3 is a diagram of correction values of the set opening correction control unit of the air conditioner according to the present embodiment.

[0042] As illustrated in FIG. 2, the set opening correction control unit 54 sets a threshold (ΔT_{sc} correction start EEVH opening threshold A [pulse]) used for correcting the set opening of the electronic expansion valve for heating (EEVH) 17 according to the rotation speed value of the compressor in steps S1 and S2-1 to S2-4.

[0043] As illustrated in FIG. 3, the set opening correction control unit 54 according to the present embodiment divides the rotation speed value of the refrigerant compressor 11 into a plurality of ranges of a to d, and the threshold of the opening of the electronic expansion valve for heating (EEVH) 17 is previously set corresponding to each divided range. Specifically, as illustrated in FIG. 3, the rotation speed value of the refrigerant compressor 11 is divided into four ranges: equal to or higher than 11 rps and lower than 40 rps (a: 11 to 40); equal to or higher than 40 rps and lower than 60 rps (b: 40 to 60); equal to or higher than 60 rps and lower than 100 rps (c: 60 to 100); and equal to or higher than 100 rps (d: 100 or higher). The threshold of the opening of the electronic expansion valve for heating (EEVH) 17 corresponds to each divided range and is set to be four values relative to a full opening 500 pulse. The four thresholds include 100 pulse (A: 100), 200 pulse (B: 200), 300 pulse (C: 300), and 350 pulse (D: 350). For example, the range of 60 rps or higher to lower than 100 rps (c: 60 to 100) is a range of the rotation speed in the rated capacity operation of the refrigerant compressor 11. In this range, the threshold of the opening of the electronic expansion valve for heating (EEVH) 17 is assumed to be 300 pulse. In the range of 11 rps or higher to lower than 40 rps (a: 11 to 40), the refrigerant compressor 11 is operated at the minimum rotation speed which is 25 % of the rated capacity when the outdoor temperature is 7°C. In the range of 40 rps or higher to lower than 60 rps (b: 40 to 60), the refrigerant compressor 11 is operated at the middle rotation speed which is 50% of the rated capacity when the outdoor temperature is 7°C. In the range of 100 rps or higher (d: 100 or higher), the refrigerant compressor 11 is operated at the maximum rotation speed when the outdoor temperature is 2°C. The range of the rotation speed value of the refrigerant compressor 11 is not limited to the above and is appropriately set according to the rotation speed of the rated capacity operation of the refrigerant compressor 11. Also, the number of divided ranges of the rotation speed value of the refrigerant compressor 11 is not limited to the above. The rotation speed value may be subdivided. Also, the corrected opening may be set in a linear manner corresponding to an arbitrary rotation speed value of the refrigerant compressor 11 without dividing the range of the rotation speed value of the refrigerant compressor 11.

[0044] That is, the set opening correction control unit 54 corrects and controls the set opening of the electronic

expansion valve for heating (EEVH) 17 in the target value correction control unit 53 to be small when the rotation speed of the refrigerant compressor 11 is low. On the other hand, the set opening correction control unit 54 corrects and controls the set opening of the electronic expansion valve for heating (EEVH) 17 in the target value correction control unit 53 to be large when the rotation speed of the refrigerant compressor 11 is high.

[0045] Subsequently, as illustrated in FIG. 2, when it is determined in step S3 that the opening of the electronic expansion valve for heating (EEVH) 17 is "EEVH $\geq$ A opening", the procedure proceeds to step S4. The target value correction control unit 53 determines the correction value ΔT_{sc} in step S4. In a case of " $\Delta T_{sc} = 0$ " in step S4, the procedure proceeds to step S5. Then, the procedure returns to the first step (step S1) after adding -1 to ΔT_{sc} . Also, in a case of "minimum value $< \Delta T_{sc} < 0$ " when the ΔT_{sc} is between zero and the minimum value, the procedure proceeds to step S6, and it is determined whether the condition "EEVH $\geq$ A" continues for five minutes. When the result is Yes, the procedure proceeds to step S5, and then, the procedure returns to the top after adding -1 to ΔT_{sc} as described above. When the result is No, the procedure returns to the top.

[0046] In addition, when it is determined in step S4 that ΔT_{sc} is equal to or less than the minimum value, the procedure proceeds to step S7 and returns to the top without applying further subtraction. In this way, when the opening is "EEVH $\geq$ A", the opening of the electronic expansion valve for cooling (EEVC) 16 is autonomously increased by correcting the target supercooling degree Tsc by gradually subtracting one from the correction value ΔT_{sc} at a time to the minimum value according to the opening.

[0047] On the other hand, when it is determined in step S3 that the opening of the electronic expansion valve for heating (EEVH) 17 is "EEVH $<$ A", the procedure proceeds to step S8, and the correction value ΔT_{sc} is determined. When the condition " $\Delta T_{sc} = 0$ " is satisfied in step S3, the procedure returns to the top. When the condition " $\Delta T_{sc} < 0$ " is satisfied, the procedure proceeds to step S9. It is determined in step S9 whether "EEVH $<$ A" has been continued for five minutes. In a case of Yes, the procedure proceeds to step S10, and the value + 1 is added to ΔT_{sc} . Then, the procedure returns to the top. In a case of No, the procedure proceeds to step S11, and the procedure returns to the top without applying further addition. In this way, when the opening of the electronic expansion valve for heating (EEVH) 17 is less than A, the correction value ΔT_{sc} is returned to the initial value of zero, and the target supercooling degree Tsc is set to be a normal value.

[0048] FIG. 4 is a diagram of a conventional example of the air conditioner. FIG. 5 is a diagram of an embodiment of the air conditioner. As illustrated in FIG. 4, in the conventional example which does not perform the above control, the opening of the electronic expansion valve for cooling (EEVC) 16 is made to be small to have a large

supercooling degree (1). According to (1), the electronic expansion valve for heating (EEVH) 17 is opened (2). When the rotation speed of the refrigerant compressor 11 is reduced due to the load variation in this state (3), an operation to decrease the opening takes time because the opening of the electronic expansion valve for heating (EEVH) 17 is large (4). Then, a liquid back flow occurs, and a compressor oil temperature is excessively lowered (5). On the other hand, in the air conditioner 1 according to the embodiment for performing the above control, since the opening of the electronic expansion valve for heating (EEVH) 17 exceeds the threshold, the supercooling degree is corrected and the electronic expansion valve for cooling (EEVC) 16 is not closed (11). According to (11), the electronic expansion valve for heating (EEVH) 17 maintains the proper opening (12). Even when the rotation speed of the refrigerant compressor 11 is reduced due to the load variation in this state (13), the opening of the electronic expansion valve for heating (EEVH) 17 can follow the above change, it does not take to perform the operation to make the opening be small (14). Therefore, the liquid back flow does not occur, and the compressor oil temperature is not significantly lowered (15).

[0049] In this way, according to the air conditioner 1 of the present embodiment, when the rotation speed of the refrigerant compressor 11 is changed, the set opening of the electronic expansion valve for heating (EEVH) 17 is corrected by correcting the set opening of the electronic expansion valve for heating (EEVH) 17 in the target value correction control unit 53 according to the rotation speed of the refrigerant compressor 11 by the set opening correction control unit 54.

[0050] Accordingly, in the air conditioner 1, when the rotation speed of the refrigerant compressor 11 is changed, generation of the liquid back flow to the refrigerant compressor 11 caused by excessively opening the opening of the electronic expansion valve for heating (EEVH) 17 and generation of shortage of the suctioned refrigerant amount in the refrigerant compressor 11 caused by excessively restricting the opening of the electronic expansion valve for heating (EEVH) 17 can be prevented. In the above air conditioner 1, the superheating degree and the supercooling degree are independently controlled, and the target supercooling degree Tsc of the electronic expansion valve for cooling (EEVC) 16 is changed according to the set opening of the electronic expansion valve for heating (EEVH) 17 by the target value correction control unit 53. As a result, the stability of the operation can be improved.

[0051] Also, in the air conditioner 1 according to the present embodiment, the set opening correction control unit 54 corrects the set opening of the electronic expansion valve for heating (EEVH) 17 in the target value correction control unit 53 to be smaller than the rated capacity operation when the rotation speed of the refrigerant compressor 11 is lower than the rated capacity operation. On the other hand, the set opening correction

control unit 54 corrects the set opening of the electronic expansion valve for heating (EEVH) 17 in the target value correction control unit 53 to be larger than the rated capacity operation when the rotation speed of the refrigerant compressor 11 is higher than the rated capacity operation.

[0052] According to the air conditioner 1, when the rotation speed of the refrigerant compressor 11 is lower than the rated capacity operation, the electronic expansion valve for cooling (EEVC) 16 is opened before the electronic expansion valve for heating (EEVH) 17 is opened too large, and the refrigerant is supplied to the downstream side, and the suction superheating degree of the compressor can be controlled by the appropriate opening of the electronic expansion valve for heating (EEVH) 17, by correcting the set opening of the electronic expansion valve for heating (EEVH) 17 in the target value correction control unit 53 to be smaller than the rated capacity operation. Therefore, when the rotation speed of the compressor is changed due to the load variation, the generation of the liquid back flow to the refrigerant compressor 11 can be prevented. On the other hand, when the rotation speed of the refrigerant compressor 11 is higher than the rated capacity operation, the supercooling degree Tsc at a high load can be appropriately provided by correcting the set opening of the electronic expansion valve for heating (EEVH) 17 in the target value correction control unit 53 to be larger than the rated capacity operation.

[0053] Also, in the air conditioner 1 according to the present embodiment, it is preferable that the set opening correction control unit 54 divide the rotation speed value of the refrigerant compressor 11 into a plurality of ranges and the threshold of the correction be previously set corresponding to each range.

[0054] According to the air conditioner 1, since the set opening is corrected according to the range of the divided rotation speed value of the refrigerant compressor 11, the correction is not frequently performed, and frequent changes of the opening of the electronic expansion valve for cooling (EEVC) 16 according to the correction of the opening of the electronic expansion valve for heating (EEVH) 17 by the target value correction control unit 53 can be reduced.

[0055] In the air conditioner 1 according to the present embodiment, the set opening correction control unit 54 may previously set the corrected opening of the set opening corresponding to an arbitrary rotation speed value of the refrigerant compressor 11.

[0056] According to the air conditioner 1, since the set opening is corrected corresponding to an arbitrary rotation speed value of the refrigerant compressor 11, the air conditioner 1 can promptly cope with the change of the rotation speed of the refrigerant compressor 11.

[0057] In the air conditioner 1 according to the present embodiment, the corrected opening set by the set opening correction control unit 54 may be within + 10% of the opening of the electronic expansion valve for heating

(EEVH) 17 at the time of prescribed performance measurement.

[0058] The above prescription is the JIS B8616:2015 standard. When the corrected opening (ΔT_{sc} correction start EEVH opening threshold A [pulse]) according to the rotation speed value of the refrigerant compressor 11 is too large than a proper value, the opening of the electronic expansion valve for heating (EEVH) 17 becomes larger. As a result, it is difficult to obtain an effect. On the other hand, when the corrected opening according to the rotation speed value of the refrigerant compressor 11 is set to be smaller than or extremely close to the proper value, the correction of the supercooling degree Tsc is easily performed. Therefore, the supercooling degree is not provided, and the performance is deteriorated. Therefore, the corrected opening is set to be within + 10% of the proper opening in consideration of product variation of a single component of the electronic expansion valve for heating (EEVH) 17 so as to improve usefulness of the control by the set opening correction control unit 54. Each condition (rated heating standard capacity test, middle heating standard capacity test, minimum heating standard capacity test, and maximum heating low-temperature capacity test) includes a single rotation speed of the compressor at the time of measuring the performance. Therefore, corrected opening (ΔT_{sc} correction start EEVH opening threshold A [pulse]) in the range of the rotation speed value including the rotation speed value of the refrigerant compressor 11 at each capacity measuring condition relative to not only the time of measuring the performance but also the range of the rotation speed including the same may be within + 10% of the opening of the electronic expansion valve for heating (EEVH) 17 at the time of measuring each performance. In addition, when the corrected opening (ΔT_{sc} correction start EEVH opening threshold A [pulse]) is changed in a linear manner corresponding to an arbitrary rotation speed value of the refrigerant compressor 11, the opening of the electronic expansion valve for heating (EEVH) 17 at an arbitrary rotation speed value of the refrigerant compressor 11 under the respective performance measuring condition is interpolated. The corrected opening (ΔT_{sc} correction start EEVH opening threshold A [pulse]) may be within + 10% of the opening interpolation line of the electronic expansion valve for heating (EEVH) 17.

[0059] In the air conditioner 1 according to the present embodiment, the expansion valve for heating control unit 52 of the expansion valve control unit 50 may control the opening of the electronic expansion valve for heating (EEVH) 17 so that the refrigerant superheating degree calculated based on the difference between the temperature detected by the second heat exchange temperature sensor 47 in the middle of the heat source side heat exchanger 12 and the temperature detected by the temperature sensor 44 on the exit side of the heat source side heat exchanger 12 becomes the target superheating degree Tsh.

[0060] The pressure saturation temperature corre-

sponding to the detected values of the temperature sensor 44 and the low-pressure sensor 45 provided on the exit side of the heat source side heat exchanger 12 at the time of heating may be detected. Also, the temperature detected by the second heat exchange temperature sensor 47 in the middle of the heat source side heat exchanger 12 which can detect a saturation temperature in a pseudo-manner can be used as a substitute.

[0061] In the present embodiment, the used refrigerant may be R410A which has been traditionally used. However, R32 may be used. A discharge temperature of R32 is more easily increased than R410A. When the rotation speed value of the refrigerant compressor 11 is increased, the refrigerant compressor 11 is operated while suctioning overheated refrigerant gas, and there is a possibility that the usage limit is exceeded. Since the air conditioner 1 according to the present embodiment can control the refrigerant so as not to excessively increase the discharge temperature, the air conditioner 1 according to the present embodiment is suitable for using R32.

Reference Signs List

[0062]

1 AIR CONDITIONER

- 11 REFRIGERANT COMPRESSOR
- 12 HEAT SOURCE SIDE HEAT EXCHANGER
- 13 USE SIDE HEAT EXCHANGER
- 14 REFRIGERANT CIRCUIT
- 16 ELECTRONIC EXPANSION VALVE FOR COOLING
- 17 ELECTRONIC EXPANSION VALVE FOR HEATING
- 50 EXPANSION VALVE CONTROL UNIT
- 53 TARGET VALUE CORRECTION CONTROL UNIT
- 54 SET OPENING CORRECTION CONTROL UNIT

Claims

1. An air conditioner (1) comprising:

a refrigerant circuit (14) which includes a refrigerant compressor (11), a heat source side heat exchanger (12), an electronic expansion valve for heating, (17) an electronic expansion valve for cooling (16), and a use side heat exchanger (13); and
an expansion valve control unit (50) configured to control a refrigerant superheating degree of an exit of the heat source side heat exchanger (12) by the electronic expansion valve for heating (17) and to control a refrigerant supercooling degree of an exit of the use side heat exchanger (13) by the electronic expansion valve for cool-

ing (16) at the time of a heating cycle for heating an use side with a refrigerant by the use side heat exchanger (13), wherein
the expansion valve control unit (50) includes:

a target value correction control unit (53) which is configured to gradually lower a target supercooling degree of the electronic expansion valve for cooling (16) when an opening of the electronic expansion valve for heating (17) becomes equal to or larger than a set opening; and
a set opening correction control unit (54) which is configured to correct the set opening of the electronic expansion valve for heating (17) in the target value correction control unit according to a rotation speed of the refrigerant compressor (11).

2. The air conditioner (1) according to claim 1, wherein the set opening correction control unit (54) is configured to correct the set opening of the electronic expansion valve for heating (17) in the target value correction control unit to be smaller than a rated capacity operation when the rotation speed of the refrigerant compressor (11) is lower than the rated capacity operation and to correct the set opening of the electronic expansion valve for heating (17) in the target value correction control unit to be larger than the rated capacity operation when the rotation speed of the refrigerant compressor (11) is higher than the rated capacity operation.

3. The air conditioner (1) according to claim 1 or 2, wherein the set opening correction control unit (54) is configured to divide the rotation speed value of the refrigerant compressor (11) into a plurality of ranges, and a corrected opening of the set opening is previously set corresponding to each range.

4. The air conditioner according to claim 1 or 2, wherein the set opening correction control unit (54) is configured to previously set the corrected opening of the set opening corresponding to an arbitrary rotation speed value of the refrigerant compressor (11).

5. The air conditioner (1) according to any one of claims 1 to 4, wherein the corrected opening set by the set opening correction control unit (54) is within + 10% of the opening of the electronic expansion valve for heating (17) at the time of prescribed performance measurement.

6. The air conditioner (1) according to any one of claims 1 to 5, wherein the expansion valve control unit (50) is configured to control the opening of the electronic expansion

valve for heating (17) so that a refrigerant superheating degree calculated based on a difference between a temperature detected by a temperature sensor in the middle of the heat source side heat exchanger (12) and a temperature detected by a temperature sensor on an exit side of the heat source side heat exchanger (12) becomes a target superheating degree.

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FIG.1

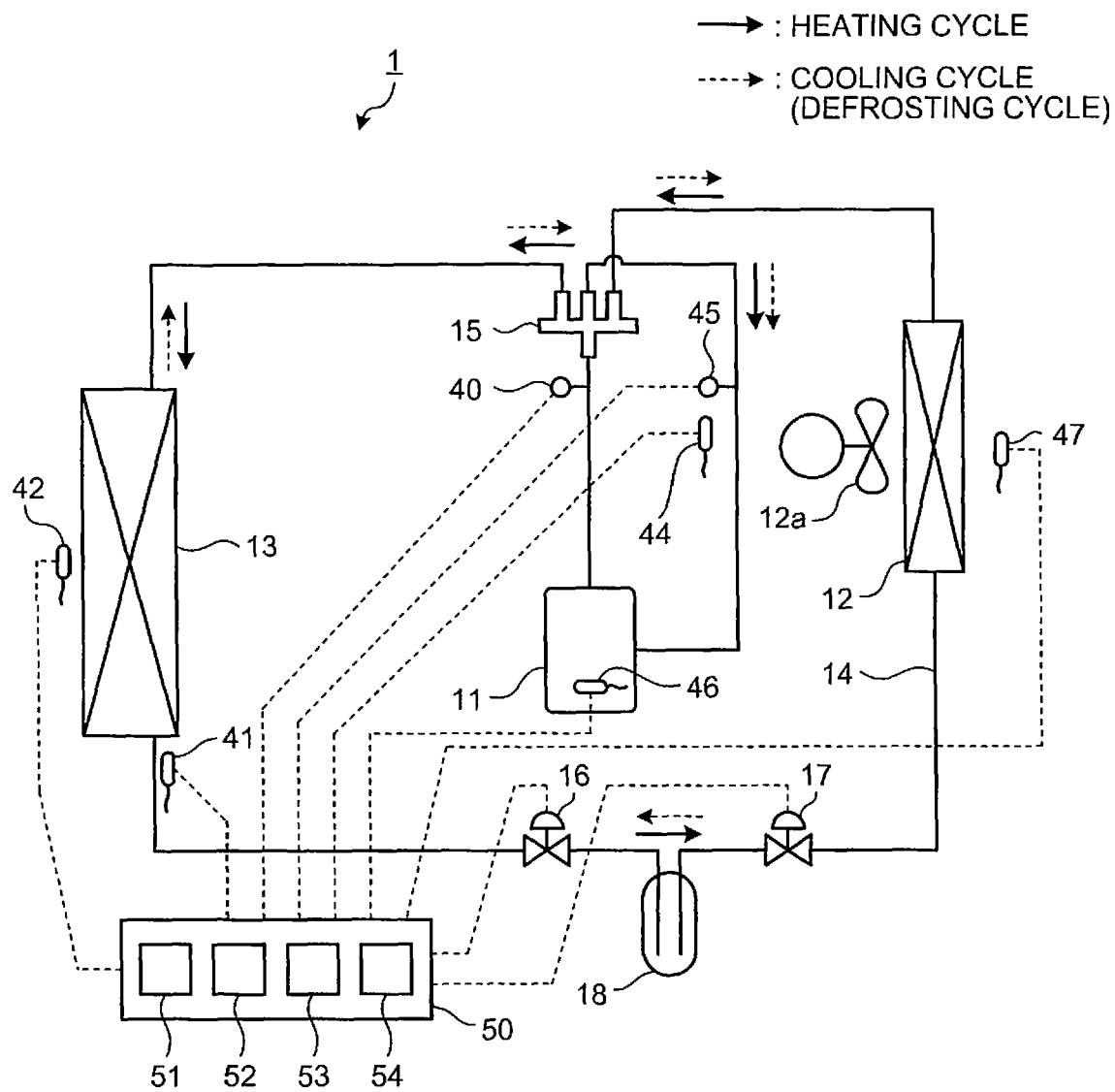


FIG.2

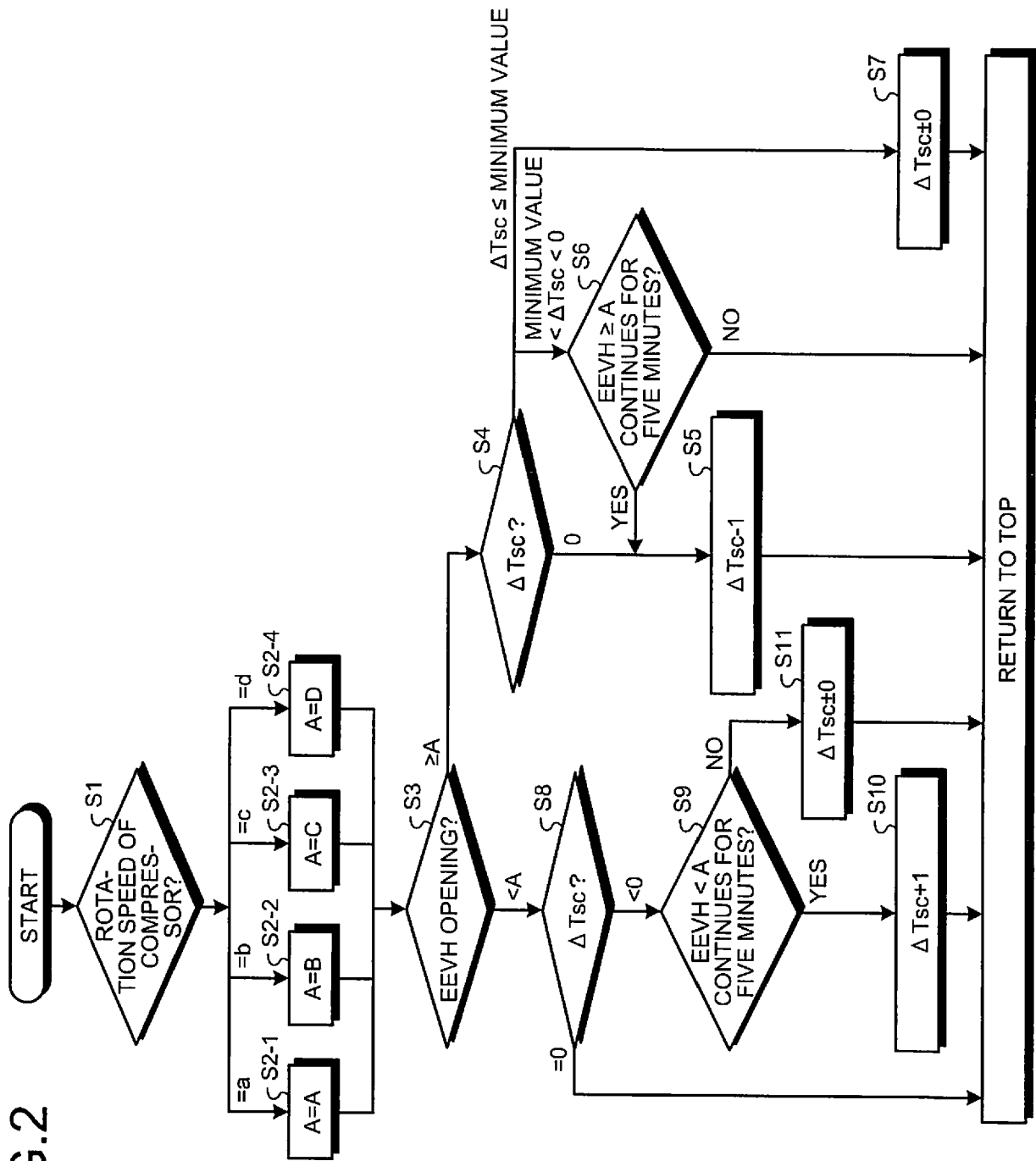


FIG.3

ROTATION SPEED VALUE OF COMPRESSOR [rps]	ΔT_{sc} CORRECTION START EEVH OPENING THRESHOLD A [PULSE]
a: 11-40	A: 100
b: 40-60	B: 200
c: 60-100	C: 300
d: 100-	D: 400

FIG.4

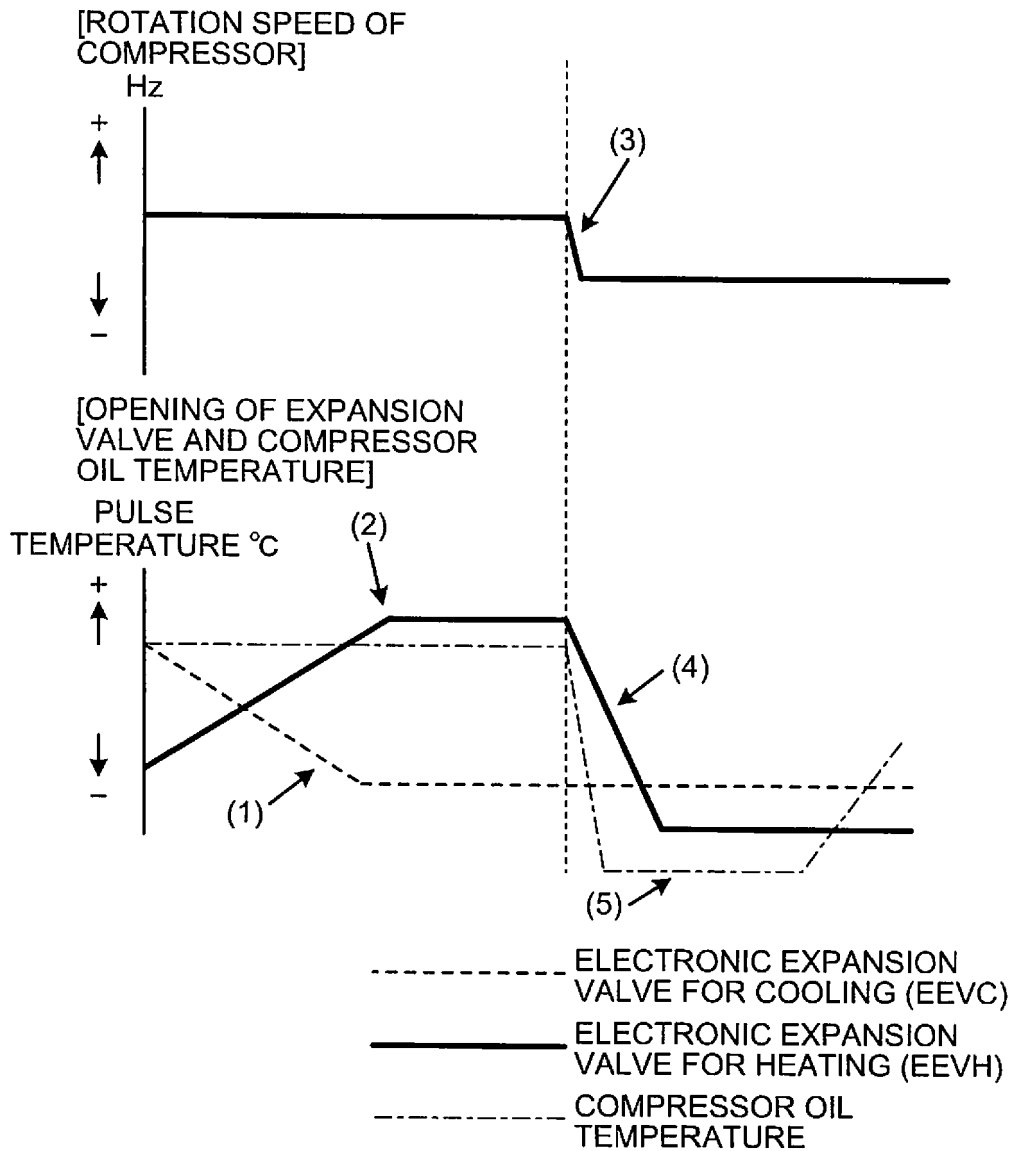
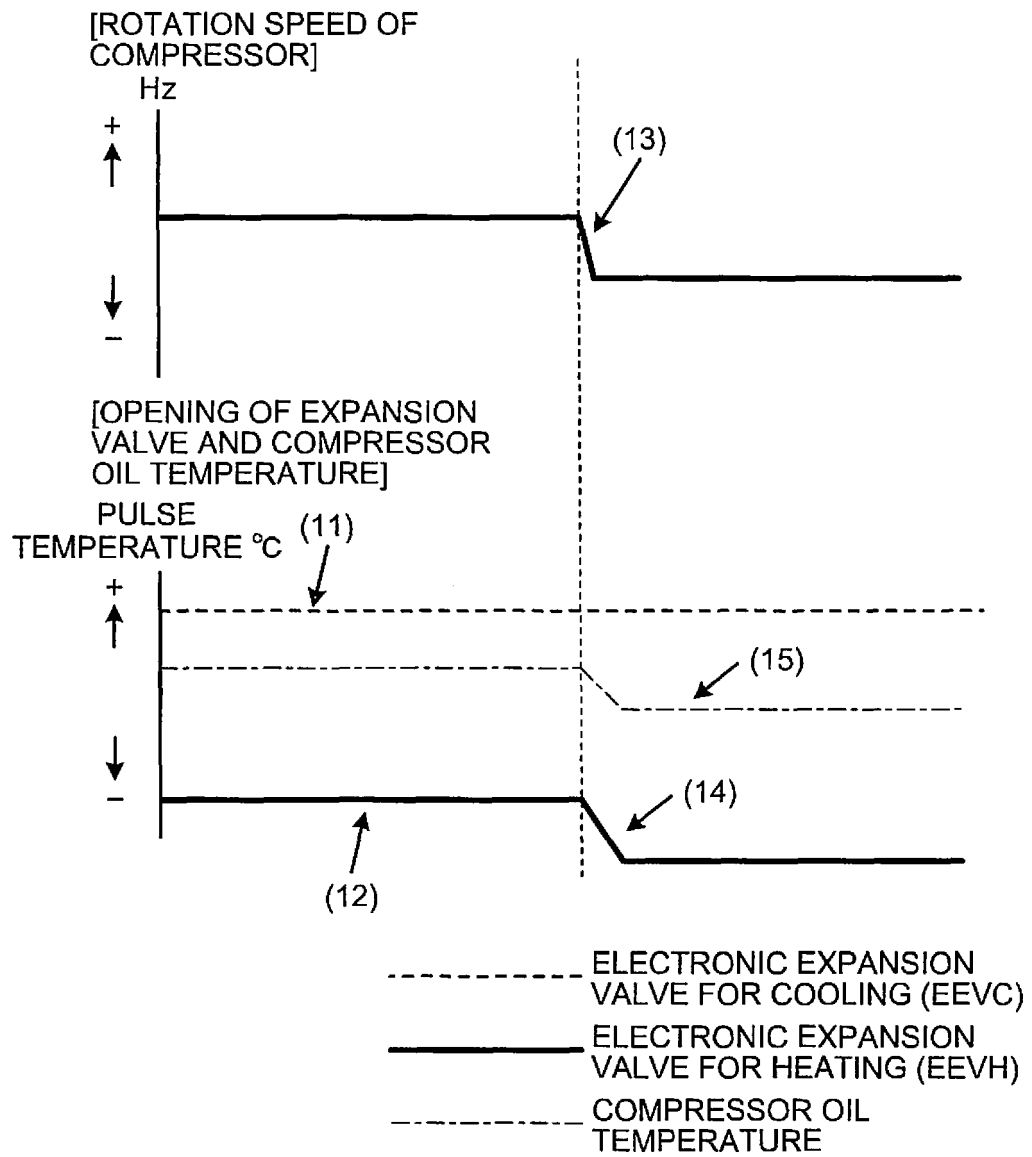


FIG.5





EUROPEAN SEARCH REPORT

 Application Number
 EP 17 15 2946

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	JP 2011 252622 A (MITSUBISHI HEAVY IND LTD) 15 December 2011 (2011-12-15) * paragraphs [0019] - [0022], [0030] - [0033]; figures 1,2 *	1-6	INV. F25B13/00 F25B49/02
Y	JP 2005 291553 A (MITSUBISHI HEAVY IND LTD) 20 October 2005 (2005-10-20) * paragraph [0007] - paragraph [0020]; figure 1 *	1-6	
A	EP 2 532 992 A1 (MITSUBISHI HEAVY IND LTD [JP]) 12 December 2012 (2012-12-12) * paragraph [0019] - paragraph [0034]; figure 1 *	1-6	
			TECHNICAL FIELDS SEARCHED (IPC)
			F25B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 18 May 2017	Examiner Amous, Moez
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			

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 EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 15 2946

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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18-05-2017

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2011252622 A	15-12-2011	JP 5601885 B2	08-10-2014
		JP 2011252622 A	15-12-2011

JP 2005291553 A	20-10-2005	NONE	

EP 2532992 A1	12-12-2012	EP 2532992 A1	12-12-2012
		JP 5797022 B2	21-10-2015
		JP 2012255599 A	27-12-2012

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- JP 2011252622 A [0003]