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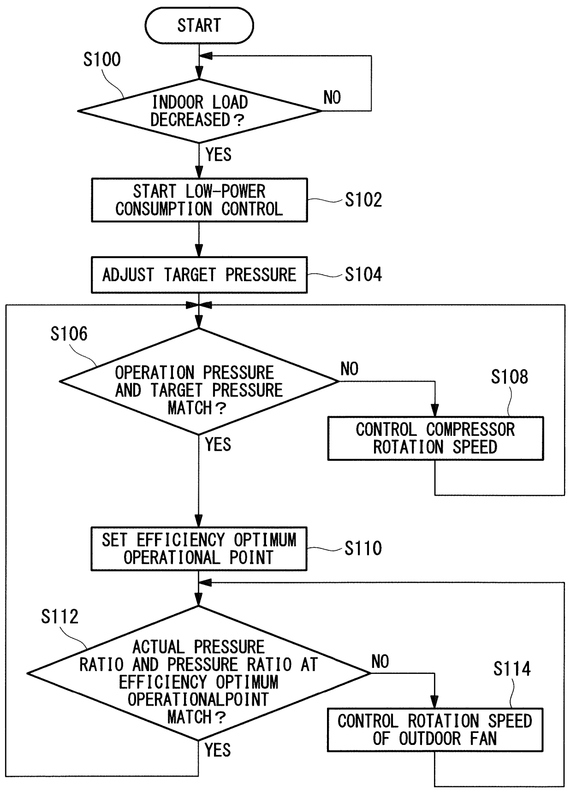
(54) **AIR CONDITIONING SYSTEM CONTROL DEVICE, AIR CONDITIONING SYSTEM, AIR CONDITIONING CONTROL PROGRAM, AND AIR CONDITIONING SYSTEM CONTROL METHOD**

(57) An air conditioning control device controls a multi-split air conditioning system so that the operating pressure of refrigerant. remains constant regardless of the indoor load. This air conditioning control device controls the rotational speed of a compressor so that the operating pressure of the refrigerant reaches a predetermined target pressure, and then after this control, controls a pressure ratio, which is the ratio of the high pressure of the refrigerant to the low pressure of the refrigerant, so that compressor efficiency is at an operating point where the efficiency is improved. Thus, the air conditioning control device can reduce compressor power consumption and allow the compressor to operate more efficiently.

FIG. 4



EP 3 260 792 A1

Description

Technical Field

[0001] The present invention relates to a control device for an air-conditioning system, an air-conditioning system, a control program for an air-conditioning system, and a control method for an air-conditioning system.

Background Art

[0002] For example, in some multi-type air-conditioning systems, which are air-conditioning systems in which one outdoor unit is connected to a plurality of indoor units, the refrigerant operation pressure is regulated independently of the indoor load and control (hereinafter referred to as "pressure regulating control") is given for ensuring performances needed for the respective loads in the plurality of indoor units.

[0003] Patent Citation 1 discloses an air-conditioning system including an injection circuit having one terminal connected between an expansion valve and an indoor heat exchanger, and another terminal connected to a compressor, as a refrigerating cycle for providing an air-conditioning performance corresponding to a needed work capacity without decreasing compressor work efficiency. In Patent Citation 1, when a rotation speed of the compressor is in a rotation speed range of the compressor performance curve in a down grade, a gas refrigerant is injected to the compressor, and when the rotation speed of the compressor is in a rotation speed range of the compressor performance curve in an up grade, a gas refrigerant is not injected to the compressor.

[0004] Further, in some cases, in addition to pressure regulating control, control (hereinafter referred to as "energy-saving control") for adjusting the target pressure with a decrease in indoor load is performed. Such a decrease in indoor load occurs, for example, when the indoor suction temperature approaches a set temperature. The target pressure is adjusted by controlling the rotation speed of the compressor. For example, needed performance is suppressed by increasing the target low pressure during cooling, and decreasing the target high pressure during heating. This leads to a reduction in the power consumption of the compressor.

[Citation List]

[Patent Citation]

[0005] Patent Citation 1: Japanese Unexamined Patent Application, Publication No. 2013-119957

Disclosure of Invention

[Technical Problem]

[0006] However, the air-conditioning system disclosed in Patent Citation 1 requires an injection circuit, which complicates the configuration of the refrigerant circuit.

[0007] Besides, under energy-saving control, adjusting the target pressure may cause the compressor to operate at an operational point deviated from an operational point that is efficient for the compressor.

[0008] It is an object of the present invention to provide a control device for an air-conditioning system, an air-conditioning system, a control program for an air-conditioning system, and a control method for an air-conditioning system that reduce the power consumption of a compressor and allows the compressor to operate efficiently.

[Solution to Problem]

[0009] To achieve this object, a control device for an air-conditioning system, an air-conditioning system, a control program for an air-conditioning system, and a control method for an air-conditioning system of the present invention employ the following solutions.

[0010] A control device for an air-conditioning system according to the first aspect of the present invention includes: a pressure control means that controls a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and a compression ratio control means that controls a pressure ratio between high pressure and low pressure of the refrigerant after control by the pressure control means, in order to provide an operational point that improves efficiency of the compressor.

[0011] A control device for an air-conditioning system according to this aspect performs, for example, control for regulating the operation pressure of the refrigerant to be constant, independently of the indoor load.

[0012] With the pressure control means, the rotation speed of the compressor is controlled such that the operation pressure of the refrigerant becomes a predetermined target pressure. This leads to a reduction in power consumption.

[0013] However, control by the pressure control means may cause the compressor to operate at an operation position deviated from an operation position that is efficient for the compressor.

[0014] For this reason, after the control by the pressure control means, a pressure ratio which is a ratio between the high pressure and low pressure of the refrigerant is controlled to provide an operational point that improves the efficiency of the compressor.

[0015] Accordingly, this aspect reduces the power consumption of the compressor and allows the compressor to operate more efficiently.

[0016] In this first aspect, the pressure control means may decrease the rotation speed of the compressor such that the operation pressure becomes the target pressure.

[0017] According to this aspect, the performance of the air-conditioning system is suppressed and the power consumption of the air-conditioning system is reduced.

[0018] In the first aspect, the compression ratio control means may control the pressure ratio without changing the rotation speed of the compressor.

[0019] According to this aspect, the rotation speed of the compressor is not changed. In particular, the control of the pressure ratio is achieved without controlling the compressor, thereby easily changing the operational point of the compressor to a desired value.

[0020] In the first aspect, the compression ratio control means may control the pressure ratio by controlling the rotation speed of a fan provided to an outdoor unit.

[0021] According to this aspect, the operational point of the compressor can easily be changed to a desired value.

[0022] In the first aspect, the compression ratio control means may control the pressure ratio by controlling the degree of opening of an expansion valve provided to an outdoor unit.

[0023] According to this aspect, the operational point of the compressor can easily be changed to a desired value.

[0024] The air-conditioning system according to the second aspect of the present invention includes an outdoor unit; an indoor unit; and the control device described above.

[0025] A control program for an air-conditioning system according to the third aspect of the present invention causes a computer to function as: a pressure control means that controls a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and a compression ratio control means that controls a pressure ratio between high pressure and low pressure of the refrigerant after control by the pressure control means, in order to provide an operational point that improves efficiency of the compressor.

[0026] A control method for an air-conditioning system according to the fourth aspect of the present invention includes: a first step of controlling a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and a second step of controlling a pressure ratio between high pressure and low pressure of the refrigerant after control by the first step, in order to provide an operational point that improves efficiency of the compressor.

[Advantageous Effects of Invention]

[0027] The present invention provides advantageous effects of a reduction in the power consumption of a compressor and efficient operation of the compressor.

Brief Description of Drawings

[0028]

[FIG. 1] FIG. 1 is a diagram of a refrigerant circuit of a multi-type air-conditioning system according to one embodiment of the present invention.

[FIG. 2] FIG. 2 is a block diagram showing an electrical configuration of an air conditioner control device according to one embodiment of the present invention.

[FIG. 3] FIG. 3 is an efficiency map of a compressor according to one embodiment of the present invention.

[FIG. 4] FIG. 4 is a flow chart of an efficiency-enhancing control process according to one embodiment of the present invention.

[FIG. 5] FIG. 5 is an efficiency map of a compressor according to one embodiment of the present invention.

Best Mode for Carrying Out the Invention

[0029] One embodiment of a control device for an air-conditioning system, an air-conditioning system, a control program for an air-conditioning system, and a control method for an air-conditioning system according to the present invention will now be described with reference to the drawings.

[0030] FIG. 1 is a diagram of a refrigerant circuit of a multi-type air-conditioning system in which one outdoor unit according to one embodiment of the present invention is connected to a plurality of indoor units.

[0031] In a multi-type air-conditioning system 1, a plurality of indoor units 3A and 3B are parallel-connected to one outdoor unit 2. The plurality of indoor units 3A and 3B are parallel-connected to each other through a branching unit 6 between gas-side piping 4 and liquid-side piping 5 connected to the outdoor unit 2.

[0032] The outdoor unit 2 is provided with an inverter-driven compressor 10 that compresses a refrigerant; a four-way switching valve 12 that switches the circulation direction of the refrigerant; an outdoor heat-exchanger 13 that exchanges heat between the refrigerant and outside air; a supercooling coil 14 that is formed integrally with the outdoor heat-exchanger 13; an outdoor expansion valve (EEVH) 15; a receiver 16 that accumulates a liquid refrigerant; a supercooling heat exchanger 17 that subjects the liquid refrigerant to supercooling; a supercooling expansion valve (EEVSC) 18 that controls the amount of refrigerant flowing into the supercooling heat exchanger 17; an accumulator 19 that separates a liquid component from refrigerant gas to be suctioned into the compressor 10, thus allowing only a gaseous component to be suctioned into the compressor 10; a gas-side operation valve 20; and a liquid-side operation valve 21.

[0033] The above-described devices in the outdoor unit 2 are sequentially connected via a refrigerant pipe 22, thus configuring a known outdoor-side refrigerant circuit 23. Furthermore, the outdoor unit 2 is provided with an outdoor fan 24 that blows outside air toward the outdoor heat-exchanger 13.

[0034] The gas-side pipe 4 and the liquid-side pipe 5 are refrigerant pipes connected to the gas-side operation valve 20 and the liquid-side operation valve 21 of the outdoor unit 2, respectively, and, at the time of installation at a site, the pipe lengths are appropriately set according to the distances from the outdoor unit 2 to the plurality of indoor units 3A and 3B to be connected to the outdoor unit 2. The plurality of branching units 6 are provided at intermediate points in the gas-side pipe 4 and the liquid-side pipe 5, and the appropriate number of indoor units 3A and 3B are connected via the branching units 6. Accordingly, a single closed refrigeration cycle (refrigerant circuit) 7 is configured.

[0035] The indoor units 3A and 3B are each provided with an indoor heat exchanger 30 that subjects indoor air to heat exchange with the refrigerant, thus cooling or heating the indoor air and making it available for indoor air-conditioning; an indoor expansion valve (EEVC) 31; an indoor fan 32 that circulates indoor air via the indoor heat exchanger 30; and an indoor controller 33. The indoor units 3A and 3B are connected to the branching units 6 via branched gas-side pipes 4A and 4B and branched liquid-side pipes 5A and 5B, which are provided at the indoor sides.

[0036] In the above-described multi-type air-conditioning system 1, a cooling operation is performed as follows.

[0037] High-temperature, high-pressure refrigerant gas that has been compressed at the compressor 10 and discharged therefrom is circulated to the outdoor heat-exchanger 13 by the four-way switching valve 12 and is condensed to liquid at the outdoor heat-exchanger 13 through heat exchange with outside air blown by the outdoor fan 24. This liquid refrigerant is further cooled at the supercooling coil 14, then passes through the outdoor expansion valve 15, and is temporarily accumulated in the receiver 16.

[0038] The liquid refrigerant, whose circulation amount is adjusted at the receiver 16, is partially branched from a liquid refrigerant pipe, while flowing in the liquid refrigerant pipe via the supercooling heat exchanger 17, and is subjected to supercooling through heat exchange with the refrigerant that has been adiabatically expanded at the supercooling expansion valve 18. This liquid refrigerant is guided from the outdoor unit 2 to the liquid-side pipe 5 via the liquid-side operation valve 21 and is branched, via the branching unit 6, into the branched liquid-side pipes 5A and 5B of the indoor units 3A and 3B.

[0039] The liquid refrigerant flowing into the branched liquid-side pipes 5A and 5B flows into each of the indoor units 3A and 3B, is adiabatically expanded at the indoor expansion valve 31, and flows into the indoor heat exchanger 30 in the form of a gas-liquid two-phase flow. At the indoor heat exchanger 30, heat exchange is performed between indoor air circulated by the indoor fan 32 and the refrigerant, thus cooling the indoor air and making it available for indoor cooling. On the other hand, the refrigerant is gasified, flows into the branching unit 6 via the corresponding branched gas-side pipe 4A or 4B, and joins, in the gas-side pipe 4, the refrigerant gas flowing from the other indoor unit.

[0040] The refrigerant gas joining in the gas-side pipe 4 returns to the outdoor unit 2 again, passes through the gas-side operation valve 20 and the four-way switching valve 12, joins refrigerant gas flowing from the supercooling heat exchanger 17, and is then guided to the accumulator 19. At the accumulator 19, the liquid component contained in the refrigerant gas is separated, and only the gaseous component is suctioned into the compressor 10. This refrigerant is compressed again at the compressor 10, and the above-described cycle is repeated, thereby performing the cooling operation.

[0041] On the other hand, a heating operation is performed as follows.

[0042] High-temperature, high-pressure refrigerant gas that has been compressed at the compressor 10 and discharged therefrom is circulated to the gas-side operation valve 20 via the four-way switching valve 12. This high-pressure gas refrigerant is guided from the outdoor unit 2 via the gas-side operation valve 20 and the gas-side pipe 4 and is guided to the plurality of indoor units 3A and 3B via the branching unit 6 and the branched gas-side pipes 4A and 4B, which are provided at the indoor sides.

[0043] The high-temperature, high-pressure refrigerant gas guided to each of the indoor units 3A and 3B is subjected, at the indoor heat exchanger 30, to heat exchange with the indoor air circulated via the indoor fan 32, and the thus-heated indoor air is blown into the room for heating. On the other hand, the refrigerant condensed to liquid at the indoor heat exchanger 30 reaches the branching unit 6 via the indoor expansion valve 31 and the corresponding branched liquid-side pipe 5A or 5B, joins the refrigerant flowing from the other indoor unit, and returns to the outdoor unit 2 via the liquid-side pipe 5. Note that, during heating, in each of the indoor units 3A and 3B, the degree of opening of the indoor expansion valve 31 is controlled via the indoor controller 33 so that the refrigerant outlet temperature or the degree of supercooling of the refrigerant at the indoor heat exchanger 30, which functions as a condenser, becomes a control target value.

[0044] The refrigerant that has returned to the outdoor unit 2 reaches the supercooling heat exchanger 17 via the liquid-side operation valve 21, is subjected to supercooling as in the case of cooling, and then flows into the receiver 16, where it is temporarily accumulated, thus adjusting the circulation amount. This liquid refrigerant is supplied to the outdoor expansion valve 15, thus being adiabatically expanded, and flows into the outdoor heat-exchanger 13 via the supercooling coil 14.

[0045] At the outdoor heat-exchanger 13, heat exchange is performed between outside air blown from the outdoor fan 24 and the refrigerant, and the refrigerant absorbs heat from the outside air, thus being evaporated and gasified. This refrigerant flows from the outdoor heat-exchanger 13, passes through the four-way switching valve 12, joins the refrigerant gas flowing from the supercooling heat exchanger 17, and is then guided to the accumulator 19. At the accumulator 19, the liquid component contained in the refrigerant gas is separated, and only the gaseous component is suctioned into the compressor 10 and is again compressed at the compressor 10. The above-described cycle is repeated, thereby performing the heating operation.

[0046] FIG. 2 is a block diagram showing the electrical configuration of an air conditioner control device 40 that is responsible for the control of the multi-type air-conditioning system 1 according to this embodiment. It should be noted that FIG. 2 shows functions related to the pressure regulating control and compression ratio control which will be described later in detail.

[0047] The air conditioner control device 40 includes, for example, a central processing unit (CPU), a random access memory (RAM), a read only memory (ROM), and a computer-readable storage medium. A process of a series of steps for achieving various functions is stored in the storage medium in the form of a program which is read out by the CPU into the RAM or the like to subject information to processing and computation, thereby achieving various functions. It should be noted that the program can be installed in advance to the ROM or other storage media, provided while being stored in the computer-readable storage medium, or distributed through communication means in a wired or wireless manner, for example. Examples of the computer-readable storage medium include a magnetic disc, a magneto-optical disc, a CD-ROM, a DVD-ROM, and a semiconductor memory. In addition, the air conditioner control device 40 is provided to the outdoor unit 2.

[0048] The air conditioner control device 40 includes a pressure control unit 42, a pressure ratio control unit 44, and a storage 46.

[0049] For example, the pressure control unit 42 performs pressure regulating control for regulating the operation pressure of the refrigerant to be constant independently of the indoor load. Under pressure regulating control, the rotation speed of the compressor 10 is controlled such that the operation pressure of the refrigerant becomes a predetermined target pressure, thereby ensuring the needed performance of the compressor 10.

[0050] Upon determination of the initial rotation speed of the compressor 10, the pressure regulating control sets the target pressure according to the machine capacity, the rotation speed (operation frequency), and the like. In addition, the suction pressure (low pressure) is detected by a compression sensor during cooling, and the ejection pressure (high pressure) is detected by the compression sensor during heating, as pressure detection values. The pressure regulating control performs comparison between the target pressure and the pressure detection value and controls the rotation speed of the compressor 10. To be specific, the pressure regulating control during cooling decreases the rotation speed of the compressor 10 when the target pressure > the pressure detection value, and increases the rotation speed of the compressor 10 when the target pressure < the pressure detection value. On the other hand, the pressure regulating control during heating increases the rotation speed of the compressor 10 when the target pressure > the pressure detection value, and decreases the rotation speed of the compressor 10 when the target pressure < the pressure detection value. When the target pressure = the pressure detection value, the rotation speed of the compressor 10 is regulated, so that the suction pressure is regulated during cooling and the ejection pressure is regulated during heating.

[0051] After the control by the pressure control unit 42, the pressure ratio control unit 44 performs the control of a pressure ratio (high pressure/low pressure) which is a ratio between the high pressure and low pressure of the refrigerant (hereinafter referred to as "compression ratio control") to provide an operational point that improves the efficiency of the compressor 10.

[0052] The storage 46 stores compressor efficiency distribution information that indicates the distribution of the efficiency of the compressor 10 obtained from the rotation speed of the compressor 10 and the pressure ratio.

[0053] FIG. 3 is an efficiency map showing an example of compressor efficiency distribution information. In FIG. 3, the horizontal axis indicates the rotation speed of the compressor 10, the vertical axis indicates the pressure ratio, and the solid contour lines indicate the efficiency of the compressor 10. In particular, the more generally centered (the inner of the contour line) in the efficiency map of FIG. 3 the point is, the higher the efficiency of the compressor 10. Compressor efficiency distribution information may be stored in storage 46 in the form of a function, a table, or the like independently of an efficiency map like that of FIG. 3.

[0054] Pressure regulating control and compression ratio control executed by the air conditioner control device 40 according to this embodiment will now be explained. In the description below, pressure regulating control and compression ratio control are collectively referred to as efficiency-enhancing control.

[0055] As described above, pressure regulating control regulates the operation pressure of the refrigerant independently of the indoor load. For example, in pressure regulating control according to this embodiment, when the indoor load decreases, the rotation speed of the compressor 10 is reduced such that the pressure of the refrigerant becomes a newly adjusted target pressure, thereby performing energy-saving control for suppressing the performance of the compressor 10.

[0056] A decrease in indoor load refers to the approach of the indoor suction temperature and the set temperature to a predetermined range. If plurality of indoor units 3 are connected like in the multi-type air-conditioning system 1 according to this embodiment, for example, when the difference between the indoor suction temperature and the set temperature of more than half of the indoor units 3 is less than or equal to 1°C, the indoor load is regarded as decreasing.

[0057] If the indoor load decreases during cooling, the pressure control unit 42 increases the current target pressure (target low pressure) to reduce the rotation speed of the compressor 10. On the contrary, if the indoor load decreases during heating, the pressure control unit 42 reduces the current target pressure (target high pressure) to reduce the rotation speed of the compressor 10. The target pressure is adjusted step by step and the difference between the indoor suction temperature and the set temperature is detected upon each adjustment. When the difference increases, the performance of the compressor 10 becomes insufficient for the indoor load, so that the adjustment of the target pressure terminates.

[0058] Variations in the operational point of the compressor 10 under energy-saving control according to this embodiment will be described with reference to FIG. 3.

[0059] The operational point represented by the point A is an operational point given under normal control before adjustment of the target pressure, i.e., before execution of energy-saving control. Meanwhile, the point B is an operational point given after execution of energy-saving control.

[0060] However, the operational point B given after energy-saving control is not necessarily an operational point efficient for the compressor 10. In the example shown in FIG. 3, even at the same rotation speed as that of the operational point B, a region with a high pressure ratio (e.g., a region containing a point C) is an operational point with higher efficiency.

[0061] For this reason, compression ratio control according to this embodiment controls the pressure ratio to provide an operational point (the point C in the example of FIG. 3 and hereinafter referred as "efficiency optimum operational point") that improves the efficiency of the compressor 10.

[0062] Table 1 shows the adjustment of the operational point of the compressor 10 during cooling and heating.

[Table 1]

#1	Cooling
#2	Heating
#3	High pressure
#4	Low pressure
#5	(a) adjust to provide an operational point that provides high efficiency of compressor (pressure ratio control)
#6	(b) decrease target pressure and decrease rotation speed of compressor (low-power consumption control)
#7	(b) increase target pressure and decrease rotation speed of compressor (low-power consumption control)
#8	(a) adjust to provide an operational point that provides high efficiency of compressor (pressure ratio control)

[0063] As shown in Table 1, compression ratio control is performed by controlling the high pressure (ejection pressure) of the refrigerant during cooling, and energy-saving control is performed by controlling the low pressure (suction pressure) of the refrigerant. On the contrary, energy-saving control is performed by controlling the high pressure of the refrigerant during heating, and compression ratio control is performed by controlling the low pressure of the refrigerant. Thus, the objectives of control during cooling and control during heating are different depending on the high pressure or low pressure of the refrigerant.

[0064] The pressure ratio control unit 44 according to this embodiment performs compression ratio control by changing the rotation speed of an outdoor fan 24, for example.

[0065] To be specific, when the pressure ratio after energy-saving control is lower than the efficiency optimum operational point, the rotation speed of the outdoor fan 24 is decreased. Thus, the high pressure of the refrigerant during cooling increases and the low pressure of the refrigerant during heating decreases. Accordingly, the pressure ratio increases, while the operational point approaches the efficiency optimum operational point.

[0066] On the contrary, when the pressure ratio after energy-saving control is higher than the efficiency optimum operational point, the rotation speed of the outdoor fan 24 is increased. Thus, the high pressure of the refrigerant during cooling decreases, while the low pressure of the refrigerant during heating increases. Accordingly, the pressure ratio decreases, while the operational point approaches the efficiency optimum operational point.

[0067] As described above, compression ratio control can be achieved without changing the rotation speed of the compressor 10. In particular, compression ratio control achieves the control of the pressure ratio without controlling the compressor 10 and easily changes the operational point of the compressor 10 to a desired value.

[0068] In addition, the efficiency optimum operational point is predetermined to be, for example, a pressure ratio that provides the highest efficiency for the rotation speed of the compressor 10, and may have a certain width in the scale direction of the pressure ratio.

[0069] FIG. 4 is a flow chart of an efficiency-enhancing control process executed by the air conditioner control device 40. A program for executing this process (an efficiency-enhancing control program) is stored in advance in a predetermined region in the storage 46. It should be noted that before execution of the efficiency-enhancing control process, pressure regulating control (normal control) without energy-saving control is performed in the air conditioner control device 40.

[0070] In Step S100, whether the indoor load has decreased to a level at which energy-saving control can be started is determined. If yes, the process proceeds to Step S102. If no, normal control is continued.

[0071] In Step S102, normal control is terminated and settings are made to start energy-saving control.

[0072] In the next Step S104, the target pressure is adjusted to perform energy-saving control. It should be noted that during cooling, the target pressure (target low pressure) is increased, and during heating, the target pressure (target high pressure) is decreased.

[0073] In the next Step S106, whether the operation pressure matches the adjusted target pressure is determined. If yes, the process proceeds to Step S110. If no, the process proceeds to Step S108.

[0074] In Step S108, the rotation speed of the compressor 10 is controlled such that the operation pressure and the target pressure match. The process returns to Step S106 in which the operation pressure is compared with the adjusted target pressure.

[0075] To be specific, if, during cooling, the low pressure (suction pressure) of the refrigerant is lower than the target low pressure, or if, during heating, the high pressure (ejection pressure) of the refrigerant is higher than the target high pressure, the rotation speed of the compressor 10 is decreased. On the contrary, if, during cooling, the low pressure is higher than the target low pressure, or if, during heating, the high pressure is lower than the target high pressure, the rotation speed of the compressor 10 is increased.

[0076] In Step S110, the efficiency optimum operational point depending on the rotation speed of the compressor 10 is set.

[0077] In the next Step S112, whether the actual pressure ratio and a pressure ratio at the efficiency optimum operational point match is determined. If no, the process proceeds to Step S114. If yes, the process returns to Step S106 and energy-saving control and compression ratio control are repeatedly continued.

[0078] In Step S114, the rotation speed of the outdoor fan 24 is controlled such that the actual pressure ratio and the pressure ratio at the efficiency optimum operational point match. The process returns again to Step S112 in which the pressure ratio is compared with the pressure ratio at the efficiency optimum operational point.

[0079] To be specific, if the actual pressure ratio is lower than the pressure ratio at the efficiency optimum operational point, the rotation speed of the outdoor fan 24 is decreased. Accordingly, during cooling, the high pressure increases, and during heating, the low pressure decreases, so that the actual pressure ratio increases. On the contrary, if the actual pressure ratio is higher than the pressure ratio at the efficiency optimum operational point, the rotation speed of the outdoor fan 24 is increased. Accordingly, during cooling, the high pressure decreases, and during heating, the low pressure increases, so that the actual pressure ratio decreases.

[0080] As described above, the air conditioner control device 40 according to this embodiment controls the rotation speed of the compressor 10 such that the operation pressure of the refrigerant becomes a predetermined target pressure and, after this control, controls the pressure ratio between the high pressure and low pressure of the refrigerant to provide an operational point that improves the efficiency of the compressor 10.

[0081] Accordingly, the air conditioner control device 40 reduces the power consumption of the compressor 10 and allows the compressor 10 to operate more efficiently.

[0082] Although the present invention has been described so far referring to the above embodiment, the technical scope of the present invention is not limited to that of the above embodiment.

[0083] For example, although the rotation speed of the outdoor fan 24 is controlled to control the pressure ratio according to the description of the above embodiment, the present invention is not limited to this, and the degree of opening of the outdoor expansion valve 15 may be controlled to control the pressure ratio.

[0084] In this case, in the above-described Step S114, if the actual pressure ratio is lower than the pressure ratio at the efficiency optimum operational point, the outdoor expansion valve 15 is closed. Accordingly, during cooling, the high pressure increases, and during heating, the low pressure decreases, so that the actual pressure ratio increases. On the contrary, if the actual pressure ratio is higher than the pressure ratio at the efficiency optimum operational point, the outdoor expansion valve 15 is opened. Accordingly, during cooling, the high pressure decreases, and during heating, the low pressure increases, so that the actual pressure ratio decreases.

[0085] Further, both the rotation speed of the outdoor fan 24 and the degree of opening of the outdoor expansion valve 15 may be controlled to control the pressure ratio.

[0086] Moreover, instead of the outdoor expansion valve 15, parallel-connected multiple refrigerant circuits each including a throttle and an electromagnetic valve may be provided and the degree of throttling may be changed by changing the flow path of the refrigerant by opening and closing the electromagnetic valve, thereby controlling the pressure ratio.

[0087] Further, a plurality of outdoor heat-exchangers 13 may be provided and the pressure ratio may be controlled by changing the number (capacity) of outdoor heat-exchangers 13 carrying the refrigerant.

[0088] In addition, although compression ratio control is performed after energy-saving control according to the description of the above embodiment, the present invention is not limited to this and compression ratio control may be performed without energy-saving control.

[0089] In this case, as shown in the example in FIG. 5, after normal control (the operational point A), compression ratio control may be performed to make the operational point of the compressor 10 be the operational point C with higher efficiency.

[0090] Further, although the air conditioner control device 40 performs pressure regulating control for regulating the operation pressure of the refrigerant to be constant independently of the indoor load according to the description of the above embodiment, the present invention is not limited to this and energy-saving control may be performed without pressure regulating control.

[0091] Further, although energy-saving control is performed when the indoor load decreases according to the description of the above embodiment, the present invention is not limited to this and energy-saving control may be performed not only when the indoor load decreases but also when the user (manager) of the multi-type air-conditioning system 1 changes settings, for example, a setting for decreasing the rotation speed of the compressor 10 or a setting for changing the target pressure of the refrigerant.

Explanation of Reference:

[0092]

1:	multi-type air-conditioning system
2:	outdoor unit
3A, 3B:	indoor unit
10:	compressor
15:	outdoor expansion valve
24:	outdoor fan
40:	air conditioner control device
42:	pressure control unit
44:	pressure ratio control unit

Claims

1. A control device for an air-conditioning system, comprising:

a pressure control means that controls a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and

a compression ratio control means that controls a pressure ratio between high pressure and low pressure of the refrigerant after control by the pressure control means, in order to provide an operational point that improves efficiency of the compressor.

2. The control device for an air-conditioning system according to Claim 1, wherein the pressure control means decreases the rotation speed of the compressor such that the operation pressure becomes the target pressure.

3. The control device for an air-conditioning system according to Claim 1 or 2, wherein the compression ratio control means controls the pressure ratio without changing the rotation speed of the compressor.

4. The control device for an air-conditioning system according to any one of Claims 1 to 3, wherein the compression ratio control means controls the pressure ratio by controlling a rotation speed of a fan provided to an outdoor unit.

5. The control device for an air-conditioning system according to any one of Claims 1 to 4, wherein the compression ratio control means controls the pressure ratio by controlling the degree of opening of an expansion valve provided to an outdoor unit.

6. An air-conditioning system comprising:

an outdoor unit;
an indoor unit; and
the control device according to any one of Claims 1 to 5.

7. A control program for an air-conditioning system that causes a computer to function as:

a pressure control means that controls a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and
a compression ratio control means that controls a pressure ratio between high pressure and low pressure of the refrigerant after control by the pressure control means, in order to provide an operational point that improves efficiency of the compressor.

8. A control method for an air-conditioning system, comprising:

a first step of controlling a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and
a second step of controlling a pressure ratio between high pressure and low pressure of the refrigerant after control by the first step, in order to provide an operational point that improves efficiency of the compressor.

Amended claims under Art. 19.1 PCT

1. A control device for an air-conditioning system, comprising:

a pressure control means that controls a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and
a compression ratio control means that controls a pressure ratio between high pressure and low pressure of the refrigerant after control by the pressure control means, in order to provide an operational point that improves efficiency of the compressor, wherein
during cooling, the compression ratio control means controls the high pressure of the refrigerant and the pressure control means controls the low pressure of the refrigerant, and during heating, the pressure control means controls the high pressure of the refrigerant and the compression ratio control means controls the low pressure of the refrigerant.

2. The control device for an air-conditioning system according to Claim 1, wherein the pressure control means decreases the rotation speed of the compressor such that the operation pressure becomes the target pressure.

3. The control device for an air-conditioning system according to Claim 1 or 2, wherein the compression ratio control means controls the pressure ratio without changing the rotation speed of the compressor.

4. The control device for an air-conditioning system according to any one of Claims 1 to 3, wherein the compression ratio control means controls the pressure ratio by controlling a rotation speed of a fan provided to an outdoor unit.

5. The control device for an air-conditioning system according to any one of Claims 1 to 4, wherein the compression ratio control means controls the pressure ratio by controlling the degree of opening of an expansion valve provided to an outdoor unit.

6. An air-conditioning system comprising:

an outdoor unit;
an indoor unit; and
the control device according to any one of Claims 1 to 5.

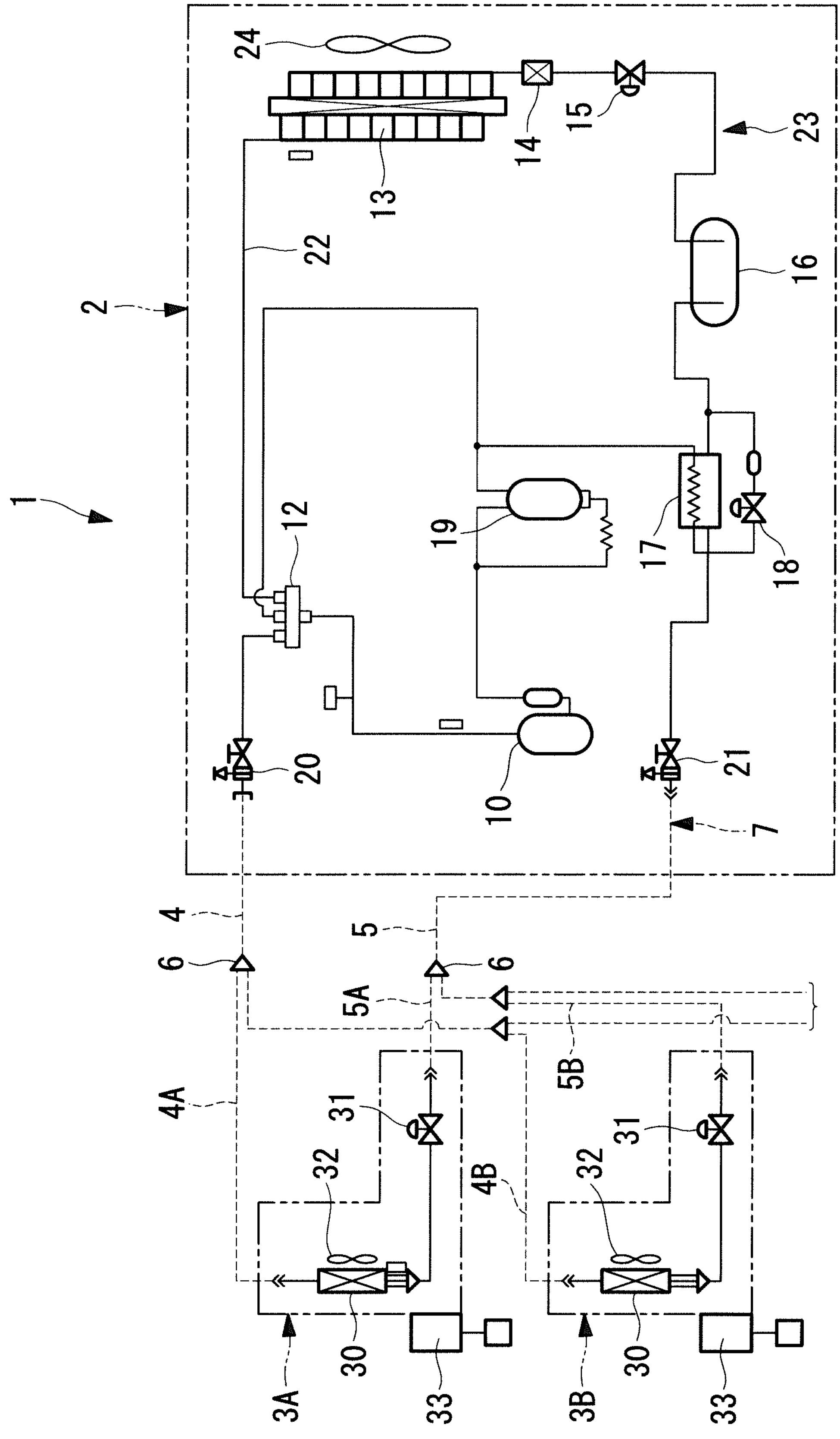
7. A control program for an air-conditioning system that causes a computer to function as:

a pressure control means that controls a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and
a compression ratio control means that controls a pressure ratio between high pressure and low pressure of the refrigerant after control by the pressure control means, in order to provide an operational point that improves efficiency of the compressor, wherein
during cooling, the compression ratio control means controls the high pressure of the refrigerant and the pressure control means controls the low pressure of the refrigerant, and during heating, the pressure control means controls the high pressure of the refrigerant and the compression ratio control means controls the low pressure of the refrigerant.

8. A control method for an air-conditioning system, comprising:

a first step of controlling a rotation speed of a compressor such that an operation pressure of a refrigerant becomes a predetermined target pressure; and
a second step of controlling a pressure ratio between high pressure and low pressure of the refrigerant after control by the first step, in order to provide an operational point that improves efficiency of the compressor, wherein
during cooling, the second step controls the high pressure of the refrigerant and the first step controls the low pressure of the refrigerant, and during heating, the first step controls the high pressure of the refrigerant and the second step controls the low pressure of the refrigerant.

FIG. 1


1
2
4
4A
4B
5
5A
5B
6
7
10
12
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19
20
21
22
23
24
30
31
32
33
3A
3B

FIG. 2

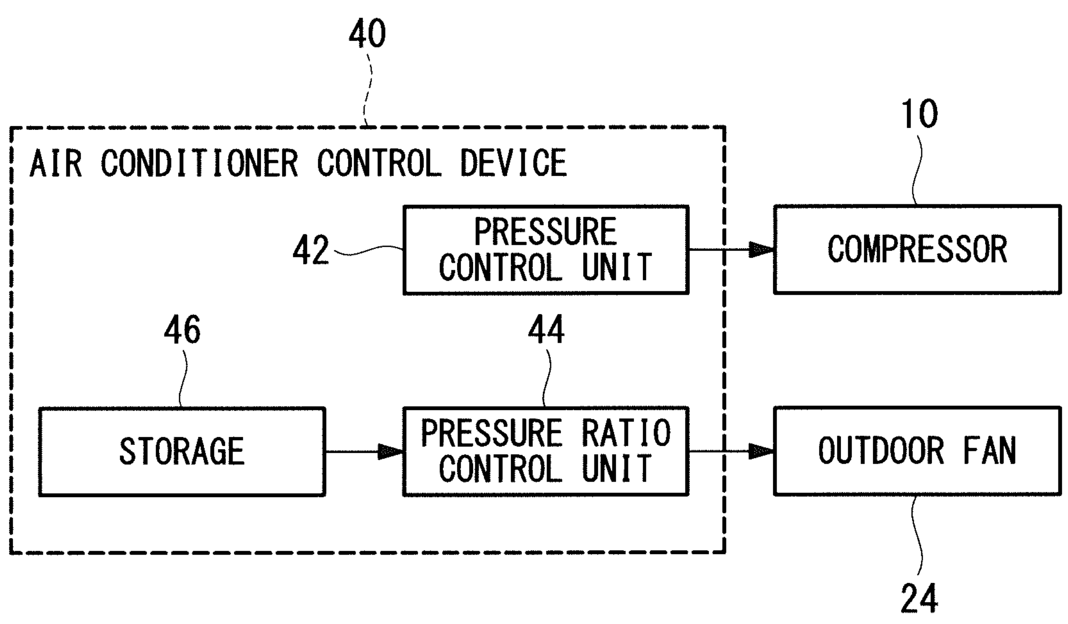

40
AIR CONDITIONER CONTROL DEVICE
42
PRESSURE CONTROL UNIT
46
44
STORAGE
PRESSURE RATIO CONTROL UNIT
10
COMPRESSOR
OUTDOOR FAN
24

FIG. 3

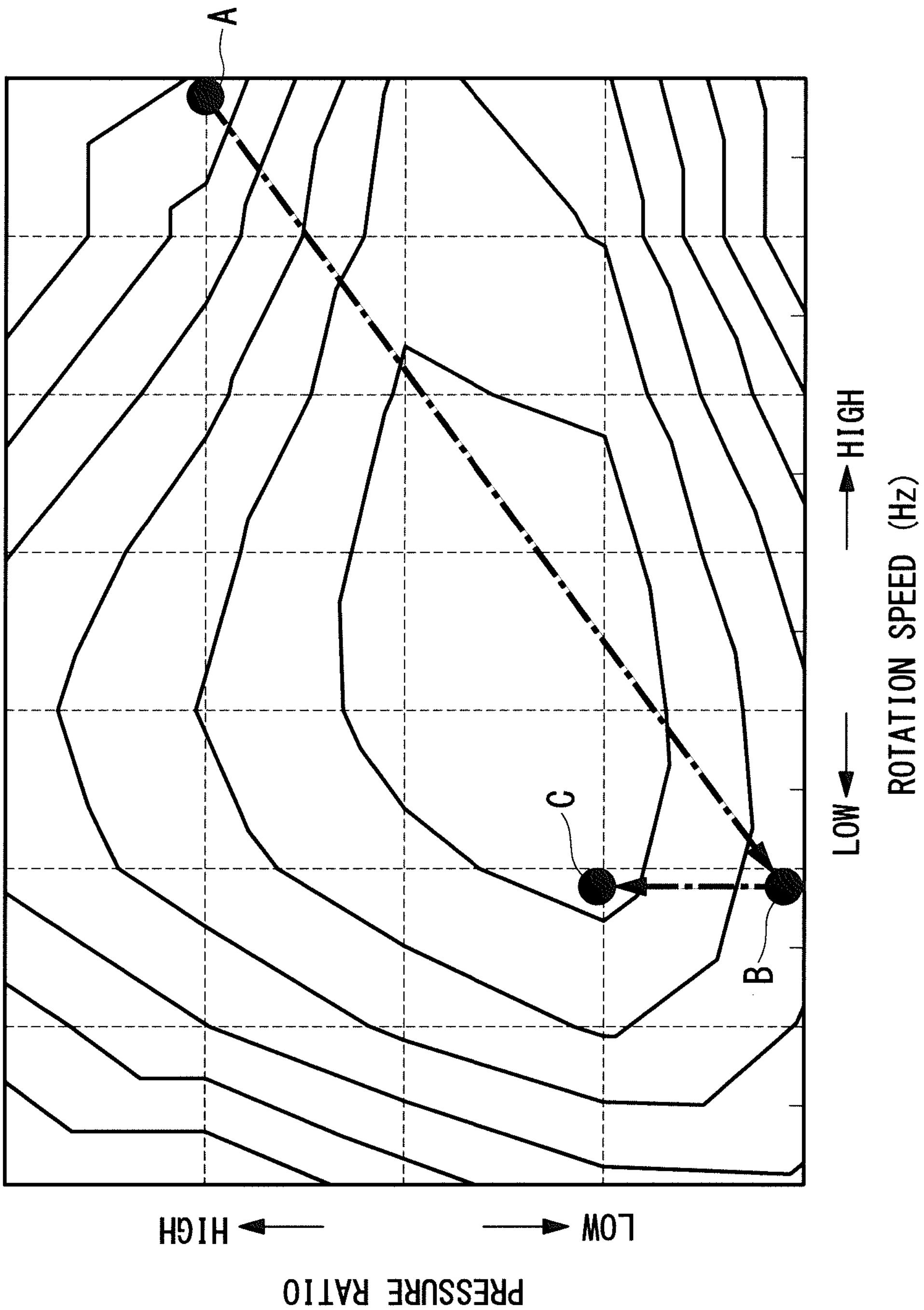


FIG. 4

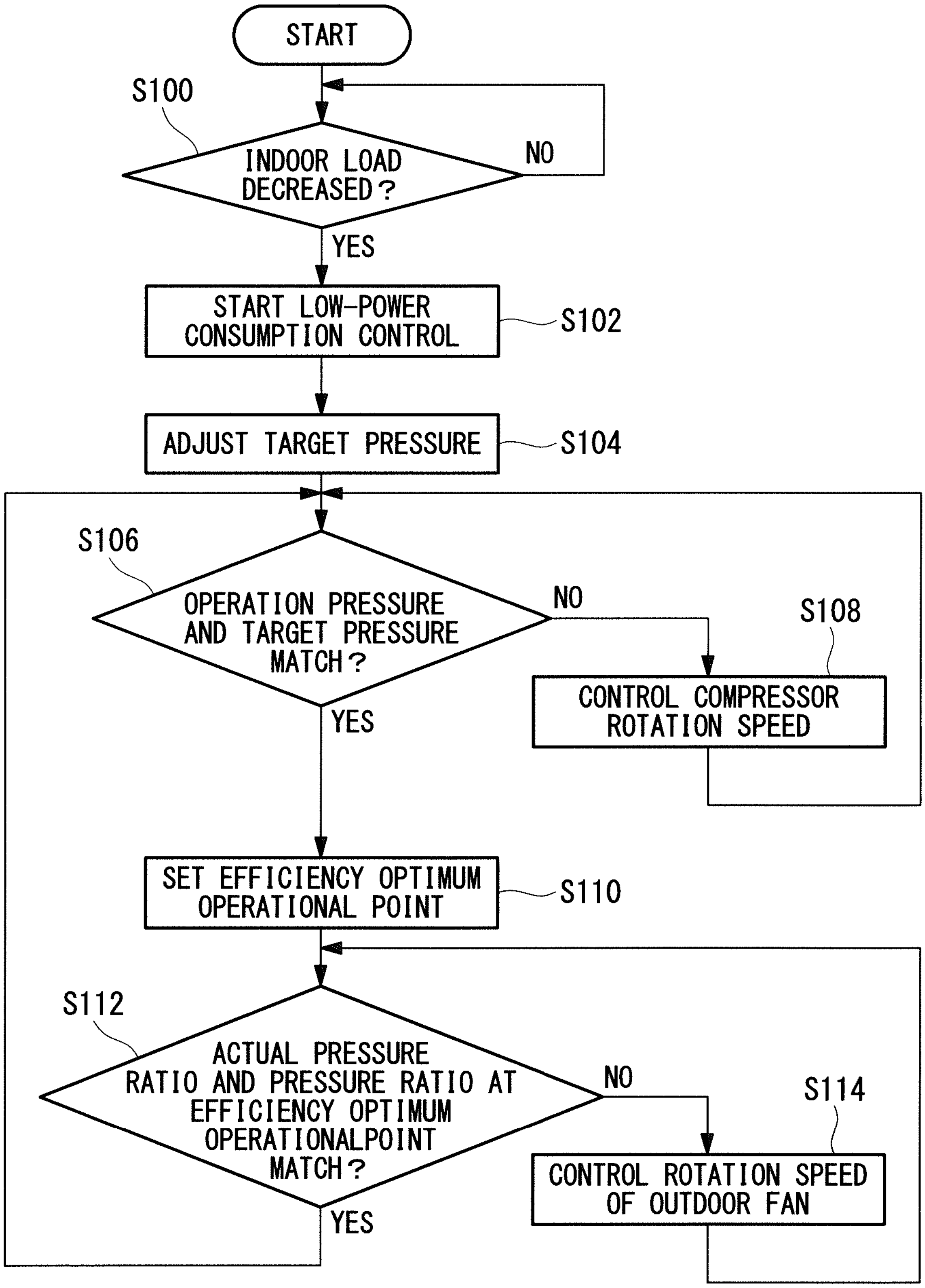
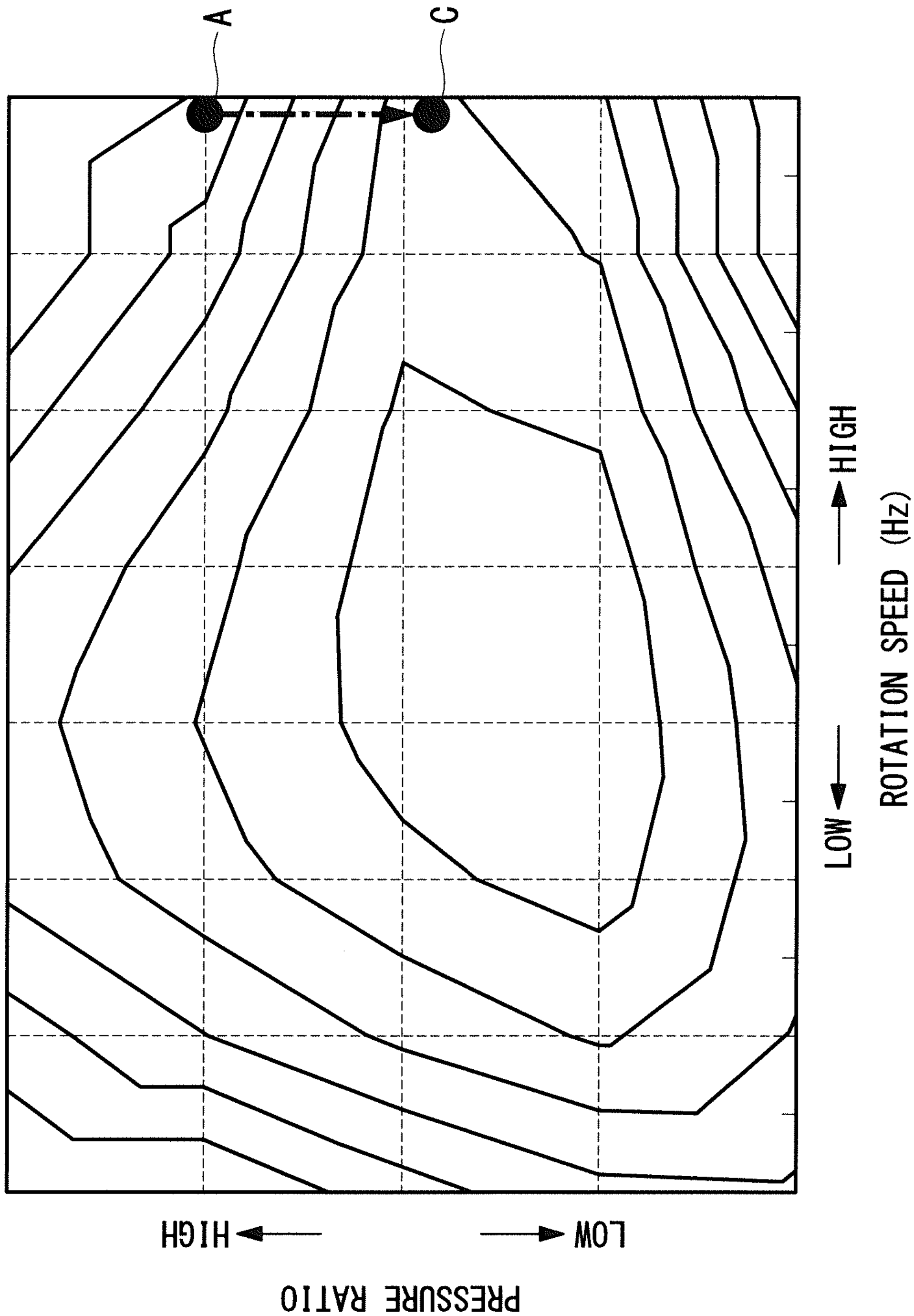

START
S100
INDOOR LOAD DECREASED?
NO
YES
START LOW-POWER CONSUMPTION CONTROL
S102
ADJUST TARGET PRESSURE
S104
S106
OPERATION PRESSURE AND TARGET PRESSURE MATCH?
NO
S108
CONTROL COMPRESSOR ROTATION SPEED
YES
SET EFFICIENCY OPTIMUM OPERATIONAL POINT
S110
S112
ACTUAL PRESSURE RATIO AND PRESSURE RATIO AT EFFICIENCY OPTIMUM OPERATIONALPOINT MATCH?
NO
S114
CONTROL ROTATION SPEED OF OUTDOOR FAN
YES

FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/057550

A. CLASSIFICATION OF SUBJECT MATTER
F24F11/02(2006.01)i, *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)
F24F11/02, F25B1/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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	JP 2000-18685 A (Matsushita Refrigeration Co.), 18 January 2000 (18.01.2000), paragraphs [0025] to [0036]; fig. 1 to 3, 7 (Family: none)	1-8
Y	WO 2014/156313 A1 (Hitachi Appliances, Inc.), 02 October 2014 (02.10.2014), paragraphs [0023] to [0029]; fig. 1, 3 to 4 (Family: none)	1-8
Y	JP 2003-254589 A (Matsushita Electric Industrial Co., Ltd.), 10 September 2003 (10.09.2003), paragraphs [0053] to [0058], [0062] to [0070]; fig. 2, 5 to 6 (Family: none)	2-6

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

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 June 2016 (03.06.16)	14 June 2016 (14.06.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/057550

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-190759 A (Daikin Industries, Ltd.), 21 August 2008 (21.08.2008), paragraphs [0019] to [0039], [0048]; fig. 1 to 5 (Family: none)	1-8
A	JP 2003-262385 A (Hitachi, Ltd.), 19 September 2003 (19.09.2003), paragraphs [0004] to [0026]; fig. 1 to 2 (Family: none)	1-8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013119957 A **[0005]**