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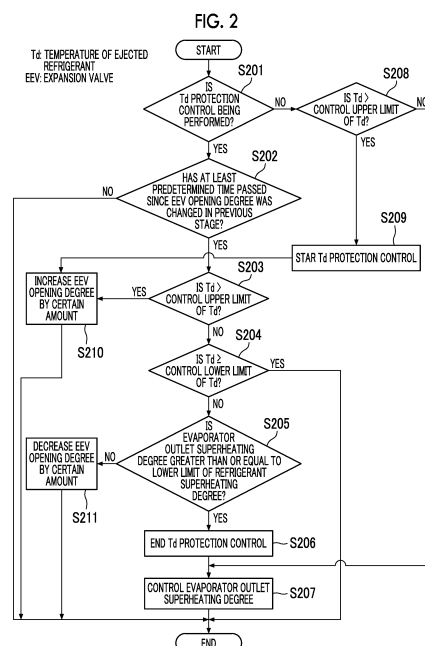
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(54) **CONTROL DEVICE OF FREEZER, FREEZER, METHOD FOR CONTROLLING FREEZER, AND PROGRAM FOR CONTROLLING FREEZER**

(57) The purpose of the present invention is to provide a control device of a freezer, a freezer, a method for controlling the freezer, and a program for controlling the freezer, in which the temperature of an ejected refrigerant can be preserved while suppressing performance degradation. Provided is a control device (10) of a freezer that comprises: a compressor (2) for compressing a refrigerant; a condenser (3) for condensing the compressed refrigerant; an expansion valve (5) for expanding a liquid refrigerant, the opening degree of the expansion valve being controlled by means of an evaporator outlet superheating degree control that controls the superheating degree of the refrigerant at an outlet of the evaporator (6) to a value within a first predetermined range; and the evaporator (6) for evaporating the refrigerant. When the temperature of the ejected refrigerant exceeds a first threshold, the evaporator outlet superheating degree control is stopped, and the opening degree of the expansion valve (5) is controlled to increase by means of an ejected refrigerant temperature protection control that controls the temperature of the ejected refrigerant to a value within a second predetermined range. When the temperature of the ejected refrigerant is below a second threshold lower than the first threshold, and the superheating degree of the refrigerant at the outlet of the evaporator (6) is greater than or equal to a third threshold, the

ejected refrigerant temperature protection control is stopped, and the opening degree of the expansion valve (5) is controlled by means of the evaporator outlet superheating degree control.



Description

Technical Field

[0001] The present invention relates to a control device of a chiller, a chiller, a method for controlling a chiller, and a program for controlling a chiller.

Background Art

[0002] It is known that a chiller has a larger pressure ratio between a low pressure and a high pressure during operation, as compared with an air conditioner. In an operation with a high pressure ratio (high pressure ratio operation) like a chiller, the discharged-refrigerant temperature of the compressor is likely to rise. Under operating conditions in which the discharged-refrigerant temperature of the compressor exceeds the allowable temperature of the compressor, a protective operation of lowering the discharged-refrigerant temperature is required.

[0003] For example, as a protection method for lowering the discharged-refrigerant temperature (a discharged-refrigerant temperature protection method), a method of lowering the number of revolutions of the compressor to reduce the pressure ratio, or a method of by-

passing part of the liquid refrigerant to the suction side of the compressor to cool the compressor is used.

[0004] PTL 1 discloses that the opening degree of the expansion valve is controlled to increase until the discharged-refrigerant temperature of the compressor reaches the target discharge temperature.

[0005] PTL 2 discloses that the opening degree of the expansion valve is increased to increase the refrigerant flow rate when the degree of superheat of the refrigerant is high, and the operation for recovering the refrigerant is ended when the discharged refrigerant temperature reaches a predetermined set value.

Citation List

Patent Literature

[0006]

[PTL 1] International Publication No. 2015/174054
[PTL 2] Japanese Patent Laid-Open No. 2000-39237

Summary of Invention

Technical Problem

[0007] However, the inventions for lowering the number of revolutions of the compressor and the invention for bypassing the liquid refrigerant disclosed above have a problem that the refrigerating capacity is significantly reduced.

[0008] In particular, when the liquid refrigerant is by-

passed, the liquid refrigerant is returned to the compressor, so that the oil in the compressor is diluted and the lubricity may be affected. Further, in the invention disclosed above, since the liquid return amount changes due to the pressure difference between the low pressure and the high pressure, it is difficult to normally control the optimum liquid return amount.

[0009] The invention disclosed in PTL 1 does not disclose the condition for ending the expansion valve opening control, and it is difficult to control the chiller only by the invention disclosed in PTL 1.

[0010] The invention disclosed in PTL 2 is not an invention intended to protect the discharged-refrigerant temperature of the compressor, but an invention that increases the refrigerant by adding the superheating degree and takes out excess refrigerant stored in the accumulator.

[0011] The inventions disclosed in PTLs 1 and 2 are both inventions in an air conditioner. The chiller is operated such that the pressure ratio between the low pressure and the high pressure is larger than that of the air conditioner. The control of the air conditioner cannot be directly applied to the control of the chiller. It is difficult to apply the inventions disclosed in PTLs 1 and 2 to the control of the chiller.

[0012] The present invention has been made in view of the above circumstances, and the purpose is to provide a control device of a chiller, a chiller, a method for controlling the chiller, and a program for controlling the chiller, in which the discharged-refrigerant temperature can be preserved while suppressing capacity degradation.

Solution to Problem

[0013] In order to solve the above problems, the following means are adopted in the control device of a chiller, the chiller, the method for controlling the chiller, and the program for controlling the chiller of the present disclosure.

[0014] A control device of a chiller according to an aspect of some embodiments of the present disclosure includes a compressor that compresses a refrigerant; a condenser that condenses the refrigerant compressed by the compressor; an expansion valve that expands a liquid refrigerant introduced from the condenser, an opening degree of the expansion valve being controlled by using an evaporator outlet superheating degree control that controls a superheating degree of the refrigerant at an outlet of an evaporator to a value within a first predetermined range; and the evaporator that evaporates the refrigerant introduced from the expansion valve, wherein when a discharged-refrigerant temperature of the compressor exceeds a first threshold, the evaporator outlet superheating degree control is stopped, and the opening degree of the expansion valve is controlled to increase by using a discharged-refrigerant temperature protection control that controls the discharged-refrigerant temperature to a value within a second predetermined

range, and when the discharged-refrigerant temperature of the compressor is below a second threshold lower than the first threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is equal to or greater than a third threshold, the discharged-refrigerant temperature protection control is stopped, and the opening degree of the expansion valve is controlled by using the evaporator outlet superheating degree control.

[0015] According to the present disclosure, the discharged-refrigerant temperature is controlled to be equal to or lower than the first threshold, so that the compressor can be continuously operated without being substantially stopped.

[0016] Since the refrigerant thermal energy of the refrigerant excessively supplied to the evaporator is recovered, the reduction in the refrigerating capacity can be suppressed to an extremely small level.

[0017] Since the compressor can maintain the refrigerant gas suction, the liquid refrigerant is not sucked and the oil is not diluted, so that the lubricity of the compressor is not affected.

[0018] Since the refrigerant flow rate can be finely controlled by using the expansion valve, the refrigerant flow rate can be controlled by using the minimum liquid return amount required to maintain the discharged-refrigerant temperature to be equal to or lower than the first threshold, and thus stable operation is possible.

[0019] According to the present disclosure, when the discharged-refrigerant temperature of the compressor is below the second threshold that is smaller than the first threshold, and the refrigerant superheating degree at the outlet of the evaporator is equal to or greater than the third threshold, the temperature protection control of the discharged refrigerant is stopped, and the opening degree of the expansion valve is controlled by the evaporator outlet superheating degree control. Thus, after checking that the refrigerant superheating degree at the outlet of the evaporator is ensured, the discharged-refrigerant temperature protection control is ended and the control is shifted to the normal evaporator outlet superheating degree control, and the discharged-refrigerant temperature of the compressor which has fallen too low by the discharged-refrigerant temperature protection control can be raised.

[0020] Since the condition for ending the discharged-refrigerant temperature protection control is clear, the control can be ended correctly.

[0021] In the above aspect, when the discharged-refrigerant temperature of the compressor is a value below the second threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is a value below the third threshold, the discharged-refrigerant temperature protection control is stopped, and the opening degree of the expansion valve may be controlled to decrease by using the evaporator outlet superheating degree control.

[0022] According to the present disclosure, when the discharged-refrigerant temperature of the compressor is

a value below the second threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is a value below the third threshold, the discharged-refrigerant temperature protection control is stopped, and the opening degree of the expansion valve may be controlled to decrease by using the evaporator outlet superheating degree control. By the discharged-refrigerant temperature protection control, the discharged-refrigerant temperature of the compressor is lowered and is below the lower limit of the value at which the refrigerant superheating degree at the outlet of the evaporator is to be ensured, liquid back may occur in the compressor. According to the present disclosure, since the opening degree of the expansion valve is controlled to decrease, it is possible to increase the refrigerant superheating degree at the outlet of the evaporator and further increase the discharged-refrigerant temperature of the compressor.

[0023] In the above aspect, when the discharged-refrigerant temperature of the compressor is a value equal to or greater than the second threshold and equal to or lower than the first threshold, the opening degree of the expansion valve may be controlled to be maintained by the discharged-refrigerant temperature protection control.

[0024] According to the present disclosure, when the discharged-refrigerant temperature of the compressor is a value equal to or greater than the second threshold and equal to or lower than the first threshold, the opening degree of the expansion valve is controlled to be maintained by the discharged-refrigerant temperature protection control. Thus, in the discharged-refrigerant temperature protection control, the discharged-refrigerant temperature of the compressor is controlled to be within the second predetermined range of the second threshold or more and the first threshold or less, so that there is little fluctuation in the discharged-refrigerant temperature, and stable operation can be continued. In addition, the capacity of the chiller can be ensured and maintained.

[0025] In the above aspect, when a predetermined time or more has elapsed since the opening degree of the expansion valve is controlled by the discharged-refrigerant temperature protection control, it may be determined whether or not the discharged-refrigerant temperature of the compressor exceeds the first threshold.

[0026] According to the present disclosure, when a predetermined time or more has elapsed since the opening degree of the expansion valve is controlled by the discharged-refrigerant temperature protection control, it is determined whether or not the discharged-refrigerant temperature of the compressor exceeds the first threshold. Thus, the discharged-refrigerant temperature of the compressor is determined after the predetermined time has elapsed and the refrigerant circuit of the chiller enters the steady state, and thus the determination can be correctly performed.

[0027] In the above aspect, the third threshold may be a value smaller than a target refrigerant superheating

degree in the evaporator outlet superheating degree control.

[0028] According to the present disclosure, since the third threshold is a value smaller than the target refrigerant superheating degree in the evaporator outlet superheating degree control, the refrigerant superheating degree at the outlet of the evaporator is ensured to a minimum, and it is possible to suppress the occurrence of the liquid back in the compressor.

[0029] A chiller according to an aspect of some embodiments of the present disclosure includes a compressor that compresses a refrigerant; a condenser that condenses the refrigerant compressed by the compressor; an expansion valve that expands a liquid refrigerant introduced from the condenser, an opening degree of the expansion valve being controlled by using an evaporator outlet superheating degree control that controls a superheating degree of the refrigerant at an outlet of an evaporator to a value within a first predetermined range; the evaporator that evaporates the refrigerant introduced from the expansion valve; and any of the control devices described above.

[0030] A method for controlling a chiller according to an aspect of some embodiments of the present disclosure is a method for controlling a chiller including a compressor that compresses a refrigerant; a condenser that condenses the refrigerant compressed by the compressor; an expansion valve that expands a liquid refrigerant introduced from the condenser, an opening degree of the expansion valve being controlled by using an evaporator outlet superheating degree control that controls a superheating degree of the refrigerant at an outlet of an evaporator to a value within a first predetermined range; and the evaporator that evaporates the refrigerant introduced from the expansion valve, the method including when a discharged-refrigerant temperature of the compressor exceeds a first threshold, a step of stopping the evaporator outlet superheating degree control and controlling the opening degree of the expansion valve to increase by using a discharged-refrigerant temperature protection control that controls the discharged-refrigerant temperature to a value within a second predetermined range, and when the discharged-refrigerant temperature of the compressor is below a second threshold lower than the first threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is equal to or greater than a third threshold, a step of stopping the discharged-refrigerant temperature protection control and controlling the opening degree of the expansion valve by using the evaporator outlet superheating degree control.

[0031] A program for controlling a chiller according to an aspect of some embodiments of the present disclosure is a program for controlling a chiller including a compressor that compresses a refrigerant; a condenser that condenses the refrigerant compressed by the compressor; an expansion valve that expands a liquid refrigerant introduced from the condenser, an opening degree of the expansion valve being controlled by using an evaporator

outlet superheating degree control that controls a superheating degree of the refrigerant at an outlet of an evaporator to a value within a first predetermined range; and the evaporator that evaporates the refrigerant introduced from the expansion valve, the method including when a discharged-refrigerant temperature of the compressor exceeds a first threshold, a step of stopping the evaporator outlet superheating degree control and controlling the opening degree of the expansion valve to increase by using a discharged-refrigerant temperature protection control that controls the discharged-refrigerant temperature to a value within a second predetermined range, and when the discharged-refrigerant temperature of the compressor is below a second threshold lower than the first threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is equal to or greater than a third threshold, a step of stopping the discharged-refrigerant temperature protection control and controlling the opening degree of the expansion valve by using the evaporator outlet superheating degree control.

Advantageous Effects of Invention

[0032] According to the present disclosure, when the discharged-refrigerant temperature exceeds the first threshold, the evaporator outlet superheating degree control is stopped and the opening degree of the expansion valve is controlled by the discharged-refrigerant temperature protection control, so that it is possible to perform a protective operation of lowering the discharged-refrigerant temperature.

[0033] Further, when the discharged-refrigerant temperature of the compressor is below the second threshold, and the refrigerant superheating degree at the outlet of the evaporator is equal to or greater than the third threshold, the temperature protection control of the discharged refrigerant is stopped, and the opening degree of the expansion valve is controlled by the evaporator outlet superheating degree control, the condition for ending the discharged-refrigerant temperature protection control is clear, and the control can be stopped properly.

Brief Description of Drawings

[0034]

Fig. 1 is a schematic configuration diagram illustrating an aspect of a refrigeration cycle of a chiller according to some embodiments.

Fig. 2 is a flowchart illustrating control of a control device of the chiller according to some embodiments.

Fig. 3 is a schematic configuration diagram illustrating a refrigeration cycle of a chiller as a reference example.

Fig. 4 is a graph illustrating a change in a discharged-refrigerant temperature in the chiller as the reference example.

Fig. 5 is a graph illustrating a change in a discharged-refrigerant temperature in the chiller according to some embodiments.

Fig. 6 is a graph illustrating a change in a refrigerating capacity of the chiller as the reference example.

Fig. 7 is a graph illustrating a change in a refrigerating capacity of the chiller according to some embodiments.

Fig. 8 is a pressure-enthalpy diagram in the chiller as the reference example.

Fig. 9 is a pressure-enthalpy diagram in the chiller according to some embodiments.

Description of Embodiments

[0035] Hereinafter, embodiments of a control device of a chiller, a chiller, a method for controlling a chiller, and a program for controlling a chiller according to some embodiments of the present disclosure will be described with reference to the drawings.

[0036] Fig. 1 illustrates a schematic configuration of one aspect of a refrigeration cycle of a chiller according to some embodiments of the present disclosure.

[0037] As illustrated in Fig. 1, a refrigeration cycle 1 of a chiller is configured by connecting a compressor 2 that compresses a refrigerant gas introduced from an evaporator 6, a condenser 3 that condenses the high-temperature highpressure refrigerant gas which is sent from the compressor 2 and compressed by the compressor 2 by exchanging heat with the outside air, a gas-liquid internal heat exchanger (heat exchanger) 4 that supercools the liquid refrigerant, which is sent from the condenser 3 and condensed in the condenser 3, by exchanging heat with the gas refrigerant from the evaporator 6, an expansion valve 5 that expands the supercooled liquid refrigerant introduced from the gas-liquid internal heat exchanger 4, and the evaporator 6 that evaporates the refrigerant by exchanging heat between the expanded refrigerant and air in this order by a refrigerant pipe 8. The evaporator 6 is used to cool the inside of the chiller.

[0038] The refrigeration cycle 1 is provided with a discharged-refrigerant temperature sensor 7 that detects the temperature of the refrigerant discharged from the compressor 2 (discharged-refrigerant temperature), and the detection value of the discharged-refrigerant temperature sensor 7 is input to the control device 10.

[0039] The control device 10 has a function of adjusting the opening degree of the expansion valve 5 such that the refrigerant superheating degree at the outlet of the evaporator 6 is controlled to "a value in a first predetermined range including the target refrigerant superheating degree".

[0040] By ensuring the refrigerant superheating degree at the outlet of the evaporator 6, the evaporator 6 can be used efficiently. Therefore, a target refrigerant superheating degree that is a control target value of the refrigerant superheating degree is set. The control device 10 controls the refrigerant superheating degree at the

outlet of the evaporator 6 to be a value in a first predetermined range including the target refrigerant superheating degree.

[0041] The control of the refrigerant superheating degree is performed by the control device 10 adjusting the opening degree of the expansion valve 5. For example, when increasing the refrigerant superheating degree, the opening degree of the expansion valve 5 is controlled to decrease. When reducing the refrigerant superheating degree, the opening degree of the expansion valve 5 is controlled to increase.

[0042] For example, the target refrigerant superheating degree is 7°C.

[0043] The control device 10 includes, for example, a central processing unit (CPU), a random access memory (RAM), a read only memory (ROM), a computer-readable non-transitory storage medium, and the like. A series of processes for realizing various functions are stored in a storage medium or the like in the form of a program as an example. The CPU reads the program to a RAM or the like and to process information and executes a calculation process, thereby realizing various functions. The program may be installed in advance in a ROM or other storage medium, may be provided in a state stored in a computer readable storage medium, or may be distributed through wired or wireless communication means. The computer-readable storage medium is a magnetic disk, a magnetooptical disk, a CD-ROM, a DVD-ROM, a semiconductor memory, or the like.

[0044] It is said that the chiller has a larger pressure ratio between the low pressure and the high pressure during operation, as compared with the air conditioner. In such a high pressure ratio operation with a large pressure ratio, the discharged-refrigerant temperature of the compressor 2 is likely to rise.

[0045] On the other hand, the compressor 2 has an upper limit in the temperature at which the compressor 2 can operate, and this is set as the upper limit of the allowable temperature of the compressor. Therefore, under operating conditions in which the discharged-refrigerant temperature measured by the discharged-refrigerant temperature sensor 7 exceeds the upper limit of the allowable temperature of the compressor of the compressor 2, a protective operation of lowering the discharged-refrigerant temperature is required.

[0046] When the discharged-refrigerant temperature reaches the upper limit of the allowable temperature of the compressor, the compressor 2 may not only be stopped but may also be damaged. In some embodiments of the present disclosure, a control upper limit (first threshold), of the discharged-refrigerant temperature, which is lower than the upper limit of the allowable temperature of the compressor by a predetermined temperature is provided. When the discharged-refrigerant temperature reaches the control upper limit of the discharged-refrigerant temperature, the discharged-refrigerant temperature protection control is performed in some embodiments of the present disclosure. The con-

trol upper limit of the discharged-refrigerant temperature is, for example, the upper limit of the allowable temperature of the compressor - 15°C.

[0047] A control lower limit of the discharged-refrigerant temperature is set as a second threshold smaller than the control upper limit of the discharged-refrigerant temperature. The control lower limit of the discharged-refrigerant temperature is, for example, the control upper limit of the discharged-refrigerant temperature - 35°C. The control lower limit of the discharged-refrigerant temperature is a temperature serving as a standard for determining that the temperature of the compressor 2 is extremely low when the discharged-refrigerant temperature is below the control lower limit of the discharged-refrigerant temperature value, and for raising the temperature of the compressor 2.

[0048] The discharged-refrigerant temperature protection control is to control the discharged-refrigerant temperature to a value within the second predetermined range. The second predetermined range is a range from the control lower limit (second threshold) of the discharged-refrigerant temperature to the control upper limit (first threshold) of the discharged-refrigerant temperature. The control device 10 controls the opening degree of the expansion valve 5 such that the discharged-refrigerant temperature measured by the discharged-refrigerant temperature sensor 7 becomes a value within the second predetermined range. The control lower limit of the discharged-refrigerant temperature is a value smaller than the control upper limit of the discharged-refrigerant temperature.

[0049] Hereinafter, control of the chiller according to some embodiments of the present disclosure will be described.

[0050] Fig. 2 is a flowchart illustrating control of the control device of a chiller according to some embodiments of the present disclosure.

[0051] When the control of the control device 10 is started, it is determined whether the compressor discharged-refrigerant temperature (Td) protection control is being performed (S201). When it is determined that the compressor discharged-refrigerant temperature protection control is being performed, the process proceeds to step S202, and when it is determined that it is not being performed, the process proceeds to step S208.

[0052] In step S202, it is determined whether or not a predetermined time or more has elapsed after the opening degree of the expansion valve 5 was changed in the previous process. When the opening degree of the expansion valve 5 is changed, there is a time lag until the refrigerant circuit of the refrigeration cycle 1 reaches a steady state. Therefore, the time period in which the refrigerant circuit is predicted to be in the steady state is set to a predetermined time period, and it is determined whether or not the predetermined time period has elapsed.

[0053] When a predetermined time or more has elapsed after changing the opening degree, the process

proceeds to step S203, and when the predetermined time has not elapsed, the process is temporarily ended and the process is performed again from the beginning.

[0054] When it is determined in step S202 that the predetermined time or more has elapsed after the opening degree of the expansion valve 5 was changed, it is determined whether or not the compressor discharged-refrigerant temperature, which is the detection value of the discharged-refrigerant temperature sensor 7, exceeds the control upper limit (first threshold) of the discharged-refrigerant temperature (S203).

[0055] When it is determined in step S203 that the compressor discharged-refrigerant temperature exceeds the control upper limit of the discharged-refrigerant temperature, the process proceeds to step S210. On the other hand, when it is determined that the compressor discharged-refrigerant temperature is equal to or lower than the control upper limit of the discharged-refrigerant temperature, the process proceeds to step S204.

[0056] When it is determined in step S203 that the compressor discharged-refrigerant temperature exceeds the control upper limit of the discharged-refrigerant temperature, the opening degree of the expansion valve 5 is increased by a predetermined amount (S210). The control device 10 controls the opening degree of the expansion valve 5 to increase by a predetermined amount. Thus, the flow rate of the refrigerant circulating in the refrigeration cycle 1 increases, and the compressor discharged-refrigerant temperature decreases. In this case, the refrigerant superheating degree at the outlet of the evaporator 6 also decreases.

[0057] When the opening degree of the expansion valve 5 is increased by a predetermined amount in step S210, the process is temporarily ended, and the process is performed again from the beginning.

[0058] On the other hand, when it is determined in step S203 that the compressor discharged-refrigerant temperature is equal to or lower than the control upper limit of the discharged-refrigerant temperature, it is determined whether or not the compressor discharged-refrigerant temperature is equal to or greater than the lower limit (second threshold) of the discharged-refrigerant temperature control (S204).

[0059] When it is determined in step S204 that the compressor discharged-refrigerant temperature is equal to or greater than the control lower limit of the discharged-refrigerant temperature, the process is temporarily ended while the control is performed so as to maintain the opening degree of the expansion valve 5, and the process is performed again from the beginning.

[0060] On the other hand, when it is determined in step S204 that the compressor discharged-refrigerant temperature is below the control lower limit of the discharged-refrigerant temperature, the process proceeds to step S205.

[0061] When the compressor discharged-refrigerant temperature is below the control lower limit of the discharged-refrigerant temperature, it is necessary to raise

the discharged-refrigerant temperature of the compressor. In step S205, the refrigerant superheating degree at the outlet of the evaporator 6 is determined. When it is determined that the refrigerant superheating degree at the outlet of the evaporator 6 is equal to or greater than the control lower limit (third threshold) of the refrigerant superheating degree, the process transitions to step S206. On the other hand, when it is determined that the refrigerant superheating degree is below the control lower limit of the refrigerant superheating degree, the process transitions to step S211.

[0062] The control lower limit (third threshold) of the refrigerant superheating degree is a value to be ensured at a minimum in the refrigerant superheating degree at the outlet of the evaporator 6 in order to use the evaporator 6 efficiently. The control lower limit of the refrigerant superheating degree is a value smaller than the target refrigerant superheating degree, and for example, the target refrigerant superheating degree - 2°C is set.

[0063] When it is determined that the discharged-refrigerant temperature of the compressor is below the control lower limit of the discharged-refrigerant temperature (NO in S204) and the refrigerant superheating degree at the outlet of the evaporator 6 is equal to or greater than the control lower limit of the refrigerant superheating degree (YES in S205), it is necessary to raise the discharged-refrigerant temperature of the compressor, but the refrigerant superheating degree is ensured, so that the compressor discharged-refrigerant temperature protection control is ended (S206), and the evaporator outlet superheating degree control is performed (S207).

[0064] When the evaporator outlet superheating degree control is started in step S207, the process is temporarily ended, and the process is performed again from the beginning.

[0065] On the other hand, when it is determined that the discharged-refrigerant temperature of the compressor is below the control lower limit of the discharged-refrigerant temperature (NO in S204) and the refrigerant superheating degree at the outlet of the evaporator 6 is below the control lower limit of the refrigerant superheating degree (NO in S205), it is necessary to raise the discharged-refrigerant temperature of the compressor and refrigerant superheating degree. When the opening degree of the expansion valve 5 is increased, the refrigerant superheating degree at the outlet of the evaporator 6 may not be applied. At this time, since liquid back may occur in the compressor 2, it is necessary to ensure the refrigerant superheating degree. The opening degree of the expansion valve 5 is reduced by a predetermined amount (S211). The control device 10 controls the opening degree of the expansion valve 5 to decrease by a predetermined amount. Thus, the flow rate of the refrigerant circulating in the refrigeration cycle 1 is reduced, and the discharged-refrigerant temperature of the compressor and the refrigerant superheating degree at the outlet of the evaporator 6 are increased.

[0066] When the opening degree of the expansion

valve 5 is reduced by a predetermined amount in step S211, the process is temporarily ended, and the process is performed again from the beginning.

[0067] As described above, the compressor discharged-refrigerant temperature protection control is performed.

[0068] When it is determined in step S201 that the compressor discharged-refrigerant temperature protection control is not performed, it is determined whether or not the compressor discharged-refrigerant temperature, which is the detection value of the discharged-refrigerant temperature sensor 7, exceeds the control upper limit (first threshold) of the discharged-refrigerant temperature (S208).

[0069] When it is determined in step S208 that the compressor discharged-refrigerant temperature exceeds the control upper limit of the discharged-refrigerant temperature, the process proceeds to step S209. On the other hand, when it is determined that the compressor discharged-refrigerant temperature is equal to or lower than the control upper limit of the discharged-refrigerant temperature, the process proceeds to step S207.

[0070] When it is determined in step S208 that the compressor discharged-refrigerant temperature exceeds the control upper limit of the discharged-refrigerant temperature, the compressor discharged-refrigerant temperature protection control is started (S209) and the opening degree of the expansion valve 5 is increased by a predetermined amount (S210). The control device 10 controls the opening degree of the expansion valve 5 to increase by a predetermined amount. Thus, the flow rate of the refrigerant circulating in the refrigeration cycle 1 increases, and the compressor discharged-refrigerant temperature decreases. In this case, the refrigerant superheating degree at the outlet of the evaporator 6 also decreases.

[0071] When the opening degree of the expansion valve 5 is increased by a predetermined amount in step S210, the process is temporarily ended, and the process is performed again from the beginning.

[0072] On the other hand, when it is determined in step S208 that the compressor discharged-refrigerant temperature is equal to or lower than the control upper limit of the discharged-refrigerant temperature, evaporator outlet superheating degree control is performed (S207). When the evaporator outlet superheating degree control is started in step S207, the process is temporarily ended, and the process is performed again from the beginning. When the normal evaporator outlet superheating degree control is performed, the steps S201, S208, and S207 are performed in this order in the flowchart of Fig. 2.

[0073] Below, the control by the control device of the chiller according to some embodiments of the present disclosure will be described in comparison with the chiller as a reference example. As shown in Fig. 3, the refrigeration cycle 51 of the chiller as a reference example includes a liquid bypass line 59 that connects the outlet side of the condenser 53 and the inlet side of the com-

pressor 52. When the discharged-refrigerant temperature of the compressor 52 measured by the discharged-refrigerant temperature sensor 57 exceeds the control upper limit of the discharged-refrigerant temperature, the chiller as a reference example cools the compressor 52 by performing the liquid bypass control so as to bypass the liquid refrigerant to the inlet side of the compressor 52.

[0074] Other configurations of the chiller as the reference example are similar to those of the chillers according to some embodiments of the present disclosure, and the compressor 2, the condenser 3, the gas-liquid internal heat exchanger 4, the expansion valve 5, the evaporator 6, the discharged-refrigerant temperature sensor 7, and the refrigerant pipe 8 correspond to the compressor 52, the condenser 53, the gas-liquid internal heat exchanger 54, the expansion valve 55, the evaporator 56, the discharged-refrigerant temperature sensor 57, and the refrigerant pipe 58, respectively.

[0075] Further, the control device 50 performs liquid bypass control.

[0076] Fig. 4 is a graph illustrating a change in a discharged-refrigerant temperature in the chiller as the reference example.

[0077] In Fig. 4, the vertical axis represents the discharged-refrigerant temperature of the compressor 52, and the horizontal axis represents time. In the discharged-refrigerant temperature, a indicates a liquid bypass control end temperature to be described later, b indicates the control upper limit of the discharged-refrigerant temperature, and c indicates the upper limit of the allowable temperature of the compressor.

[0078] When time elapses from time 0 in Fig. 4, the discharged-refrigerant temperature of the compressor 52 rises and reaches the control upper limit b of the discharged-refrigerant temperature at time t1. When the discharged-refrigerant temperature reaches the control upper limit b of the discharged-refrigerant temperature, the control device 50 starts the liquid bypass control and opens the liquid bypass line 59. Since there is a time lag to start lowering the discharged-refrigerant temperature of the compressor 52 after the liquid bypass control is started, the discharged-refrigerant temperature starts to decrease after a lapse of a predetermined time after the time t1. An end temperature is set for the liquid bypass control, and this is set as a liquid bypass control end temperature a. At time t2, when the discharged-refrigerant temperature reaches the liquid bypass control end temperature a, the liquid bypass line 59 is closed and the liquid bypass control ends.

[0079] Since there is a time lag even when the discharged-refrigerant temperature of the compressor 52 starts to rise after the liquid bypass control is ended, the discharged-refrigerant temperature starts to decrease after a lapse of a predetermined time after the time t2. The start and end are alternately and continuously performed such that when the discharged-refrigerant temperature reaches the control upper limit b of the discharged-refrigerant temperature at time t3, the liquid bypass control is

started, and when the discharged-refrigerant temperature reaches the liquid bypass control end temperature a at time t4, the liquid bypass control is ended.

[0080] As shown in Fig. 4, when the liquid bypass control is performed, the temperature change of the discharged refrigerant temperature is large. Therefore, the discharged-refrigerant temperature frequently reaches the control upper limit b of the discharged-refrigerant temperature and the liquid bypass control end temperature a, and the control is switched in a short time. Since the liquid refrigerant is bypassed from the outlet of the condenser 53 to the inlet of the compressor 52, the amount of refrigerant flowing into the evaporator 56 is small, and the reduced amount of refrigerant does not contribute to the refrigeration function.

[0081] Fig. 5 is a graph illustrating a change in a discharged-refrigerant temperature in a chiller according to some embodiments of the present disclosure.

[0082] In Fig. 5, the vertical axis represents the discharged-refrigerant temperature of the compressor 52, and the horizontal axis represents time. In the discharged-refrigerant temperature, d indicates a control lower limit (second threshold) of the discharged-refrigerant temperature to be described later, b indicates a control upper limit (first threshold) of the discharged-refrigerant temperature, and c indicates an upper limit of the allowable temperature of the compressor.

[0083] At time 0 in Fig. 5, the evaporator outlet superheating degree control is being performed. When time elapses from time 0, the discharged-refrigerant temperature of the compressor 2 rises and reaches the control upper limit b of the discharged-refrigerant temperature at time t7. When the discharged-refrigerant temperature reaches the control upper limit b of the discharged-refrigerant temperature, the evaporator outlet superheating degree control is stopped and the discharged-refrigerant temperature protection control is started.

[0084] As described above, the discharged-refrigerant temperature protection control is to control the discharged-refrigerant temperature to a value within the second predetermined range. The control device 10 controls the opening degree of the expansion valve 5 such that the discharged-refrigerant temperature measured by the discharged-refrigerant temperature sensor 7 becomes a value in a second predetermined range which is a range from the control lower limit (second threshold) d of the discharged-refrigerant temperature to the control upper limit (first threshold) b of the discharged-refrigerant temperature.

[0085] When the discharged-refrigerant temperature protection control is started at time t7, the opening degree of the expansion valve 5 is controlled to increase. Since there is a time lag to start lowering the discharged-refrigerant temperature of the compressor 2 after the opening degree of the expansion valve 5 is controlled to increase, the discharged-refrigerant temperature starts to decrease after a lapse of a predetermined time after the time t7.

[0086] By performing the control shown in the flowchart of Fig. 2 in the discharged-refrigerant temperature protection control, the discharged-refrigerant temperature of the compressor 2 is controlled such that a large fluctuation is suppressed and so as to change within the second predetermined range. According to some embodiments of the present disclosure, stable operation can be continued.

[0087] In the chiller as the reference example, the difference between the liquid bypass control end temperature a and the control upper limit b of the discharged-refrigerant temperature is made large in order to avoid frequent turning on and off of the liquid bypass control. On the other hand, in the chiller according to some embodiments of the present disclosure, the refrigerant flow rate can be finely controlled by using the expansion valve 5. It is possible to control to the minimum liquid return amount required to maintain the discharged-refrigerant temperature equal to or lower than the allowable temperature upper limit of the compressor. The difference between the control lower limit d of the discharged-refrigerant temperature and the control upper limit b of the discharged-refrigerant temperature can be reduced. Since the level of the discharged refrigerant temperature is proportional to the level of the capacity of the chiller, changing the discharged refrigerant temperature to a high value also changes the capacity of the chiller to a high value.

[0088] Fig. 6 is a graph illustrating a change in refrigerating capacity of a chiller as a reference example.

[0089] In Fig. 6, the vertical axis represents the refrigerating capacity of the chiller, and the horizontal axis represents the intake air temperature of the condenser. The intake air temperature of the condenser is approximately equal to the ambient temperature. With respect to the refrigerating capacity, R1 indicates refrigerating capacity when switching from evaporator outlet superheating degree control to discharged-refrigerant temperature protection control (in this case, liquid bypass control) at the intake air temperature T1, and R2 indicates refrigerating capacity at the intake air temperature T2. The solid line shows the relationship between the refrigerating capacity and the intake air temperature of the condenser. The dot-dashed line shows the change of the refrigerating capacity that is expected when the normal evaporator outlet superheating degree control is performed.

[0090] In the chiller as the reference example, in comparison with the refrigerating capacity R1 when the liquid bypass control is started at the intake air temperature T1, the refrigerating capacity R2 when the intake air temperature rises and becomes the intake air temperature T2 is greatly reduced. When the intake air temperature is high, the discharged-refrigerant temperature protection control needs to be performed normally, and the liquid bypass line 59 is normally opened.

[0091] Fig. 7 is a graph illustrating changes in refrigerating capacity in the chiller according to some embodiments of the present disclosure.

[0092] In Fig. 7, the vertical axis represents the refrigerating capacity of the chiller, and the horizontal axis represents the intake air temperature of the condenser. With respect to the refrigerating capacity, R1 indicates refrigerating capacity when switching from evaporator outlet superheating degree control to discharged-refrigerant temperature protection control at the intake air temperature T1, and R3 indicates refrigerating capacity at the intake air temperature T2. The solid line shows the relationship between the refrigerating capacity and the intake air temperature of the condenser. The dot-dashed line shows the change of the refrigerating capacity that is expected when the normal evaporator outlet superheating degree control is performed.

[0093] In the chiller according to some embodiments of the present disclosure, compared with the refrigerating capacity R1 when the discharged-refrigerant temperature protection control is started at the intake air temperature T1, the refrigerating capacity R3 when the intake air temperature rises and becomes the intake air temperature T2 is reduced, but there is little decrease in the refrigerating capacity. This is because, as shown in Fig. 5, there is little decrease in the discharged-refrigerant temperature. R3 is a value larger than the refrigerating capacity R2 when the intake air temperature becomes the intake air temperature T2 in the chiller as the reference example shown in Fig. 6.

[0094] Fig. 8 is a pressure-enthalpy diagram in a chiller as the reference example.

[0095] In Fig. 8, the vertical axis represents pressure and the horizontal axis represents enthalpy. The thick solid line indicates the refrigeration cycle during the evaporator outlet superheating degree control, and the thick broken line indicates the isothermal curve during the evaporator outlet superheating degree control. The solid line indicates the refrigeration cycle during liquid bypass control, and the broken line indicates the isothermal curve during liquid bypass control. The dot-dashed line indicates the saturation curve.

[0096] In the refrigeration cycle shown in Fig. 8 during the evaporator outlet superheating degree control in the chiller as the reference example, h1 indicates the gas refrigerant outlet of the gas-liquid internal heat exchanger 54, h3 indicates the liquid refrigerant inlet of the gas-liquid internal heat exchanger 54, h4 indicates the liquid refrigerant outlet of the gas-liquid internal heat exchanger 54, and h6 indicates the gas refrigerant inlet of the gas-liquid internal heat exchanger 54.

[0097] In the refrigeration cycle shown in Fig. 8 during liquid bypass control, h1' indicates the gas refrigerant outlet of the gas-liquid internal heat exchanger 54, h3' indicates the liquid refrigerant inlet of the gas-liquid internal heat exchanger 54, h4' indicates the gas refrigerant outlet of the gas-liquid internal heat exchanger 54, and h6' indicate the gas refrigerant inlet of the gas-liquid internal heat exchanger 54.

[0098] Fig. 9 is a pressure-enthalpy diagram in a chiller according to some embodiments of the present disclosure.

sure.

[0099] In Fig. 9, the vertical axis represents pressure and the horizontal axis represents enthalpy. The thick solid line indicates the refrigeration cycle during the evaporator outlet superheating degree control, and the thick broken line indicates the isothermal curve during the evaporator outlet superheating degree control. The solid line indicates the refrigeration cycle during the discharged-refrigerant temperature protection control, and the broken line indicates the isothermal curve during the discharged-refrigerant temperature protection control. The dot-dashed line indicates the saturation curve.

[0100] In the refrigeration cycle shown in Fig. 9 during the evaporator outlet superheating degree control in the chiller according to some embodiments of the present disclosure, h1 indicates the gas refrigerant outlet of the gas-liquid internal heat exchanger 54, h3 indicates the liquid refrigerant inlet of the gas-liquid internal heat exchanger 54, h4 indicates the liquid refrigerant outlet of the gas-liquid internal heat exchanger 54, and h6 indicates the gas refrigerant inlet of the gas-liquid internal heat exchanger 54.

[0101] In the refrigeration cycle shown in Fig. 9 during liquid bypass control, h1" indicates the gas refrigerant outlet of the gas-liquid internal heat exchanger 54, h3" indicates the liquid refrigerant inlet of the gas-liquid internal heat exchanger 54, h4" indicates the liquid refrigerant outlet of the gas-liquid internal heat exchanger 54, and h6" indicate the gas refrigerant inlet of the gas-liquid internal heat exchanger 54.

[0102] In the chiller as the reference example, when the control is switched from the normal evaporator outlet superheating degree control to the liquid bypass control, the discharged-refrigerant temperature and the refrigerating capacity decrease.

[0103] In the chiller according to some embodiments of the present disclosure, when the control is switched from the normal evaporator outlet superheating degree control to the discharged-refrigerant temperature protection control, the discharged-refrigerant temperature and the refrigerating capacity also decrease.

[0104] In the chiller as a reference example, when the control is switched from the normal evaporator outlet superheating degree control to the liquid bypass control, the isothermal curve (thick broken line) showing the discharged-refrigerant temperature in the evaporator outlet superheating degree control moves to the isothermal curve (broken line) showing the discharged-refrigerant temperature in the liquid bypass control, and this moving distance is represented as a temperature difference of the discharged-refrigerant temperature.

[0105] On the other hand, in the chiller according to some embodiments of the present disclosure, when the control is switched from the normal evaporator outlet superheating degree control to the discharged-refrigerant temperature protection control, the isothermal curve (thick broken line) showing the discharged-refrigerant temperature in the evaporator outlet superheating de-

gree control moves to the isothermal curve (broken line) showing the discharged-refrigerant temperature in the discharged-refrigerant temperature protection control, and this moving distance is represented as a temperature difference of the discharged-refrigerant temperature.

[0106] As described above, according to the chiller according to some embodiments of the present disclosure, the discharged-refrigerant temperature of the compressor 2 can be reduced to the temperature required to maintain the temperature below the upper limit or less.

[0107] According to the chiller according to some embodiments of the present disclosure, it is possible to suppress a decrease in the discharged-refrigerant temperature as compared with the liquid bypass control.

[0108] In the chiller as the reference example, when the control is switched from the normal evaporator outlet superheating degree control to the liquid bypass control, the refrigerant evaporation temperature rises from h1 to h1' or from h6 to h6' by the difference x'. Therefore, the refrigerating capacity corresponding to the difference x' is reduced.

[0109] When the liquid bypass control is performed, the liquid refrigerant is bypassed from h3' to h1', so that the refrigerating capacity corresponding to the difference y (two-dot chain line portion) between h3' and h1' is reduced.

[0110] As described above, in the chiller as the reference example, the refrigerating capacity corresponding to x' + y decreases.

[0111] On the other hand, in the chiller according to some embodiments of the present disclosure, when the control is switched from the normal evaporator outlet superheating degree control to the discharged-refrigerant temperature protection control, the refrigerant evaporation temperature rises from h1 to h1", or from h6 to h6" by the difference x". Therefore, the refrigerating capacity corresponding to the difference x" decreases.

[0112] As described above, the decrease in the refrigerating capacity of the chiller according to some embodiments of the present disclosure is less than the decrease in the capacity during liquid bypass control. According to the chiller according to some embodiments of the present disclosure, it is possible to suppress a decrease in the refrigerating capacity to be small.

[0113] As described above, according to the control device of a chiller, the chiller, the method for controlling a chiller, and the program for controlling a chiller according to the present embodiment, the following operational effects are achieved.

[0114] According to the present disclosure, the discharged-refrigerant temperature is controlled to be equal to or lower than the control upper limit of the discharged-refrigerant temperature, so that the compressor 2 can be continuously operated without being substantially stopped.

[0115] Since the refrigerant thermal energy of the refrigerant excessively supplied to the evaporator 6 is recovered by the gas-liquid internal heat exchanger 4, the

reduction in the refrigerating capacity can be suppressed to an extremely small level.

[0116] Since the compressor 2 can maintain the refrigerant gas suction, the liquid refrigerant is not sucked and the oil is not diluted, so that the lubricity of the compressor 2 is not affected.

[0117] Since the refrigerant flow rate can be finely controlled by using the expansion valve 5, the refrigerant flow rate can be controlled by using the minimum liquid return amount required to maintain the discharged-refrigerant temperature to be equal to or lower than the control upper limit of the discharged-refrigerant temperature, and thus stable operation is possible.

[0118] When the discharged-refrigerant temperature of the compressor 2 is below the control lower limit d, of the discharged-refrigerant temperature, which is smaller than the control upper limit b of the discharged-refrigerant temperature, and the refrigerant superheating degree at the outlet of the evaporator 6 is equal to or greater than the control lower limit of the refrigerant superheating degree, the discharged-refrigerant temperature protection control is stopped, and the opening degree of the expansion valve 5 is controlled by the evaporator outlet superheating degree control. After checking that the refrigerant superheating degree at the outlet of the evaporator 6 is ensured, the discharged-refrigerant temperature protection control is ended and the control is shifted to the normal evaporator outlet superheating degree control, and the discharged-refrigerant temperature of the compressor 2 which has fallen too low by the discharged-refrigerant temperature protection control can be raised.

[0119] According to the present disclosure, when the discharged-refrigerant temperature of the compressor 2 is a value below the control lower limit d of the discharged-refrigerant temperature, and the refrigerant superheating degree at the outlet of the evaporator 6 is a value below the control lower limit of the refrigerant superheating degree, the discharged-refrigerant temperature protection control is stopped, and the opening degree of the expansion valve 5 is controlled to decrease by the evaporator outlet superheating degree control. By the discharged-refrigerant temperature protection control, the discharged-refrigerant temperature of the compressor 2 is lowered and is below the lower limit of the value at which the refrigerant superheating degree at the outlet of the evaporator 6 is to be ensured, liquid back may occur in the compressor 2. However, according to the present disclosure, since the opening degree of the expansion valve 5 is controlled to decrease, the refrigerant superheating degree at the outlet of the evaporator 6 can be increased. Further, the discharged-refrigerant temperature of the compressor 2 can be increased.

[0120] According to the present disclosure, when the discharged-refrigerant temperature of the compressor 2 is a value equal to or greater than the control lower limit d of the discharged-refrigerant temperature and equal to or lower than the control upper limit b of the discharged-refrigerant temperature, a control is performed such that

the opening degree of the expansion valve 5 by the discharged-refrigerant temperature protection control is maintained. Thus, in the discharged-refrigerant temperature protection control, the discharged-refrigerant temperature of the compressor 2 is controlled to be within the second predetermined range from the control lower limit d of the discharged-refrigerant temperature to the control upper limit b of the discharged-refrigerant temperature, so that there is little fluctuation in the discharged-refrigerant temperature, and stable operation can be continued. In addition, the capacity of the chiller can be ensured and maintained.

[0121] According to the present disclosure, when a predetermined time or more has elapsed since the opening degree of the expansion valve 5 is controlled by the discharged-refrigerant temperature protection control, it is determined whether or not the discharged-refrigerant temperature of the compressor 2 exceeds the control upper limit b of the discharged-refrigerant temperature. Thus, the discharged-refrigerant temperature of the compressor 2 is determined after the predetermined time has elapsed and the refrigerant circuit of the chiller enters the steady state, and thus the determination can be correctly performed.

[0122] According to the present disclosure, since the control lower limit of the refrigerant superheating degree is a value smaller than the target refrigerant superheating degree in the evaporator outlet superheating degree control, the refrigerant superheating degree at the outlet of the evaporator 6 is ensured to a minimum, and it is possible to suppress the occurrence of the liquid back in the compressor 2.

Reference Signs List

[0123]

- 1, 51 Refrigeration cycle
- 2, 52 Compressor
- 3, 53 Condenser
- 4, 54 Gas-liquid internal heat exchanger (heat exchanger)
- 5, 55 Expansion valve
- 6, 56 Evaporator
- 7, 57 Discharged-refrigerant temperature sensor
- 8, 58 Refrigerant pipe
- 10, 50 Control device
- 59 Liquid bypass line

Claims

1. A control device of a chiller, the chiller including:

- a compressor that compresses a refrigerant;
- a condenser that condenses the refrigerant compressed by the compressor;
- an expansion valve that expands a liquid refrigerant;

- erant introduced from the condenser, an opening degree of the expansion valve being controlled by using an evaporator outlet superheating degree control that controls a superheating degree of the refrigerant at an outlet of an evaporator to a value within a first predetermined range; and
the evaporator that evaporates the refrigerant introduced from the expansion valve, wherein when a discharged-refrigerant temperature of the compressor exceeds a first threshold, the evaporator outlet superheating degree control is stopped, and the opening degree of the expansion valve is controlled to increase by using a discharged-refrigerant temperature protection control that controls the discharged-refrigerant temperature to a value within a second predetermined range, and
wherein when the discharged-refrigerant temperature of the compressor is below a second threshold which is smaller than the first threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is equal to or greater than a third threshold, the discharged-refrigerant temperature protection control is stopped, and the opening degree of the expansion valve is controlled by using the evaporator outlet superheating degree control.
2. The control device of a chiller according to claim 1, wherein when the discharged-refrigerant temperature of the compressor is a value below the second threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is a value below the third threshold, the discharged-refrigerant temperature protection control is stopped, and the opening degree of the expansion valve is controlled to decrease by using the evaporator outlet superheating degree control.
 3. The control device of a chiller according to claim 1 or 2, wherein when the discharged-refrigerant temperature of the compressor is a value equal to or greater than the second threshold and equal to or lower than the first threshold, the opening degree of the expansion valve is controlled to be maintained by the discharged-refrigerant temperature protection control.
 4. The control device of a chiller according to any one of claims 1 to 3, wherein when a predetermined time or more has elapsed since the opening degree of the expansion valve is controlled by the discharged-refrigerant temperature protection control, it is determined whether or not the discharged-refrigerant temperature of the compressor exceeds the first threshold.
 5. The control device of a chiller according to any one of claims 1 to 4, wherein the third threshold is a value smaller than a target refrigerant superheating degree in the evaporator outlet superheating degree control.
 6. A chiller comprising:
 - a compressor that compresses a refrigerant;
 - a condenser that condenses the refrigerant compressed by the compressor;
 - an expansion valve that expands a liquid refrigerant introduced from the condenser, an opening degree of the expansion valve being controlled by using an evaporator outlet superheating degree control that controls a superheating degree of the refrigerant at an outlet of an evaporator to a value within a first predetermined range;
 - the evaporator that evaporates the refrigerant introduced from the expansion valve; and
 - the control device according to any one of claims 1 to 5.
 7. A method for controlling a chiller, the chiller including:
 - a compressor that compresses a refrigerant;
 - a condenser that condenses the refrigerant compressed by the compressor;
 - an expansion valve that expands a liquid refrigerant introduced from the condenser, an opening degree of the expansion valve being controlled by using an evaporator outlet superheating degree control that controls a superheating degree of the refrigerant at an outlet of an evaporator to a value within a first predetermined range; and
 - the evaporator that evaporates the refrigerant guided from the expansion valve, the method for controlling a chiller comprising:
 - a step of stopping the evaporator outlet superheating degree control, and controlling the opening degree of the expansion valve to increase by using a discharged-refrigerant temperature protection control that controls a discharged-refrigerant temperature of the compressor to a value within a second predetermined range, when the discharged-refrigerant temperature exceeds a first threshold; and
 - a step of stopping the discharged-refrigerant temperature protection control, and controlling the opening degree of the expansion valve by using the evaporator outlet superheating degree control, when the discharged-refrigerant temperature of the compressor is below a second threshold

which is smaller than the first threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is equal to or greater than a third threshold.

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8. A program for controlling a chiller, the chiller including:

a compressor that compresses a refrigerant;
 a condenser that condenses the refrigerant compressed by the compressor;
 an expansion valve that expands a liquid refrigerant introduced from the condenser, an opening degree of the expansion valve being controlled by using an evaporator outlet superheating degree control that controls a superheating degree of the refrigerant at an outlet of an evaporator to a value within a first predetermined range; and
 the evaporator that evaporates the refrigerant guided from the expansion valve, the program for controlling a chiller comprising:

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a step of stopping the evaporator outlet superheating degree control, and controlling the opening degree of the expansion valve to increase by using a discharged-refrigerant temperature protection control that controls a discharged-refrigerant temperature of the compressor to a value within a second predetermined range, when the discharged-refrigerant temperature exceeds a first threshold; and
 a step of stopping the discharged-refrigerant temperature protection control, and controlling the opening degree of the expansion valve by using the evaporator outlet superheating degree control, when the discharged-refrigerant temperature of the compressor is below a second threshold which is smaller than the first threshold, and the superheating degree of the refrigerant at the outlet of the evaporator is equal to or greater than a third threshold.

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FIG. 1

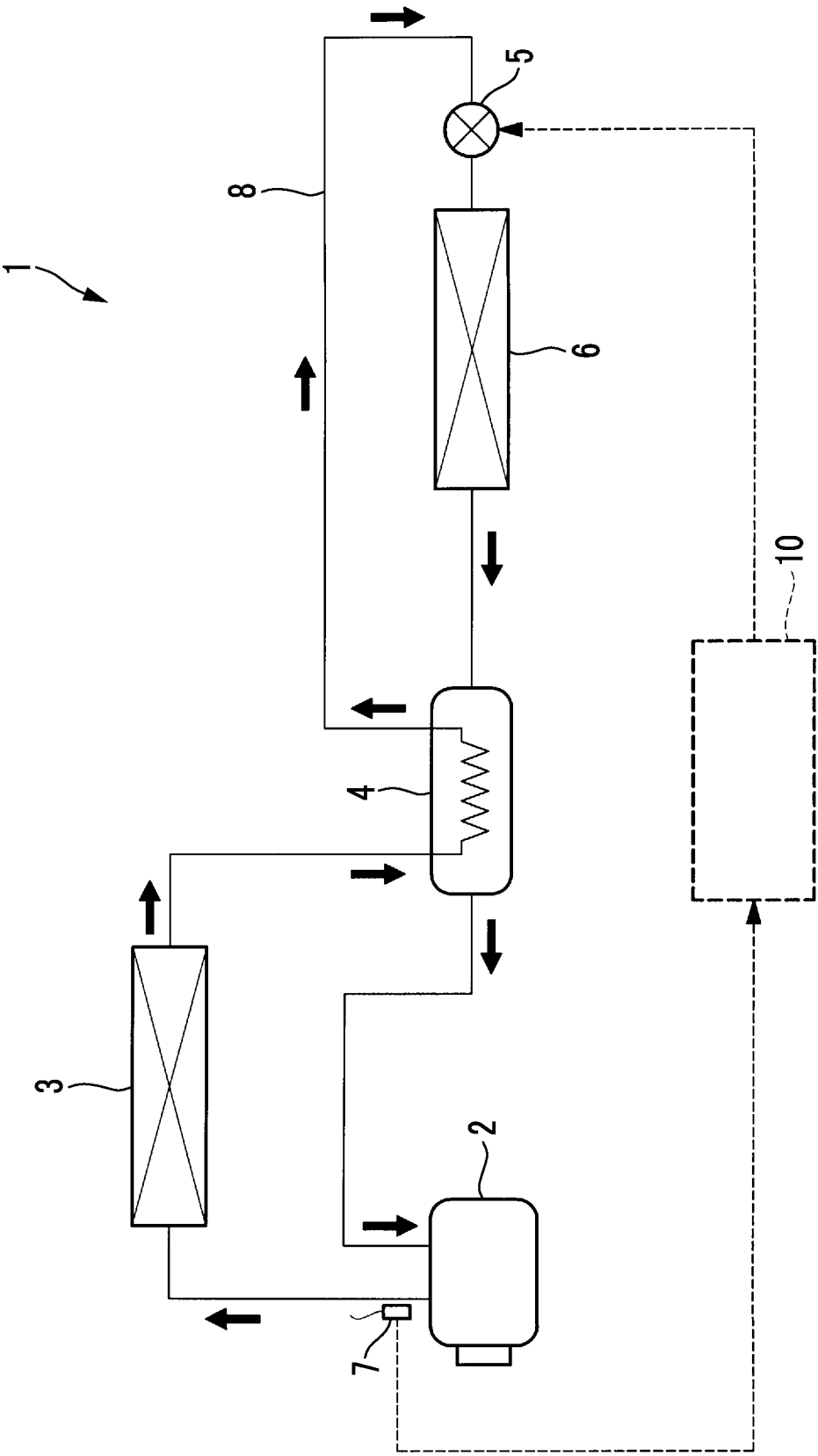


FIG. 2

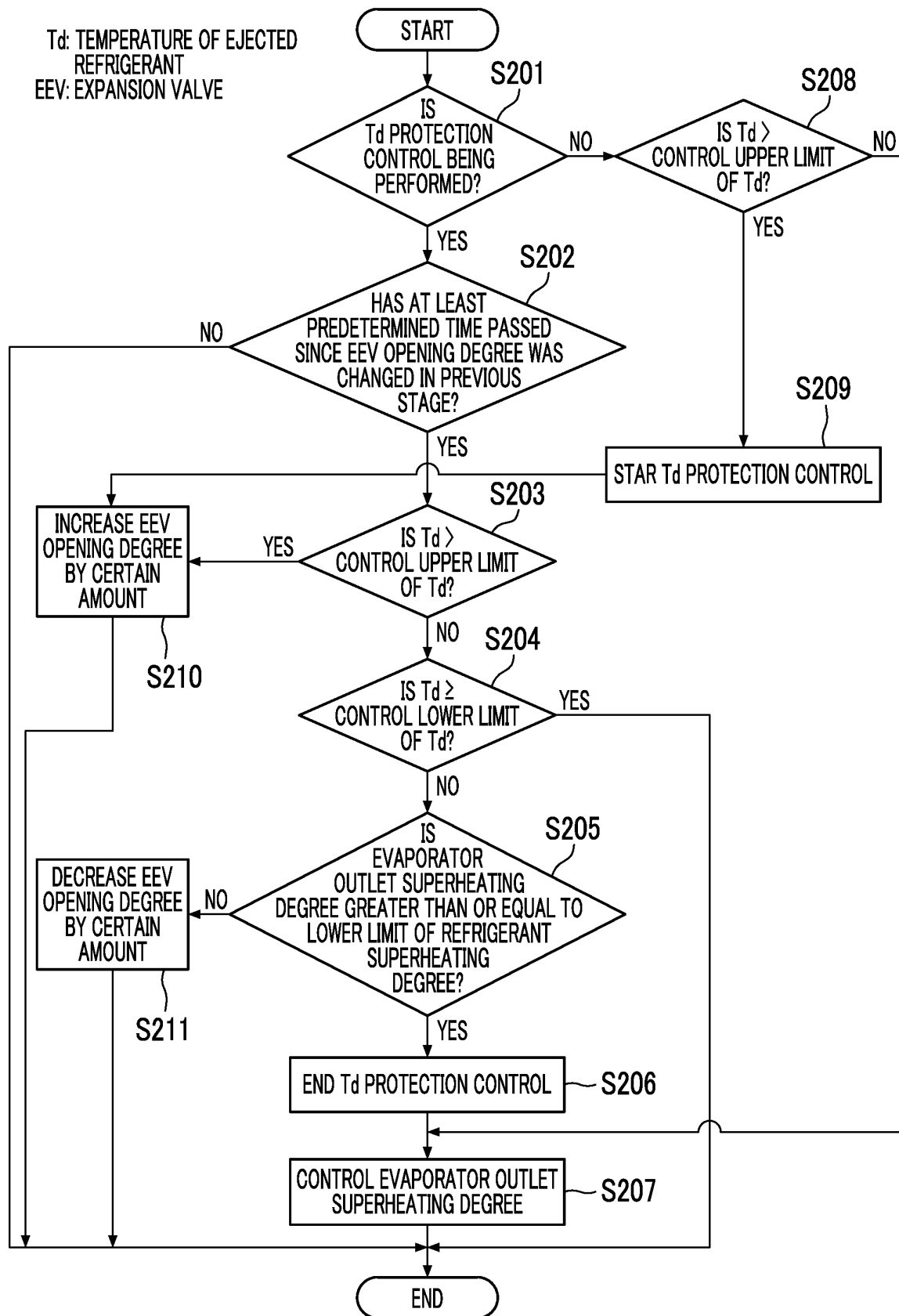


FIG. 3

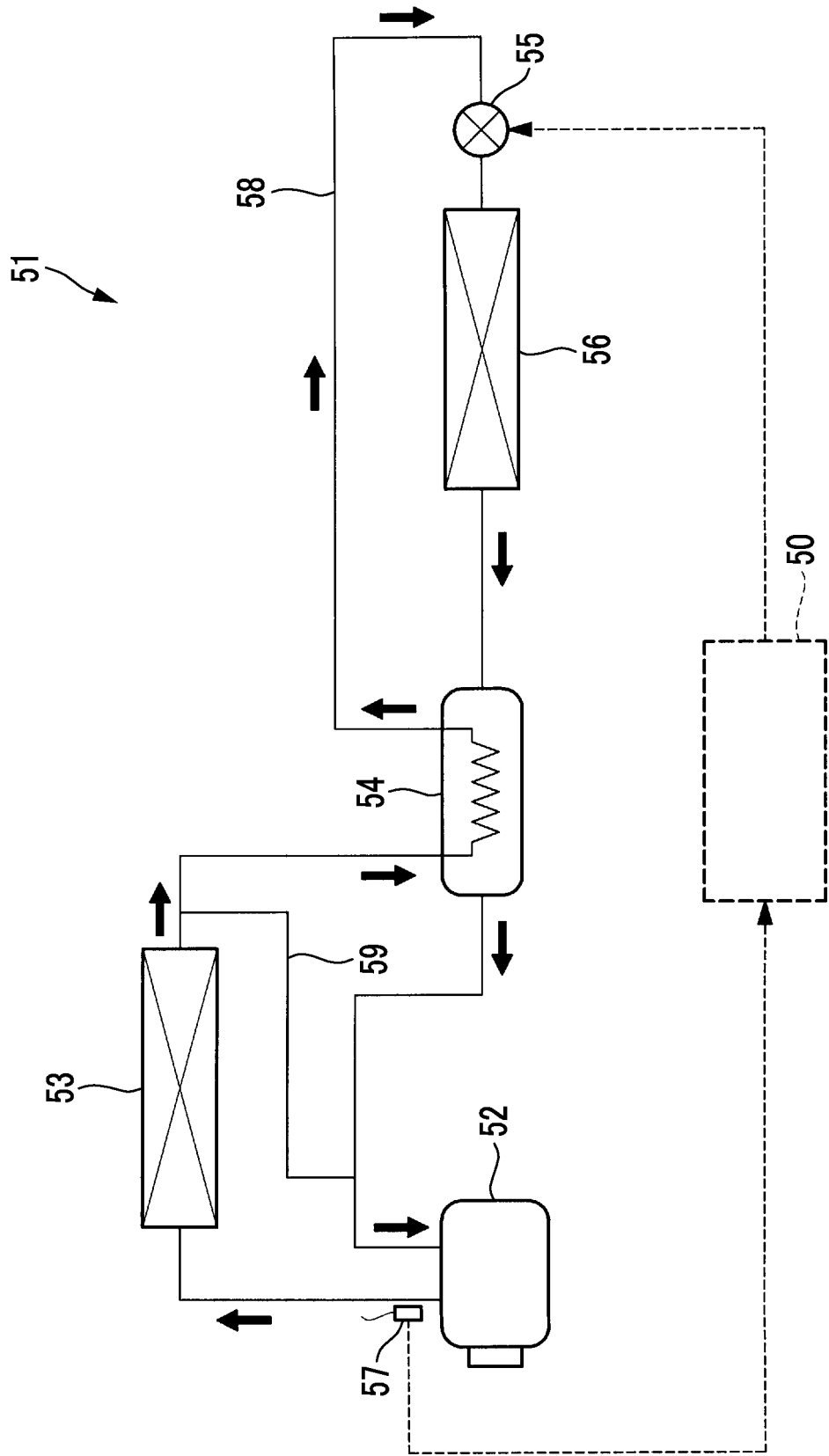


FIG. 4

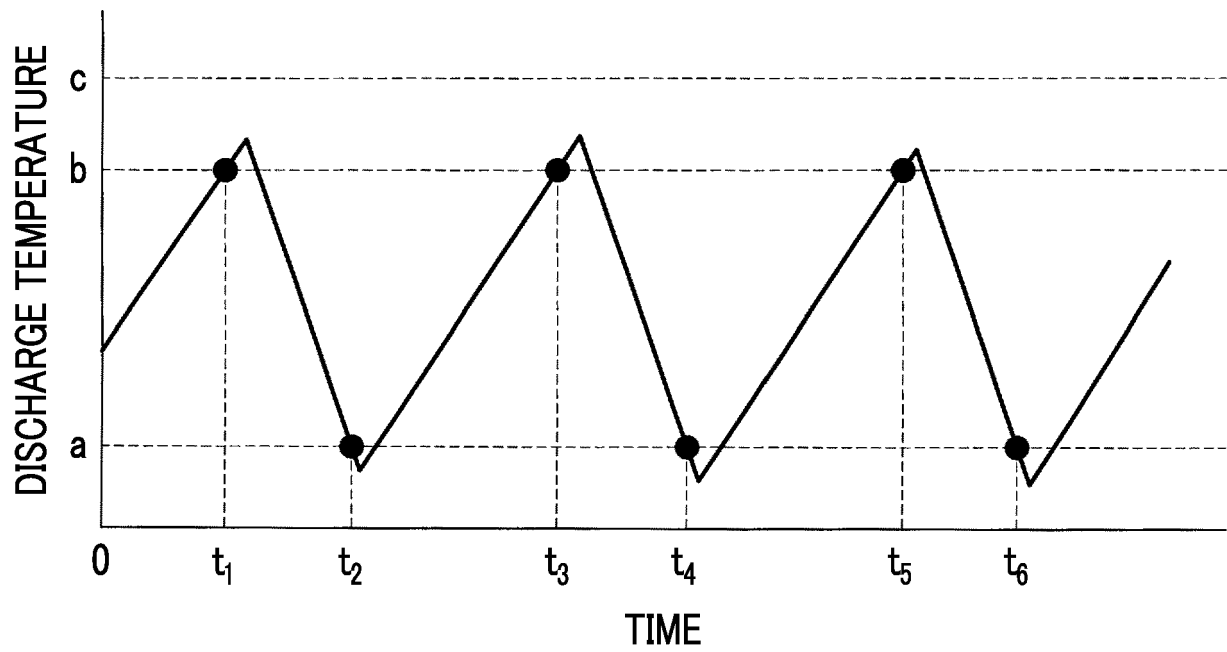


FIG. 5

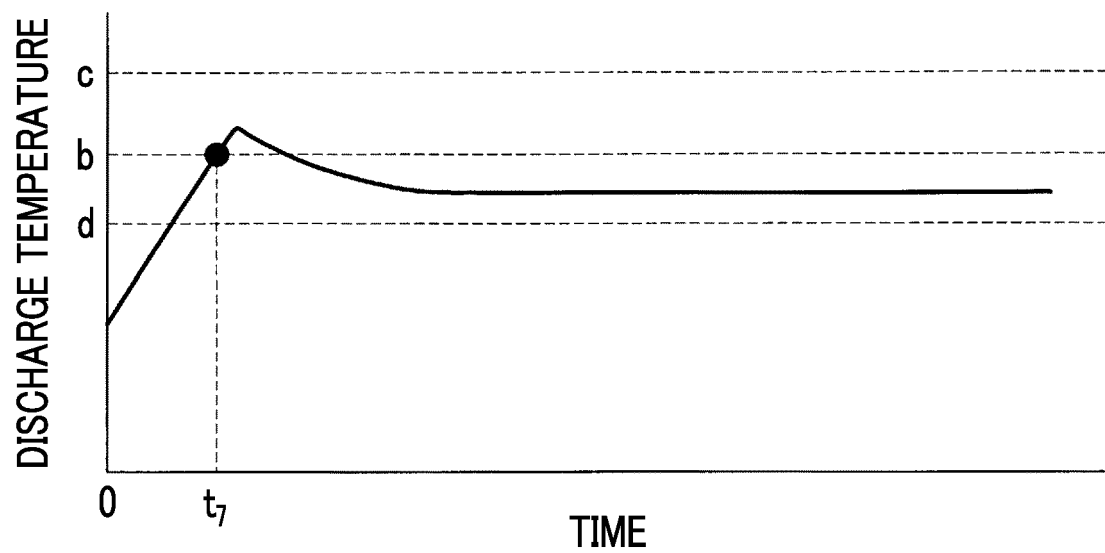


FIG. 6

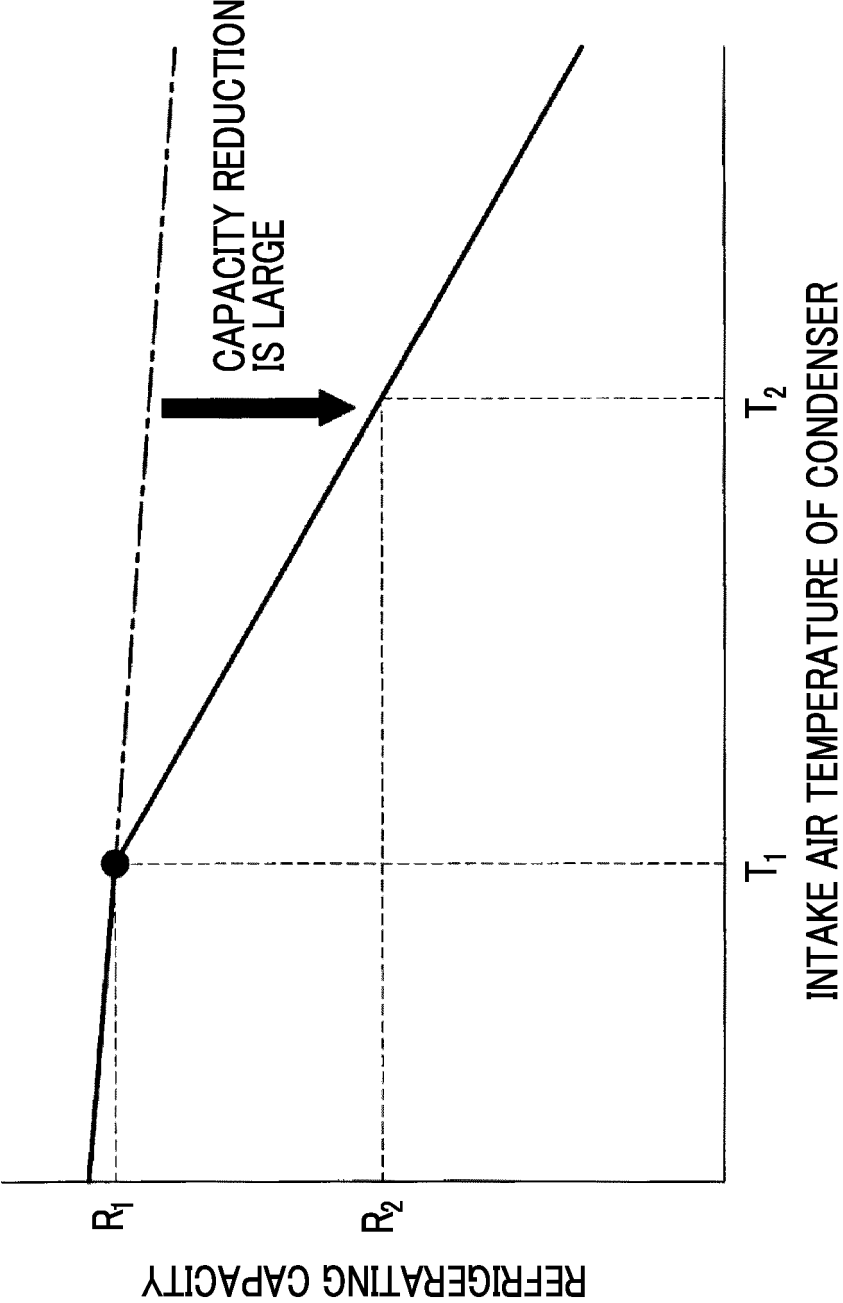


FIG. 7

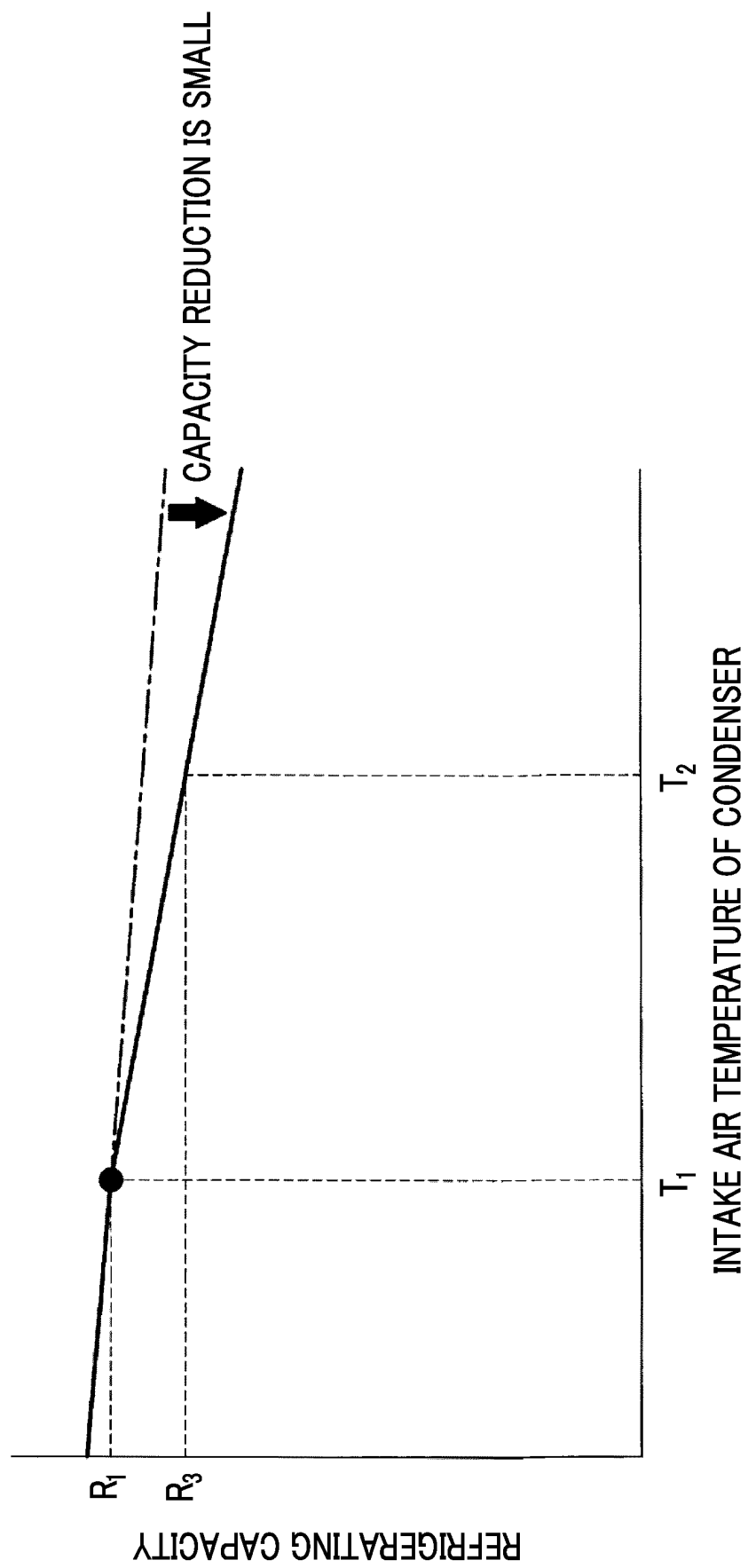


FIG. 8

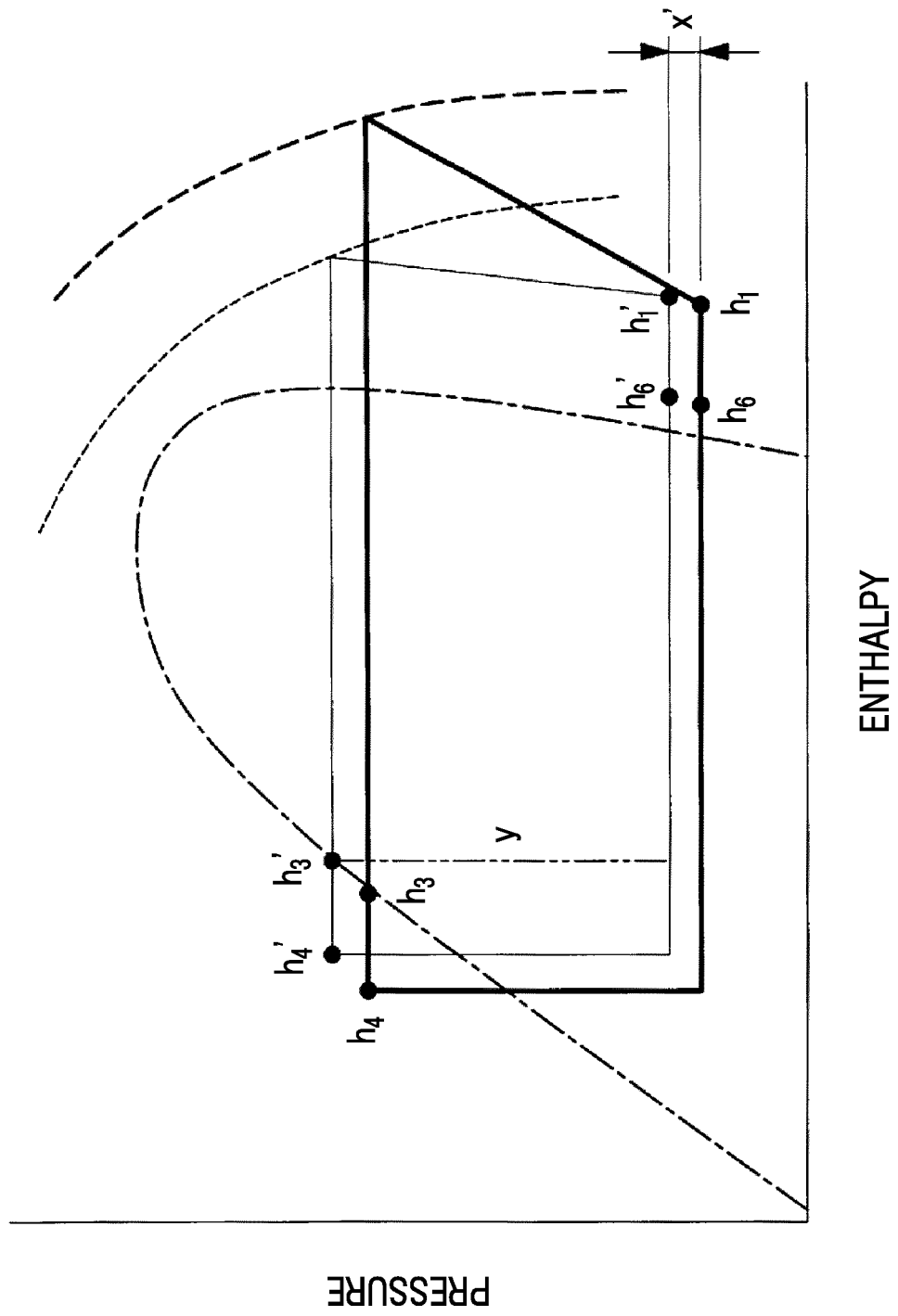
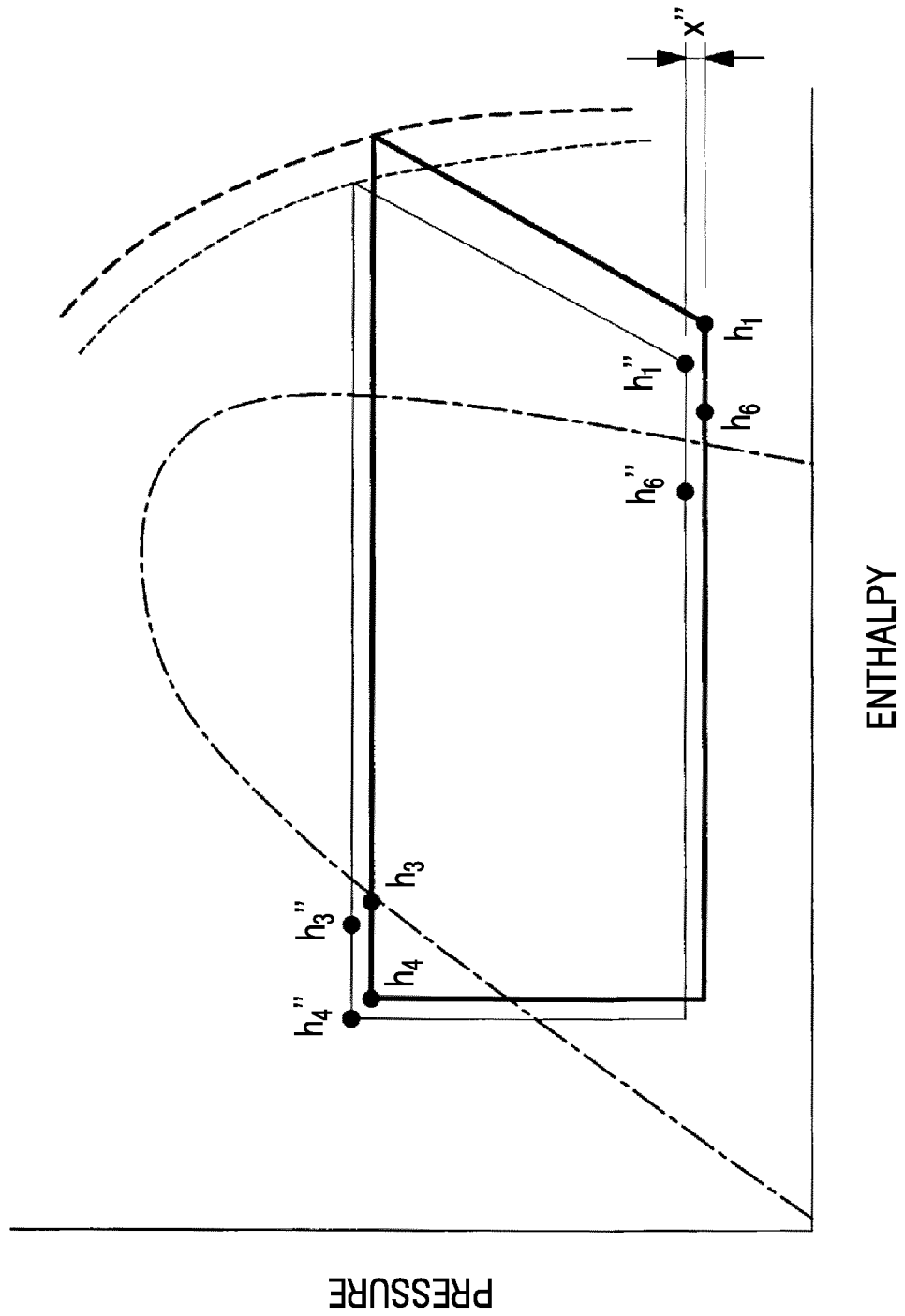


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/013853

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F25B1/00 (2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F25B1/00

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 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 61-62770 A (HITACHI, LTD.) 31 March 1986, page 1, right column, line 16 to page 3, upper right column, line 13, fig. 1-3 (Family: none)	1-4, 6-8 5
Y A	JP 2006-125738 A (SANYO ELECTRIC CO., LTD.) 18 May 2006, paragraphs [0004], [0005], [0042], fig. 3 (Family: none)	1-4, 6-8 5
Y A	JP 4-356664 A (TOSHIBA CORPORATION) 10 December 1992, paragraphs [0019], [0033], fig. 1, 2 (Family: none)	3-4, 6 5



Further documents are listed in the continuation of Box C.



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"&" document member of the same patent family

Date of the actual completion of the international search
28.05.2019Date of mailing of the international search report
11.06.2019Name and mailing address of the ISA/
Japan Patent Office
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Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/013853

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 58-184454 A (HITACHI, LTD.) 27 October 1983, page 2, lower left column, line 9 to lower right column, line 4, fig. 4 (Family: none)	4, 6 5
A	JP 2016-217614 A (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 22 December 2016, entire text, all drawings (Family: none)	1-8
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 063585/1980 (Laid-open No. 163257/1981) (DAIKIN INDUSTRIES, LTD.) 04 December 1981, entire text, all drawings (Family: none)	1-8

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REFERENCES CITED IN THE DESCRIPTION

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