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(54) **AIR CONDITIONER**

(57) The present invention provides an air conditioner that can optimize the COP even if usage conditions vary. A refrigerant circuit (**10**) comprises and connects a compressor (**21**), an outdoor heat exchanger (**23**), an indoor expansion valve (**41, 51**), and an indoor heat exchanger (**42, 52**) such that a refrigerant circulates therein. An outdoor fan (**28**) feeds a fluid toward the outdoor heat exchanger (**23**). A heat exchanging temperature sensor (**33**) senses a condensing temperature of the refrigerant. An outdoor temperature sensor (**36**) senses the temperature of the outdoor air, which exchanges heat with the refrigerant inside the outdoor heat exchanger (**23**). A control unit (**8**) controls at least one member selected from the group consisting of the compressor (**21**), the indoor expansion valve (**41, 51**), and the outdoor fan (**28**) using as a target value a value calculated by dividing a degree of supercooling of the refrigerant in the vicinity of an outlet of the outdoor heat exchanger (**23**) by the difference between the condensing temperature ascertained by the heat exchanging temperature sensor **(33)** and the outdoor temperature ascertained by the outdoor temperature sensor (**36**).

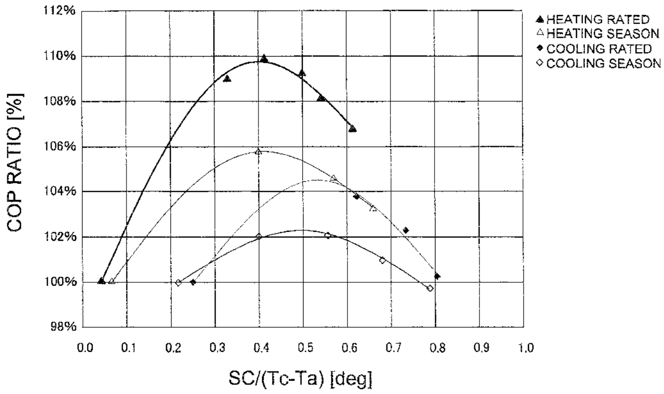

FIG. 4

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Description

TECHNICAL FIELD

[0001] The present invention relates to the control of an air conditioner's operation such that the air conditioner's coefficient of performance is optimized.

BACKGROUND ART

[0002] In a conventional refrigeration apparatus, which comprises a refrigerant circuit that comprises and connects a compressor, a condenser, an expansion valve, and an evaporator, control is performed to improve the coefficient of performance (COP).

[0003] Accordingly, in an air conditioner described in Patent Document 1 below, for example, controlling each component in the refrigerant circuit such that a degree of supercooling remains constant at a target value improves the COP.

Patent Document 1
Japanese Unexamined Patent Application Publication No. 2001-263831

DISCLOSURE OF THE INVENTION

<Technical Problem>

[0004] However, because the target degree of supercooling differs both between a cooling operation and a heating operation and in accordance with the output during these operations, the air conditioner control recited in the abovementioned Patent Document 1 cannot optimize the COP under various conditions.

[0005] The present invention was conceived considering the points discussed above, and it is an object of the present invention to provide an air conditioner that can optimize the COP under any of various conditions.

<Solution to Problem>

[0006] An air conditioner according to a first aspect of the invention comprises a refrigerant circuit, a fluid feeding mechanism, a condensing temperature ascertaining means, a fluid temperature ascertaining means, and a control unit. The refrigerant circuit comprises and connects a compressor, a condenser, an expansion mechanism, and an evaporator such that a refrigerant circulates therein. The fluid feeding mechanism feeds a fluid toward the condenser. The condensing temperature ascertaining means senses a physical quantity in order to derive a condensing temperature of the refrigerant. The fluid temperature ascertaining means senses a physical quantity in order to derive the temperature of the fluid, which exchanges heat with the refrigerant inside the condenser. The control unit controls at least one member selected from the group consisting of the compressor, the expansion mechanism, and the fluid feeding mechanism using as a target value a value calculated by dividing a degree of supercooling of the refrigerant in the vicinity of the condenser outlet by the difference between the condensing temperature ascertained by a detection value of the condensing temperature ascertaining means and a fluid temperature ascertained by a detection value of the fluid temperature sensing means.

[0007] Furthermore, herein, the means of sensing the physical quantity includes, for example, not only sensing the temperature directly with a temperature sensor, but also converting the pressure sensed by a pressure sensor and the like to a temperature.

[0008] Here, it is possible to improve the COP using a simple method of control even if the usage conditions of the air conditioner fluctuate.

[0009] An air conditioner according to a second aspect of the invention is the air conditioner according to the first aspect of the invention that comprises a first fluid temperature ascertaining means and a second fluid temperature ascertaining means. The first fluid temperature ascertaining means senses a physical quantity in order to derive the temperature of the fluid prior to exchanging heat with the refrigerant inside the condenser. The second fluid temperature ascertaining means senses a physical quantity in order to derive the temperature of the fluid after exchanging heat with the refrigerant inside the condenser. Furthermore, the control unit sets the condensing temperature to the temperature ascertained by calculating the average of the detection value of the first fluid temperature ascertaining means and the detection value of the second fluid temperature ascertaining means.

[0010] Here, the COP can be improved even more because a condensing temperature suited to the calculation of the COP is obtained.

[0011] An air conditioner according a third aspect of the invention is the air conditioner according to the first or second aspects of the invention, wherein the target value is greater than or equal to 0.15 and less than 0.75.

[0012] Here, the COP can be even more reliably improved even if ambient environmental conditions fluctuate during operation.

[0013] An air conditioner according a fourth aspect of the invention is an air conditioner according to the first or second aspects of the invention, wherein the target value is greater than or equal to 0.4 and less than 0.6.

[0014] Here, the COP can be even more reliably improved even if ambient environmental conditions fluctuate during operation.

[0015] An air conditioner according to a fifth aspect of the invention is the air conditioner according to any of the first through third aspects of the invention, wherein the fluid temperature ascertaining means senses an outside air temperature in the state wherein the refrigerant circuit is undergoing a cooling operation cycle.

[0016] Here, the outdoor heat exchanger functions as a condenser of the refrigerant during the cooling operation; however, by making the fluid temperature ascertaining means sense the outdoor temperature, the temperature of the air that passes through the outdoor heat exchanger, which functions as the condenser, can be sensed.

[0017] An air conditioner according to a sixth aspect of the invention is the air conditioner according to any of the first through fifth aspects of the invention, wherein the fluid temperature ascertaining means senses an indoor temperature in the state wherein the refrigerant circuit is undergoing a heating operation cycle.

[0018] Here, the indoor heat exchanger functions as a condenser of the refrigerant during the heating operation; however, by making the fluid temperature ascertaining means sense the indoor temperature, the temperature of the air that passes through the indoor heat exchanger, which functions as the condenser, can be sensed.

<Advantageous Effects of Invention>

[0019] In an air conditioner according to the first aspect of the invention, the COP can be improved using a simple method of control even if usage conditions of the air conditioner fluctuate.

[0020] In an air conditioner according to the second aspect of the invention, the COP can be improved even more because a condensing temperature suited to the calculation of the COP is obtained.

[0021] In an air conditioner according to the third aspect of the invention, the COP can be more reliably improved even if ambient environmental conditions fluctuate during operation.

[0022] In an air conditioner according to the fourth aspect of the invention, the COP can be more reliably improved even if ambient environmental conditions fluctuate during operation.

[0023] In an air conditioner according to the fifth aspect of the invention, the temperature of the air that passes through an outdoor heat exchanger, which functions as a condenser, can be sensed.

[0024] In an air conditioner according to the sixth aspect of the invention, the temperature of the air that passes through an indoor heat exchanger, which functions as a condenser, can be sensed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a schematic view of an air conditioner according to one embodiment of the present invention.

FIG. 2 is a control block diagram of the air conditioner.

FIG. 3 is a control flow chart showing a flow when an optimal COP control operation is performed.

FIG. 4 is a graph showing a coefficient of performance versus a value that is calculated by dividing a degree of supercooling by the difference between a condensing temperature and an air temperature.

FIG. 5 is a graph showing a relationship between the condensing temperature and the degree of supercooling that satisfies a prescribed relationship.

FIG. 6 is a schematic drawing of the air conditioner according to a modified example (C).

FIG. 7 is a control block diagram of the air conditioner according to the modified example (C).

FIG. 8 is a graph showing for an air conditioner according to a modified example (G), an APF ratio versus the value that is calculated by dividing the degree of supercooling by the difference between the condensing temperature and the air temperature.

[0026] **FIG. 9** is a conventional graph showing the coefficient of performance versus the degree of supercooling.

EXPLANATION OF THE REFERENCE NUMERALS

[0027]

1	Air conditioner
8	Control unit
10	Refrigerant circuit
21	Compressor
23	Outdoor heat exchanger (condenser)
28	Outdoor fan (fluid feeding mechanism)
33	Heat exchanging temperature sensor (condensing temperature ascertaining means)
36	Outdoor temperature sensor (fluid)
361	Pre-passage outdoor temperature sensor (first fluid temperature ascertaining means)
362	Post-passage outdoor temperature sensor (second fluid temperature ascertaining means)
41, 51	Indoor expansion valves (expansion mechanisms)
42, 52	Indoor heat exchangers (evaporators)

BEST MODE FOR CARRYING OUT THE INVENTION

[0028] The following text explains the embodiments of an air conditioner according to the present invention, referencing the drawings.

<Configuration of Air Conditioner 1>

[0029] **FIG. 1** is a schematic drawing of an air conditioner **1** according to one embodiment of the present invention.

[0030] The air conditioner **1** is used to cool and heat an indoor space of, for example, a building by performing a vapor compression type refrigeration cycle operation. The air conditioner **1** principally comprises: a single outdoor unit **2,** which serves as a heat source unit; a plurality of indoor units **4, 5** (in the present embodiment, two), which are connected in parallel with the outdoor unit **2** and serve as utilization units; and a liquid refrigerant connection piping **6** and a gas refrigerant connection piping **7,** which connect the outdoor unit **2** and the indoor units **4, 5** and serve as refrigerant connection pipings. Namely, a vapor compression type refrigerant circuit **10** of the air conditioner **1** of the present embodiment is configured by the connection of the outdoor unit 2, the indoor units **4, 5,** the liquid refrigerant connection piping **6,** and the gas refrigerant connection piping 7.

<Indoor Units **4, 5**>

[0031] The indoor units **4, 5** are, for example, embedded in or suspended from the indoor ceiling of a building or attached to an indoor wall surface. The indoor units **4, 5** are connected to the outdoor unit **2** via the liquid refrigerant connection piping **6** and the gas refrigerant connection piping 7 and constitute part of the refrigerant circuit **10.**

[0032] The following text explains the configuration of the indoor units **4, 5.** Furthermore, because the indoor unit **4** and the indoor unit **5** are configured similarly, only the configuration of the indoor unit **4** will be explained herein; in addition, the constituent parts of the indoor unit **5** are assigned reference numerals in the 50s instead of the 40s, which are used for the constituent components of the indoor unit **4,** and the explanation of each constituent part of the indoor unit **5** is omitted.

[0033] The indoor unit **4** principally comprises an indoor side refrigerant circuit **10a** (in the indoor unit **5,** an indoor side refrigerant circuit **10b**), which constitutes part of the refrigerant circuit **10.** The indoor side refrigerant circuit **10a** principally comprises an indoor expansion valve **41,** which serves as an expansion mechanism, and an indoor heat exchanger **42,** which serves as a utilization side heat exchanger.

[0034] In the present embodiment, the indoor expansion valve **41** is a motor operated expansion valve that is connected to a liquid side of the indoor heat exchanger **42** and serves to, for example, regulate the flow volume of the refrigerant that flows inside the indoor side refrigerant circuit **10a;** furthermore, the opening and closing of the indoor expansion valve **41** is controlled in accordance with a pulse signal. During the optimal COP control operation discussed below, a control unit **8** controls the indoor expansion valves **41, 51** by, for example, adjusting or fixing their degrees of opening, so as to optimize the COP of the refrigeration cycle.

[0035] In the present embodiment, the indoor heat exchanger **42** is a cross fin type fin and tube heat exchanger that comprises a heat transfer pipe and numerous fins and functions during the cooling operation as an evaporator of the refrigerant, thereby cooling the indoor air, and during the heating operation as a condenser of the refrigerant, thereby heating the indoor air.

[0036] In the present embodiment, the indoor unit **4** comprises an indoor fan **43,** which serves as a ventilation fan that sucks the indoor air into the unit, exchanges heat between that air and the refrigerant via the indoor heat exchanger **42,** and then supplies that air to the indoor space as supplied air. The indoor fan **43** is capable of varying the volume of the air supplied to the indoor heat exchanger **42** and, in the present embodiment, is a centrifugal fan, a multiblade fan, or the like that is driven by a motor **43a,** which has a DC fan motor.

[0037] In addition, the indoor unit **4** is provided with various sensors. A liquid side temperature sensor **44,** which detects the temperature of the refrigerant (i.e., the condensing temperature during the heating operation or the refrigerant temperature that corresponds to the evaporating temperature during the cooling operation), is provided to the liquid side of the indoor heat exchanger **42.** A gas side temperature sensor **45,** which detects the temperature of the refrigerant, is provided to a gas side of the indoor heat exchanger **42.** An indoor temperature sensor **46,** which detects the temperature of the indoor air (i.e., the indoor temperature) that flows into the unit, is provided to the indoor air inlet side of the indoor unit **4.** In the present embodiment, the liquid side temperature sensor **44,** the gas side temperature sensor **45,** and the indoor temperature sensor **46** each has a thermistor. In addition, the indoor unit **4** comprises an indoor side control unit **47,** which controls the operation of all parts that constitute the indoor unit **4.** Furthermore, the indoor side control unit **47** comprises a microcomputer, memory, and the like, which are provided so that the indoor side control unit **47** can control the indoor unit **4;** furthermore, the indoor side control unit **47** can exchange both control signals with a remote control (not shown), which is for the purpose of separately operating the indoor unit **4,** and control signals and the like with the outdoor unit **2** via a transmission line **8a**.

<Outdoor Unit **2**>

[0038] The outdoor unit **2** is installed on the outside of a building, is connected to the indoor units **4, 5** via the liquid refrigerant connection piping **6** and the gas refrigerant connection piping **7,** and constitutes the refrigerant circuit **10** between the indoor units **4, 5.**

[0039] The following text explains the configuration of the outdoor unit **2.** The outdoor unit **2** principally comprises an outdoor side coolant circuit **10c**, which constitutes part of the refrigerant circuit **10**. The outdoor side coolant circuit **10c** principally comprises: a compressor **21;** a four-way switching valve **22;** an outdoor heat exchanger **23,** which serves as a heat source side heat exchanger; an outdoor expansion valve **38,** which serves as an expansion mechanism; an accumulator **24;** a supercooler **25,** which serves as a temperature regulating mechanism; a liquid side shutoff valve **26;** and a gas side shutoff valve **27.**

[0040] The compressor **21** is capable of varying its operating capacity and, in the present embodiment, is a positive-displacement compressor that is driven by a motor **21a** whose rotational speed is controlled by an inverter. In the present embodiment, there is only one compressor **21,** but the present invention is not limited thereto; two or more compressors may be connected in parallel in accordance with, for example, the number of indoor units connected.

[0041] The four-way switching valve **22** switches the refrigerant's flow direction; furthermore, during the cooling operation, the four-way switching valve **22** can both connect a discharge side of the compressor **21** and a gas side of the outdoor heat exchanger **23** as well as an inlet side of the compressor **21** (specifically, the accumulator **24)** and the gas refrigerant connection piping **7** side of the four-way switching valve 22 (refer to the solid lines of the four-way switching valve **22** in **FIG. 1)** in order to cause both the outdoor heat exchanger **23** to function as a condenser of the refrigerant compressed by the compressor **21** and the indoor heat exchangers **42, 52** to function as evaporators of the refrigerant condensed in the outdoor heat exchanger **23;** in addition, during the heating operation, the four-way switching valve **22** can both connect the discharge side of the compressor **21** and the gas refrigerant connection piping 7 side of the four-way switching valve **22** as well as the inlet side of the compressor **21** and the gas side of the outdoor heat exchanger **23** (refer to the broken lines of the four-way switching valve **22** in **FIG. 1)** in order to cause both the indoor heat exchangers **42, 52** to function as condensers of the refrigerant compressed by the compressor **21** and the outdoor heat exchanger **23** to function as an evaporator of the refrigerant condensed in the indoor heat exchangers **42, 52.**

[0042] In the present embodiment, the outdoor heat exchanger **23** is a cross fin type fin and tube heat exchanger that comprises a heat transfer pipe and numerous fins, functions as a condenser of the refrigerant during the cooling operation, and functions as an evaporator of the refrigerant during the heating operation. The gas side of the outdoor heat exchanger **23** is connected to the four-way switching valve **22,** and the liquid side of the outdoor heat exchanger 23 is connected to the liquid refrigerant connection piping 6.

[0043] In the present embodiment, the outdoor expansion valve **38** is a motor operated expansion valve that is connected to the liquid side of the outdoor heat exchanger **23** and serves to regulate the pressure, flow volume, and the like of the refrigerant that flows inside the outdoor side refrigerant circuit **10c.**

[0044] In the present embodiment, the outdoor unit **2** comprises an outdoor fan **28,** which serves as a ventilation fan for the purpose of sucking outdoor air into the unit, exchanging heat between that air and the refrigerant via the outdoor heat exchanger **23,** and then discharging that air to the outdoor space. The outdoor fan **28** is capable of varying the air volume *Wo* of the air supplied to the outdoor heat exchanger **23** and, in the present embodiment, is a propeller fan or the like that is driven by a motor **28a,** which has a DC fan motor.

[0045] The accumulator **24** is a vessel that is connected to and disposed between the four-way switching valve **22** and the compressor **21** and is capable of accumulating surplus refrigerant generated inside the refrigerant circuit **10** in accordance with, for example, fluctuations in the operating loads of the indoor units **4, 5.**

[0046] In the present embodiment, the supercooler 25 is a double pipe type heat exchanger that is provided in order to cool the refrigerant fed to the indoor expansion valves **41, 51** after the refrigerant has been condensed in the outdoor heat exchanger **23.** In the present embodiment, the supercooler **25** is connected to and disposed between the outdoor expansion valve **38** and the liquid side shutoff valve **26.**

[0047] The present embodiment provides a bypass refrigerant circuit **61,** which serves as a cooling source of the supercooler **25.** Furthermore, in the explanation below, the portion of the refrigerant circuit **10** that excludes the bypass refrigerant circuit **61** is called a main refrigerant circuit for the sake of convenience.

[0048] The bypass refrigerant circuit **61** is connected to the main refrigerant circuit such that some of the refrigerant that is fed from the outdoor heat exchanger **23** to the indoor expansion valves **41, 51** branches off from the main refrigerant circuit and returns to the inlet side of the compressor **21.** Specifically, the bypass refrigerant circuit **61** comprises: a branching circuit **61a,** which is connected such that some of the refrigerant that is fed from the outdoor expansion valve **38** to the indoor expansion valves **41, 51** branches from a position between the outdoor heat exchanger **23** and the supercooler **25;** and a merging circuit **61b,** which is connected to the inlet side of the compressor **21** such that the refrigerant returns from an outlet on the bypass refrigerant circuit side of the supercooler **25** to the inlet side of the compressor **21.** Furthermore, a bypass expansion valve **62,** which serves to regulate the flow volume of the refrigerant that flows through the bypass refrigerant circuit **61,** is provided to the branching circuit **61a.** Here, the bypass expansion valve **62** has a motor operated expansion valve. Thereby, the refrigerant that is fed from the outdoor heat exchanger **23** to the indoor expansion valves **41, 51** is decompressed by the bypass expansion valve **62** and then is cooled by the refrigerant that flows through the bypass refrigerant circuit **61** in the supercooler **25.** Namely, the performance of the supercooler **25** is controlled by regulating the degree of opening of the bypass expansion valve **62.** Furthermore, the control **unit 8** also controls the bypass expansion valve **62** by, for example, adjusting or fixing the degree of opening in order to optimize the COP of the refrigeration cycle during optimal COP control operation discussed below.

[0049] The liquid side shutoff valve **26** and the gas side shutoff valve **27** are provided to a connection port that connects to external equipment and piping (specifically, the liquid refrigerant connection piping **6** and the gas refrigerant connection piping 7). The liquid side shutoff valve **26** is connected to the outdoor heat exchanger **23.** The gas side shutoff valve **27** is connected to the four-way switching valve **22.**

[0050] In addition, various sensors are provided to the outdoor unit **2.** Specifically, an inlet pressure sensor **29,** which detects an inlet pressure of the compressor **21,** a discharge pressure sensor **30,** which detects a discharge pressure of the compressor **21,** an inlet temperature sensor **31,** which detects an inlet temperature *Ts* of the compressor **21,** and a discharge temperature sensor **32,** which detects a discharge temperature Td of the compressor **21,** are provided to the outdoor unit **2.** The inlet temperature sensor **31** is provided at a position between the accumulator **24** and the compressor **21.** A heat exchanging temperature sensor **33,** which detects the temperature of the refrigerant that flows inside the outdoor heat exchanger **23** (i.e., the refrigerant temperature that corresponds to the condensing temperature during the cooling operation or the evaporating temperature during the heating operation) is provided to the outdoor heat exchanger **23.** A liquid side temperature sensor **34,** which detects the temperature of the refrigerant, is provided to the liquid side of the outdoor heat exchanger **23.** A liquid pipe temperature sensor **35,** which detects the temperature of the refrigerant (i.e., a liquid pipe temperature), is provided to an outlet on the main refrigerant circuit side of the supercooler **25.** A bypass temperature sensor **63,** which serves to detect the temperature of the refrigerant that flows through the outlet on the bypass refrigerant circuit side of the supercooler **25,** is provided to the merging circuit **61b** of the bypass refrigerant circuit **61.** An outdoor temperature sensor **36,** which detects the temperature of the outdoor air that flows inside the unit (i.e., the outdoor temperature), is provided to the outdoor air inlet side of the outdoor unit **2.**

[0051] In the present embodiment, the inlet temperature sensor **31,** the discharge temperature sensor **32,** the heat exchanging temperature sensor **33,** the liquid side temperature sensor **34,** the liquid pipe temperature sensor 35, the outdoor temperature sensor **36,** and the bypass temperature sensor **63** each has a thermistor.

[0052] In addition, the outdoor unit **2** comprises an outdoor side control unit **37,** which controls the operation of all parts that constitute the outdoor unit **2.** Furthermore, the outdoor side control unit **37** comprises, for example, a microcomputer and memory, which are provided to control the outdoor unit **2,** and an inverter circuit, which controls the motor **21a,** and is capable of exchanging control signals and the like with the indoor side unit 47 in the indoor unit **4** and the indoor side unit 57 in the indoor unit **5** via the transmission line **8a.** Namely, the control unit **8,** which controls the operation of the entire air conditioner **1**, comprises the indoor side control units **47, 57,** the outdoor side control unit **37,** and the transmission line **8a,** which connects the control units **37, 47, 57.**

[0053] As shown in **FIG. 2,** which is a control block diagram of the air conditioner **1**, the control unit 8 is connected such that it can both receive the detection signals of the various sensors **29** to **36, 44** to **46, 54** to **56, 63** and can control the various equipment and valves **21, 22, 24, 28a, 38, 41, 43a, 51, 62** based on these detection signals.

<Refrigerant Connection Pipings 6, 7>

[0054] The refrigerant connection pipings **6, 7** are refrigerant pipings that are laid onsite when the air conditioner 1 is installed at an installation location, such as a building, and comprise pipes of various lengths and pipe diameters in accordance with the installation location and the installation conditions, such as the particular combination of outdoor units and indoor units to be configured.

[0055] As described above, in the air conditioner **1** of the present embodiment, the control unit **8,** which comprises the indoor side control units **47, 57** and the outdoor side control unit **37,** both switches between the cooling operation and the heating operation via the four-way switching valve **22** and controls each piece of equipment of the outdoor unit **2** and the indoor units **4, 5** in accordance with the operating load of each of the indoor units **4, 5.**

<Optimal COP Control Operation>

(Optimal COP Control during the Cooling Operation)

[0056] First, the optimal COP control operation, which is performed during the cooling operation, will be explained, referencing **FIG. 1** and **FIG. 2.**

[0057] If the control unit **8** (more specifically, the indoor side control units **47, 57**, the outdoor side control unit **37**, and the transmission line **8a** that connects the control units **37**, **47, 57**) receives an instruction from, for example, the external remote control (not shown) to perform the cooling operation, then, during the refrigeration cycle, the control unit 8 controls the connection state of the four-way switching valve **22** such that the four-way switching valve **22** is in the state indicated by the solid lines in **FIG. 1**, namely, the state wherein the discharge side of the compressor **21** is connected to the gas side of the outdoor heat exchanger **23** and, further, the inlet side of the compressor **21** is connected to the gas side of the indoor heat exchangers **42, 52** via the gas side shutoff valve **27** and the gas refrigerant connection piping **7.**

[0058] At this time, the outdoor expansion valve **38** is set to the fully open state. The liquid side shutoff valve **26** and the gas side shutoff valve **27** are set to an open state.

[0059] In optimal COP control during the cooling operation, the control unit **8** first calculates a value by dividing a degree of supercooling *SCr* by the difference between a condensing temperature *Tc* of the refrigerant and an air temperature *Ta,* as shown in the flow chart in **FIG. 3** (i.e., step **S10).**

[0060] Furthermore, the method determines whether the value calculated in step **S10** is 0.5 (i.e., step **S20).** Here, if the value calculated in step **S10** is 0.5, then control continues as is.

[0061] Furthermore, if the value calculated in step **S10** is not 0.5, then the control unit **8** performs compensatory control by regulating the degree of opening of each of the indoor expansion valves **41, 51** and the degree of opening of the bypass expansion valve **62** such that the refrigeration cycle can be carried out in the state wherein the value calculated by dividing the degree of supercooling *SCr* by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta* is 0.5 (i.e., step **S30**). Furthermore, the step **S20** is repeated.

[0062] Here, in the present embodiment, each value is detected as described below.

[0063] First, the control unit 8 calculates the degree of supercooling SCr of the refrigerant at the outlet of the outdoor heat exchanger **23** by subtracting the value sensed by the heat exchanging temperature sensor **33,** which detects the temperature of the refrigerant flowing through the outdoor heat exchanger **23,** from the value sensed by the liquid pipe temperature sensor 35, which detects the temperature of the refrigerant at the outlet of the supercooler **25** on the main refrigerant circuit side. In addition, the control unit **8** uses the value sensed by the heat exchanging temperature sensor **33** of the outdoor heat exchanger **23** to ascertain the condensing temperature *Tc* of the refrigerant. Furthermore, the control unit **8** uses the value sensed by the outdoor temperature sensor **36** of the outdoor unit **2** to ascertain a temperature *Ta* of the outdoor air.

[0064] When the refrigerant circuit **10** is in this state, the control **unit 8** activates the compressor **21**, the outdoor fan **28,** and the indoor fans **43, 53.** In so doing, low pressure gas refrigerant is sucked into and compressed by the compressor **21,** thereby turning into high pressure gas refrigerant. Subsequently, the high pressure gas refrigerant is fed to the outdoor heat exchanger **23** via the four-way switching valve **22,** is condensed by the exchange of its heat with the outdoor air supplied by the outdoor fan **28,** and turns into high pressure liquid refrigerant.

[0065] Furthermore, this high pressure liquid refrigerant passes through the outdoor expansion valve **38,** flows into the supercooler **25,** exchanges heat with the refrigerant that flows through the bypass refrigerant circuit **61,** and thereby is further cooled such that it transitions to the supercooled state. At this time, some of the high pressure liquid refrigerant condensed in the outdoor heat exchanger **23** branches to the bypass refrigerant circuit **61** and, after its pressure is reduced by the bypass expansion valve **62,** returns to the inlet side of the compressor **21.** Here, that portion of the refrigerant that passes through the bypass expansion valve **62** evaporates as a result of its pressure being reduced to a level close to that of the inlet pressure of the compressor **21**. Furthermore, the refrigerant that flows from the outlet of the bypass expansion valve **62** of the bypass refrigerant circuit **61** toward the inlet side of the compressor **21** passes through the supercooler **25** and exchanges heat with the high pressure liquid refrigerant that is fed from the outdoor heat exchanger **23** on the main refrigerant circuit side to the indoor units **4, 5.**

[0066] Furthermore, the high pressure liquid refrigerant, which is now in a supercooled state, transits the liquid side shutoff valve **26** and the liquid refrigerant connection piping 6 and is fed to the indoor units **4, 5.** The indoor expansion valves **41, 51** reduce the pressure of the high pressure liquid refrigerant fed to the indoor units **4, 5** such that this pressure almost reaches the inlet pressure of the compressor **21,** and thereby the high pressure liquid refrigerant turns into low pressure refrigerant in the vapor-liquid two-phase state, is subsequently fed to the indoor heat exchangers **42, 52,** exchanges heat with the indoor air via the indoor heat exchangers **42, 52,** evaporates, and turns into low pressure gas refrigerant.

[0067] This low pressure gas refrigerant transits the gas refrigerant connection piping **7**, is fed to the outdoor unit **2,** transits the gas side shutoff valve **27** and the four-way switching valve **22,** and flows into the accumulator **24.** Furthermore, the low pressure gas refrigerant that flows into the accumulator **24** is once again sucked into the compressor **21**.

[0068] The control unit **8** performs the abovementioned optimal COP control operation during the cooling operation by regulating the degree of opening of each of the indoor expansion valves **41, 51** and of the bypass expansion valve **62** and thereby can optimize the coefficient of performance (COP) during the cooling operation.

(optimal COP Control Operation during the Heating Operation)

[0069] The following text explains the optimal COP control operation during the heating operation.

[0070] If the control unit **8** (more specifically, the indoor side control units **47, 57,** the outdoor side control unit **37,** and the transmission line **8a** that connects the control units **37, 47, 57)** receives an instruction from, for example, an external remote control (not shown) to perform the heating operation, then, during the refrigeration cycle, the control unit **8** controls the connection state of the four-way switching valve **22** such that the four-way switching valve **22** is in the state indicated by the broken lines in **FIG. 1**, namely, the state wherein the discharge side of the compressor **21** is connected to the gas side of the indoor heat exchangers **42, 52** via the gas side shutoff valve **27** and the gas refrigerant connection piping **7** and, further, the inlet side of the compressor **21** is connected to the gas side of the outdoor heat exchanger **23.**

[0071] In addition, the control unit **8** sets the liquid side shutoff valve **26** and the gas side shutoff valve **27** to the open state and closes the bypass expansion valve **62.**

[0072] Furthermore, to reduce the pressure of the refrigerant that flows into the outdoor heat exchanger **23** to an extent such that the refrigerant can evaporate (i.e., the evaporating pressure) in the outdoor heat exchanger **23,** the control unit **8** regulates the degree of opening of the outdoor expansion valve **38.**

[0073] In optimal COP control during the heating operation, too, as in the cooling operation, the control unit **8** first calculates a value by dividing a degree of supercooling *SCr* by the difference between a condensing temperature *Tc* of the refrigerant and an air temperature *Ta,* as shown in the flow chart in **FIG.** 3 (i.e., step **S10).**

[0074] Furthermore, the method determines whether the value calculated in step **S10** is 0.5 (i.e., step **S20).** Here, if the value calculated in step **S10** is 0.5, then control continues as is.

[0075] Furthermore, if the value calculated in step **S10** is not 0.5, then the control unit **8** performs compensatory control by regulating the degree of opening of each of the indoor expansion valves **41, 51** such that the refrigeration cycle can be carried out in the state wherein the value calculated by dividing the degree of supercooling *SCr* by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta* is 0.5. Furthermore, the step **S20** is repeated.

[0076] Here, in the present embodiment, each value is detected as described below. First, the control unit **8** detects the degree of supercooling *SCr* of the refrigerant at the outlet of each of the indoor heat exchangers **42, 52** by converting the discharge pressure of the compressor **21** detected by the discharge pressure sensor **30** to the saturation temperature value that corresponds to the condensing temperature and then subtracting the refrigerant temperature value detected by the liquid side temperature sensors **44, 54** from this refrigerant saturation temperature value. In addition, the control unit **8** uses the value sensed by the liquid side temperature sensors **44, 54** of the indoor heat exchangers **42, 52** to ascertain the condensing temperature *Tc* of the refrigerant. Furthermore, the control unit **8** uses the value sensed by the indoor temperature sensors **46, 56** of the indoor units **4, 5** to ascertain the temperature *Ta* of the indoor air.

[0077] If the control unit **8** activates the compressor **21,** the outdoor fan **28,** and the indoor units **43, 53** when the refrigerant circuit **10** is in this state, the low pressure gas refrigerant is sucked into and compressed by the compressor **21,** turns into a high pressure gas refrigerant, and is then fed to the indoor units **4, 5** via the four-way switching valve **22,** the gas side shutoff valve **27,** and the gas refrigerant connecting pipe **7**.

[0078] Furthermore, the high pressure gas refrigerant fed to the indoor units **4, 5** exchanges heat with the indoor air in the indoor heat exchangers **42, 52** and is thereby condensed and transitions to high pressure liquid refrigerant, after which it passes through the indoor expansion valves **41, 51,** at which time its pressure is reduced in accordance with the degree of opening of each of the indoor expansion valves **41, 51.**

[0079] The refrigerant that passes through the indoor expansion valves **41, 51** is fed to the outdoor unit **2** via the liquid refrigerant connection piping **6,** the refrigerant's pressure is further reduced via the liquid side shutoff valve **26,** the supercooler **25,** and the outdoor expansion valve **38,** and the refrigerant then flows into the outdoor heat exchanger **23.** Furthermore, the vapor-liquid two-phase low pressure refrigerant that flows into the outdoor heat exchanger **23** exchanges heat with the outdoor air supplied by the outdoor fan **28,** evaporates, turns into low pressure gas refrigerant, transits the four-way switching valve **22,** and flows into the accumulator **24.** Furthermore, the low pressure gas refrigerant that flows into the accumulator **24** is once again sucked into the compressor **21.**

[0080] The control unit **8** performs the abovementioned optimal COP control operation during the heating operation by regulating the degree of opening of each of the indoor expansion valves **41, 51** and thereby can optimize the coefficient of performance (COP) during the heating operation.

<Features of the Air Conditioner **1** of the Present Embodiment>

[0081] The air conditioner **1** of the present embodiment has the following features.

[0082] In a conventional air conditioner, a degree of supercooling index that enables COP optimization is defined, and control is performed such that the degree of supercooling remains constant at the value of this index.

[0083] However, with this approach, as shown in, for example, **FIG. 9,** the relationship between the COP and a degree of supercooling *SC* corresponds to the state in which the air conditioner is driven, which is not particularly exceptional. Namely, the optimal degree of supercooling during the cooling rated operation is 7 degree, during the cooling season operation is 3 degree, during the heating rated operation is 9 degree, and during the heating season operation is 4 degree. Furthermore, if the refrigeration cycle is controlled using a specific value as the target degree of supercooling, then the optimal degree of supercooling will vary with the conditions, thereby making it impossible to optimize the COP. Furthermore, if a target degree of supercooling that corresponds to the abovementioned state is used and the refrigeration cycle is controlled such that the target degree of supercooling is maintained at a constant level, then not only would it be necessary to retain numerous target values, but control would become complicated and optimizing the COP may not be possible. Furthermore, here, it is assumed that, for example, the outside air temperature is in the range of 18°C through 20°C during the cooling season and in the range of 13°C through 18°C during the heating season.

[0084] In contrast, in the air conditioner **1** of the present embodiment, the control unit **8** performs control wherein the degree of opening of, for example, each of the indoor expansion valves **41, 51** is regulated such that the refrigeration cycle can be performed in the state wherein the value calculated by dividing the degree of supercooling *SCr* by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta* is

0.5. Here, with reference to the relationship between the COP and the value calculated by dividing the degree of supercooling by the difference between the condensing temperature and the air temperature as shown in **FIG. 4,** then it is evident that under every condition, regardless of whether it is during the cooling rated operation, the cooling season operation, the heating rated operation, or the heating season operation, the optimal value of the COP as calculated by dividing the degree of supercooling by the difference between the condensing temperature and the air temperature will fall within the range of 0.4 through 0.6.

[0085] Consequently, as discussed above, the control unit **8** performs optimal COP control such that the value calculated by dividing the degree of supercooling by the difference between the condensing temperature and the air temperature is 0.5, which makes it possible both to optimize the COP using a simple method of control-that is, merely by setting a single value to a target of 0.5 without maintaining a target value for every condition-and to save energy, whether during the cooling rated operation, the cooling season operation, the heating operation, or the heating season operation.

<Other Embodiments>

[0086] The above text explained an embodiment of the present invention based on the drawings, but the specific configuration of the present invention is not limited to these embodiments, and it is understood that variations and modifications may be effected without departing from the spirit and scope of the invention.

(A)

[0087] The abovementioned embodiment explained an exemplary case wherein the control unit **8** controls the degree of opening of each of the indoor expansion valves **41, 51** such that the value calculated by dividing the degree of supercooling *SCr* by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta* is 0.5.

[0088] However, the present invention is not limited thereto; for example, **FIG.** 5 shows a graph derived by transforming a relational expression between *Tc* and *SC* that satisfies $SCr/(Tc - Ta) = 0.5$. Specifically, the relational expression is $Tc = 2SC + Ta$.

[0089] Furthermore, from among the coordinate values that satisfy this relational expression, for example, the control unit **8** may derive a target coordinate value (S) that is closest to a coordinate value **(P)** of an actual measured value in the current state and may perform various types of control, such as controlling the indoor expansion valves **41, 51,** the bypass expansion valve **62,** and the like, controlling the rotational speed of the motor **43a** of the indoor fan **43,** controlling the rotational speed of the motor **21a** of the compressor **21,** controlling both the adjustment and fixing of the degree of opening of the outdoor expansion valve **38,** controlling the rotational speed of the motor **28a** of the outdoor fan **28,** and so on, such that the degree of supercooling and the condensing temperature at the target coordinate value (S) are achieved.

[0090] Even in this case, effects equal to those in the abovementioned embodiments can be achieved.

(B)

[0091] The abovementioned embodiment explained an exemplary case wherein, when optimal COP control is performed during the heating operation, the control unit **8** detects the degree of supercooling *SCr* by calculating the degree of supercooling *SCr* through converting the discharge pressure of the compressor **21** detected by the discharge pressure sensor **30** to the saturation temperature value that corresponds to the condensing temperature and then subtracting the refrigerant temperature value detected by the liquid side temperature sensors **44, 54** from the refrigerant's saturation temperature value.

[0092] However, the present invention is not limited thereto; for example, temperature sensors that detect the temperature of the refrigerant flowing inside each of the indoor heat exchangers **42, 52** may be provided in advance, and the control **unit 8** may detect the degree of supercooling *SCr* of the refrigerant at the outlets of the indoor heat exchangers **42, 52** by calculating the degree of supercooling *SCr* of optimal COP control during the heating operation through subtracting the refrigerant temperature value that corresponds to the condensing temperature detected by the temperature sensors from the refrigerant temperature value detected by the liquid side temperature sensors **44, 54.**

(C)

[0093] The abovementioned embodiment explained an exemplary case wherein optimal COP control operation is performed using the value sensed by a single sensor that senses a single heat exchanger (i.e., the outdoor temperature sensor **36,** and the indoor temperature sensors **46, 56)** as the air temperature *Ta.*

[0094] However, the present invention is not limited thereto; for example, optimal COP control operation may be performed using the average of values obtained by two temperature sensors per heat exchanger as the air temperature *Ta.*

[0095] Specifically, for example, as shown in **FIG 6** and **FIG. 7,** a pre-passage outdoor temperature sensor **361,** which senses the indoor temperature before air passes through the outdoor heat exchanger **23,** and a post-passage outdoor temperature sensor **362,** which senses the temperature of the air after the air has passed through the outdoor heat exchanger **23** and exchanged heat, may be provided, and the average of the detection values sensed by these sensors may be used as the value of the air temperature *Ta.*

[0096] In such a case, it would be possible to more accurately ascertain the temperature of the air subjected to the exchange of heat, to further optimize the COP, and to save energy.

(D)

[0097] The abovementioned embodiment explained an exemplary case wherein optimal COP control is performed in the refrigerant circuit **10,** which is provided with the bypass refrigerant circuit **61.**

[0098] However, the present invention is not limited thereto; for example, optimal COP control may be performed as it is in the abovementioned embodiment, but on a refrigeration cycle that comprises, for example, only the main refrigerant circuit and not the bypass refrigerant circuit **61** discussed above. In this case as well, it is possible to achieve the energy saving effect of the present invention.

(E)

[0099] The abovementioned embodiment explained an exemplary case of an air cooled air conditioner.

[0100] However, the present invention is not limited thereto; for example, the air conditioner may be a water cooled type wherein water is used as the fluid that passes through the heat exchanger.

(F)

[0101] The abovementioned embodiment explained an exemplary case wherein the control unit **8** controls the degree of opening of each of the indoor expansion valves **41, 51** such that the value calculated by dividing the degree of supercooling *SCr* by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta* is 0.5.

[0102] However, the present invention is not limited thereto; for example, the control **unit 8** may control the degree of opening of each of the indoor expansion valves **41, 51** such that the value calculated by dividing the degree of supercooling *SCr* by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta* falls within a range of greater than or equal to 0.4 and less than 0.6. Even in this case, it is possible to achieve the same effects as those achieved in the abovementioned embodiments.

(G)

[0103] The abovementioned embodiment explained an exemplary case wherein a COP related target value that can yield a satisfactory COP ratio is specified by comparing the value (i.e., the COP related target value) obtained by dividing the degree of supercooling *SCr* by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta* with the COP ratio (i.e., the COP ratio at each degree of supercooling (*SC*) for the case wherein the COP is 100% at a certain degree of supercooling (*SC*)), and then controlling the degree of opening of each of the indoor expansion valves **41, 51** such that the COP related target value falls within the specified range.

[0104] However, the present invention is not limited thereto. For example, as shown in **FIG. 8,** an optimal AFP control may be performed. The optimal AFP control, for example, controlls the degree of opening of each of the indoor expansion valves **41, 51** such that a AFP related target value falls within a specified range. The range of the AFP related target value which can yield a satisfactory AFP (Annual Performance factor) may be specified by comparing the AFP with a value (i.e., the AFP related target value) obtained by dividing the degree of supercooling *SCr* by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta.* Here, when the range of the APF related target value is specified, for example, a range may be derived such that an APF ratio indicated by the ordinate in **FIG. 8** is 100% or greater. This APF ratio is called the APF ratio at each degree of supercooling (*SC*) when the APF is 100% at a certain degree of supercooling (*SC*).

[0105] This APF is a value that indicates the cooling and heating capacity per 1 KW of power consumption when an air conditioner is operated for one year under certain fixed conditions. Here, APF can be calculated by the expression APF = (the aggregate of performance exhibited during the cooling season + the aggregate of performance exhibited during the heating season)/(the aggregate of the amount of power consumed during the cooling season + the aggregate of the amount of power consumed during the heating season).

[0106] Furthermore, APF can be calculated more finely by, for example, complying with the conditions specified in JRA 4048:2006 (i.e., the standard for implementing JIS B8616:2006) created by the Japan Refrigeration and Air Conditioning Industry Association Standards.

[0107] When creating the graph in **FIG. 8,** first, based on measurement conditions specified in the standard, the weighting factor for each COP ratio-that is, the COP ratio during the cooling rated operation, the COP ratio during the cooling season operation, the COP ratio during the heating rated operation, the COP ratio during the heating season operation, and the COP ratio during the heating low temperature operation-is back calculated. Furthermore, each calculated weighting factor is multiplied by the corresponding COP ratio-that is, the COP ratio during the cooling rated operation, the COP ratio during the cooling season operation, the COP ratio during the heating rated operation, the COP ratio during the heating season operation, and the COP ratio during the heating low temperature operation-these values are totaled, and thereby the APF ratio is obtained as a value that can fully evaluate the aggregate of cooling and heating.

[0108] Furthermore, performing an evaluation that is closer to actual usage-by performing optimal APF control that targets a satisfactory APF value-than can be achieved using the COP-which evaluates the performance for a case (i.e., the rated condition) wherein operation is performed under a certain constant temperature condition-makes it possible to obtain a greater energy saving effect.

(H)

[0109] The abovementioned embodiment explained an exemplary case wherein the control unit **8** controls the degree of opening of each of the indoor expansion valves **41**, **51** such that the value calculated by dividing by the difference between the condensing temperature *Tc* of the refrigerant and the air temperature *Ta* is 0.5.

[0110] However, the present invention is not limited thereto; for example, so that values suited to, for example, the season and operating environmental conditions for the COP related target value, the APF related target value, discussed in the modified example (G) section can be used, control may be performed such that, for example, the COP related target value and the APF related target value are modified according to the season, the operating environmental conditions, and the like.

[0111] For example, operation may be performed wherein two different COP related target values and two different APF related target values-one for the circuit connection state wherein the cooling operation is performed and one for the circuit connection state wherein the heating operation is performed-are prescribed.

INDUSTRIAL APPLICABILITY

[0112] The present invention is particularly useful for operating an air conditioner such that it saves energy under various conditions, thereby optimizing the COP even when usage conditions vary.

Claims

1. An air conditioner (**1**), comprising:

    a refrigerant circuit (**10**) comprising and connecting a compressor (**21**), a condenser (**23**), an expansion mechanism **(41, 51),** and an evaporator (**42, 52**) such that a refrigerant circulates therein;
    a fluid feeding mechanism (**28**) feeding a fluid toward the condenser (**23**);
    a condensing temperature ascertaining means (**33**) sensing a physical quantity in order
    to derive a condensing temperature of the refrigerant;
    a fluid temperature ascertaining means (**36**) sensing a physical quantity in order to derive the temperature of the fluid, the fluid exchanging heat with the refrigerant inside the condenser (**23**); and
    a control unit (**8**) controlling at least one member selected from the group consisting of the compressor (**21**), the expansion mechanism **(41, 51),** and the fluid feeding mechanism (**28**) using as a target value a value calculated by dividing a degree of supercooling of the refrigerant in the vicinity of an outlet of the condenser by the difference between the condensing temperature ascertained by a detection value of the condensing temperature ascertaining means (**33**) and a fluid temperature ascertained by a detection value of the fluid temperature sensing means **(36).**

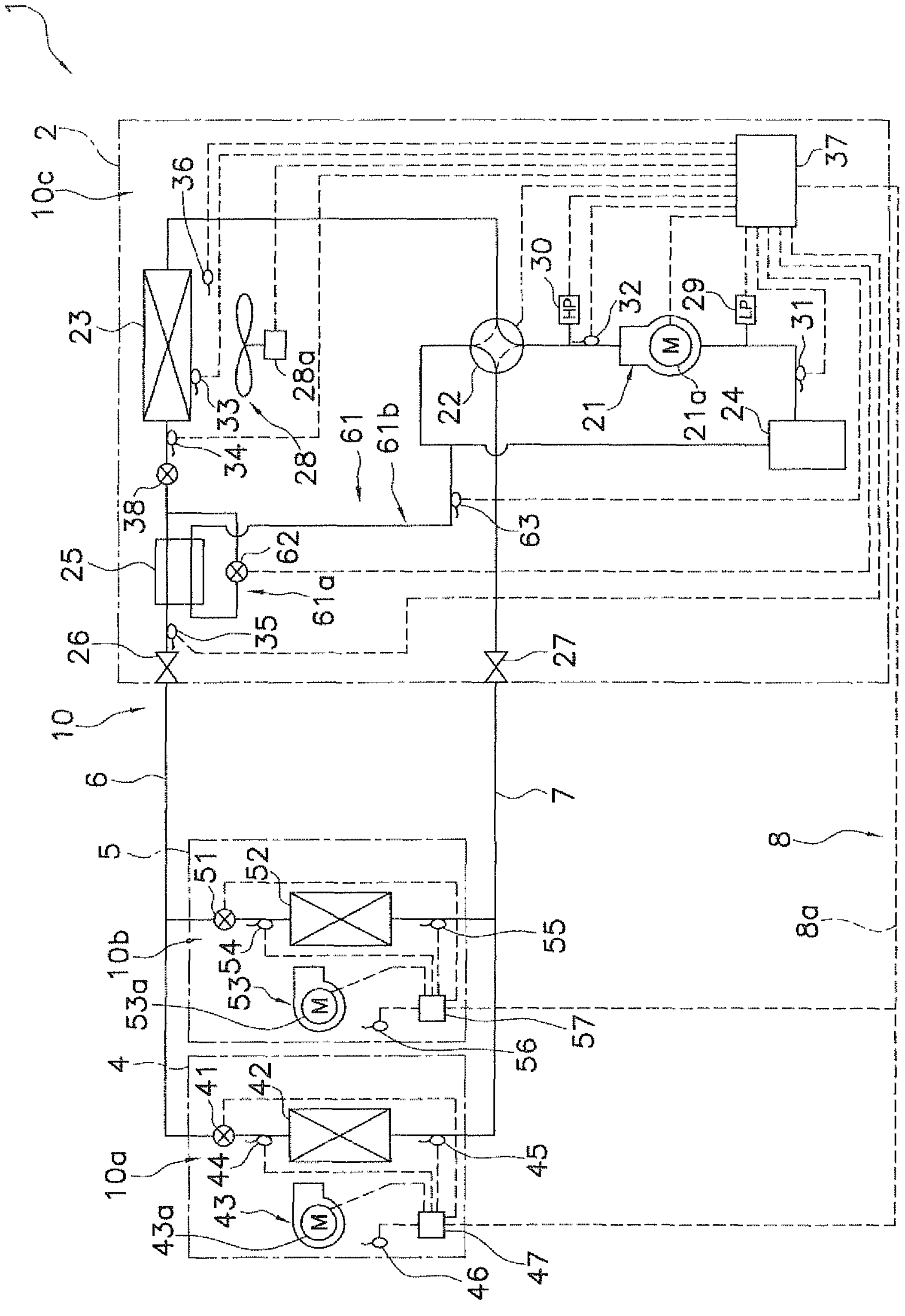
2. The air conditioner **(1)** according to claim 1, wherein the fluid temperature ascertaining means (**36**) comprises a first fluid temperature ascertaining means (**361**) sensing a physical quantity in order to derive the temperature of the fluid prior to exchanging heat with the refrigerant inside the condenser (**23**), and a second fluid temperature ascertaining means (**362**) sensing a physical quantity in order to derive the temperature of the fluid after exchanging heat with the refrigerant inside the condenser (**23**); and
    the control unit (**8**) sets the condensing temperature to the temperature ascertained by calculating the average of the detection value of the first fluid temperature ascertaining means **(36a)** and the detection value of the second fluid temperature ascertaining means **(36b).**

3. The air conditioner (**1**) according to claim 1 or claim 2, wherein
    the target value is greater than or equal to 0.15 and less than 0.75.

4. The air conditioner (**1**) according to claim 1 or claim 2, wherein
    the target value is **greater** than or equal to 0.4 and less than 0.6.

5. The air conditioner (**1**) according to any one of claim 1 through claim 3, wherein the fluid temperature ascertaining means (**36**) senses an outside air temperature in the state wherein the refrigerant circuit (**10**) is undergoing a cooling operation cycle.

6. The air conditioner (**1**) according to any one of claim 1 through claim 5, wherein the fluid temperature ascertaining means (**36**) senses an indoor temperature in the state wherein the refrigerant circuit (**10**) is undergoing a heating operation cycle.


1
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36
23
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32
29
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31
37
33
28a
28
34
22
61
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21
M
21a
24
38
25
62
61a
63
35
26
27
10
6
7
5
51
52
10b
54
53
53a
55
57
56
4
41
42
10a
44
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43
43a
46
47
8
8a

FIG. 1

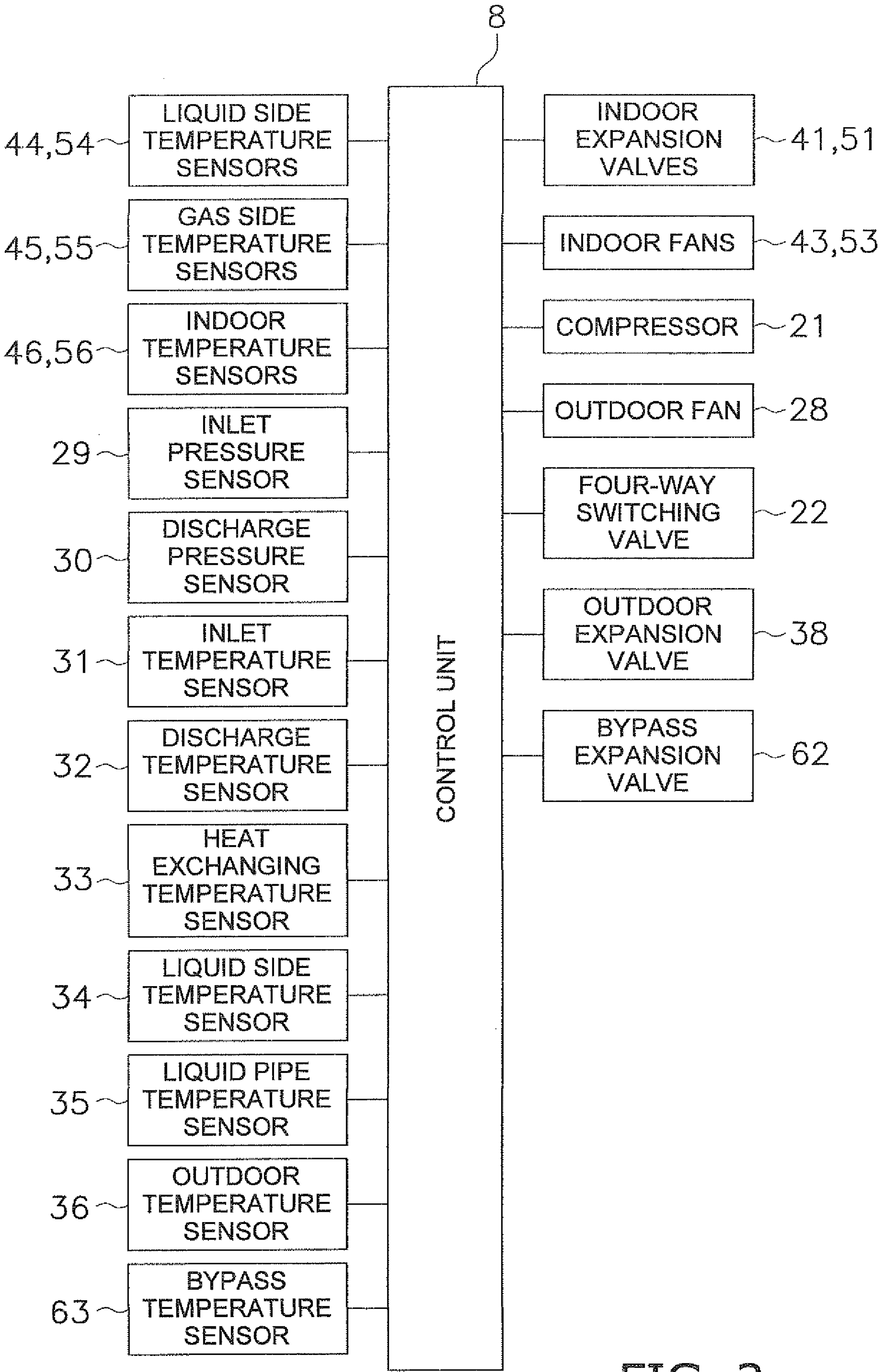
8
CONTROL UNIT
44,54
LIQUID SIDE TEMPERATURE SENSORS
45,55
GAS SIDE TEMPERATURE SENSORS
46,56
INDOOR TEMPERATURE SENSORS
29
INLET PRESSURE SENSOR
30
DISCHARGE PRESSURE SENSOR
31
INLET TEMPERATURE SENSOR
32
DISCHARGE TEMPERATURE SENSOR
33
HEAT EXCHANGING TEMPERATURE SENSOR
34
LIQUID SIDE TEMPERATURE SENSOR
35
LIQUID PIPE TEMPERATURE SENSOR
36
OUTDOOR TEMPERATURE SENSOR
63
BYPASS TEMPERATURE SENSOR
INDOOR EXPANSION VALVES
41,51
INDOOR FANS
43,53
COMPRESSOR
21
OUTDOOR FAN
28
FOUR-WAY SWITCHING VALVE
22
OUTDOOR EXPANSION VALVE
38
BYPASS EXPANSION VALVE
62

FIG. 2

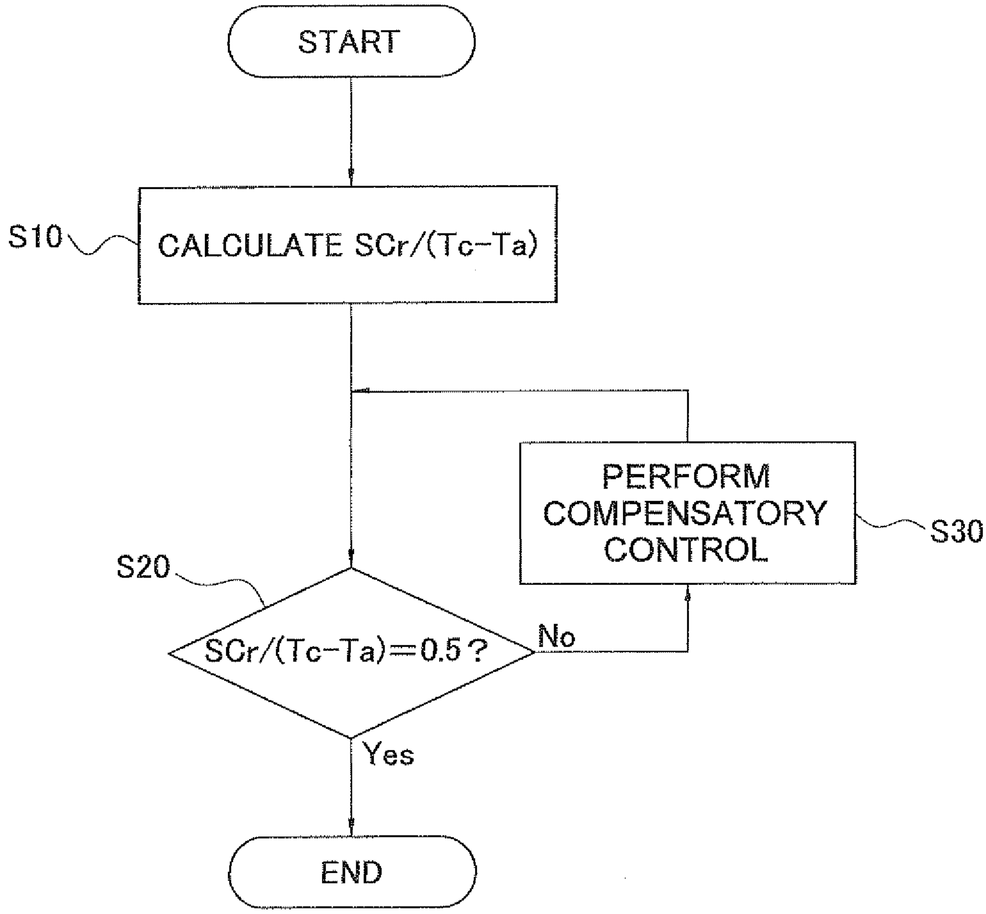
START
S10
CALCULATE SCr/(Tc−Ta)
PERFORM
COMPENSATORY
CONTROL
S30
S20
SCr/(Tc−Ta)=0.5?
No
Yes
END

FIG. 3

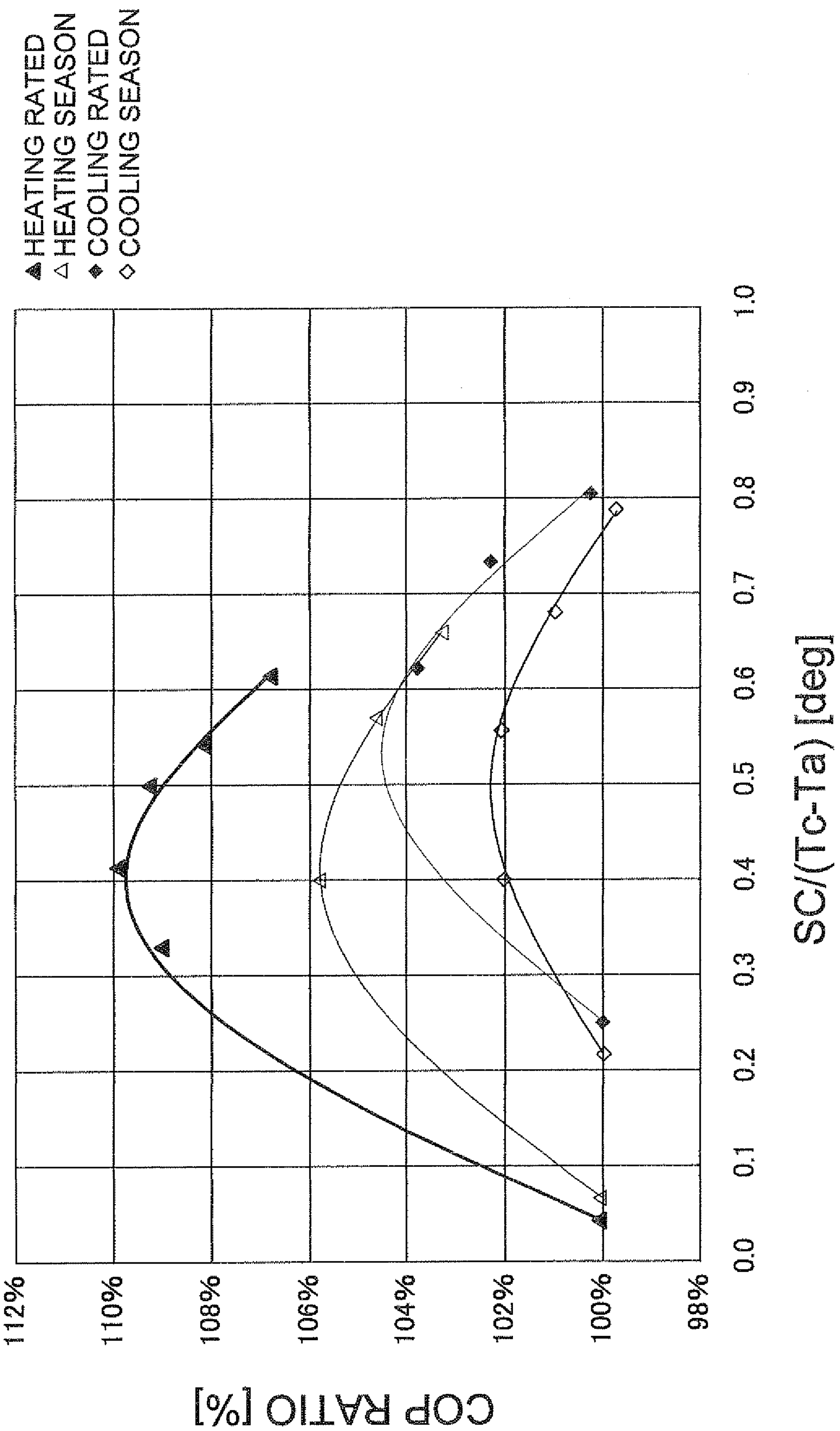
HEATING RATED
HEATING SEASON
COOLING RATED
COOLING SEASON
COP RATIO [%]
112%
110%
108%
106%
104%
102%
100%
98%
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
SC/(Tc-Ta) [deg]

FIG. 4

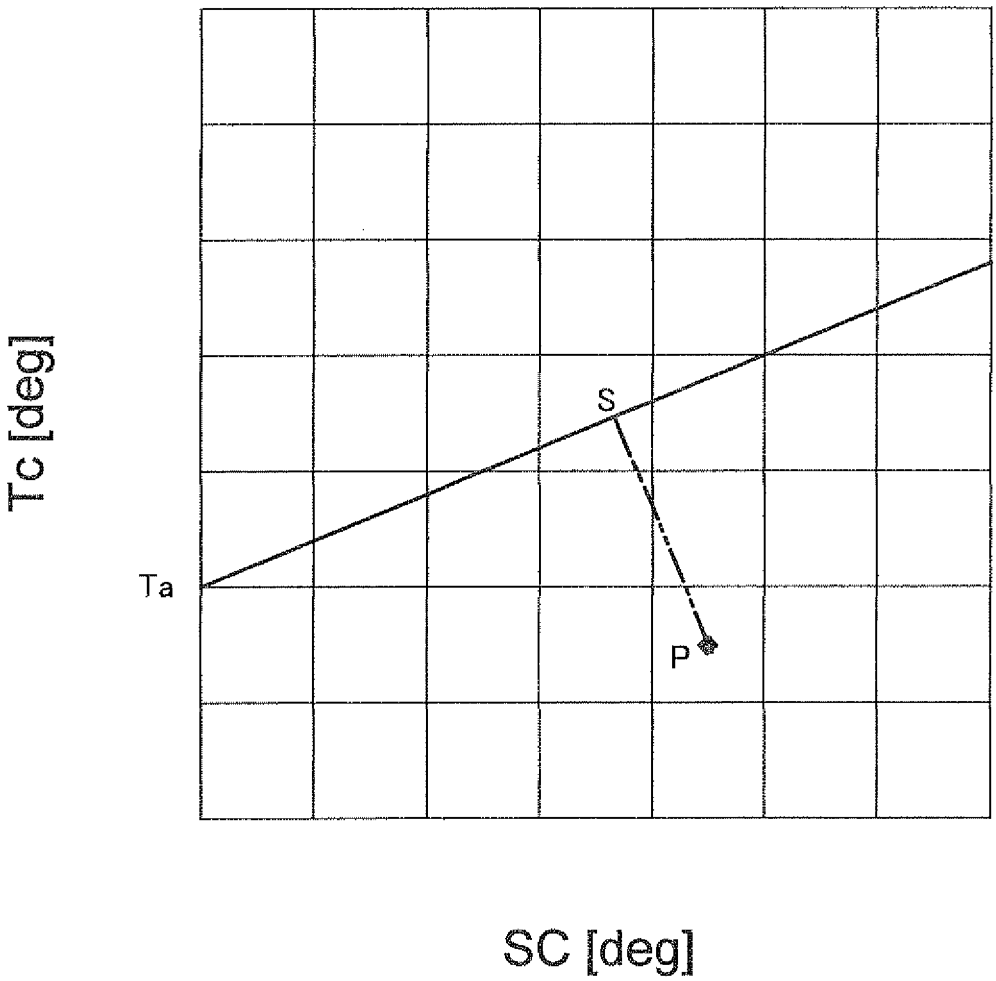

FIG. 5

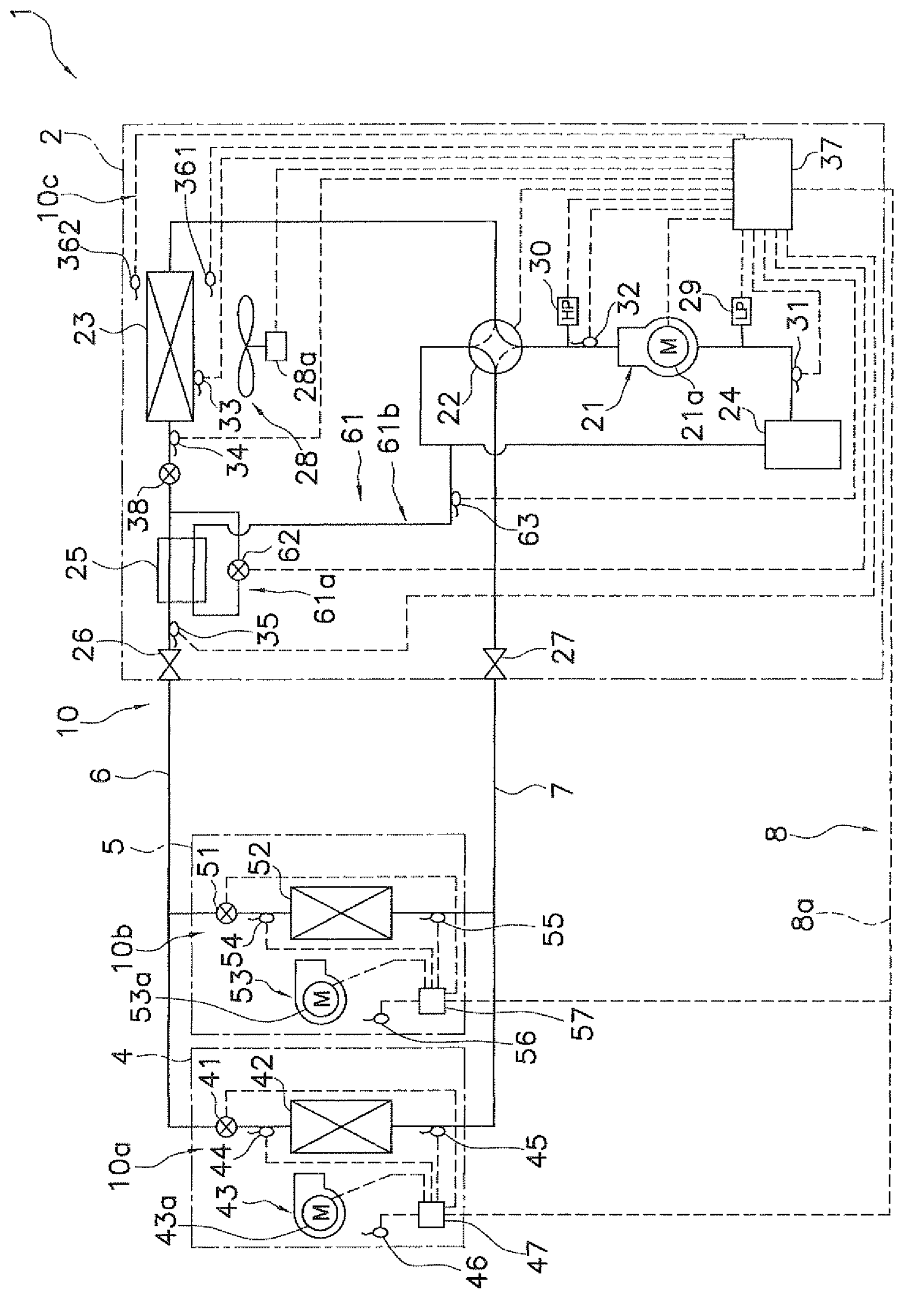
1
2
10c
361
362
23
33
34
28
28a
37
30
HP
32
29
LP
31
22
21
M
21a
24
61
61b
63
38
25
62
61a
35
26
27
10
6
7
5
51
52
55
10b
54
53
53a
57
56
4
41
42
45
10a
44
43
43a
47
46
8
8a

FIG. 6

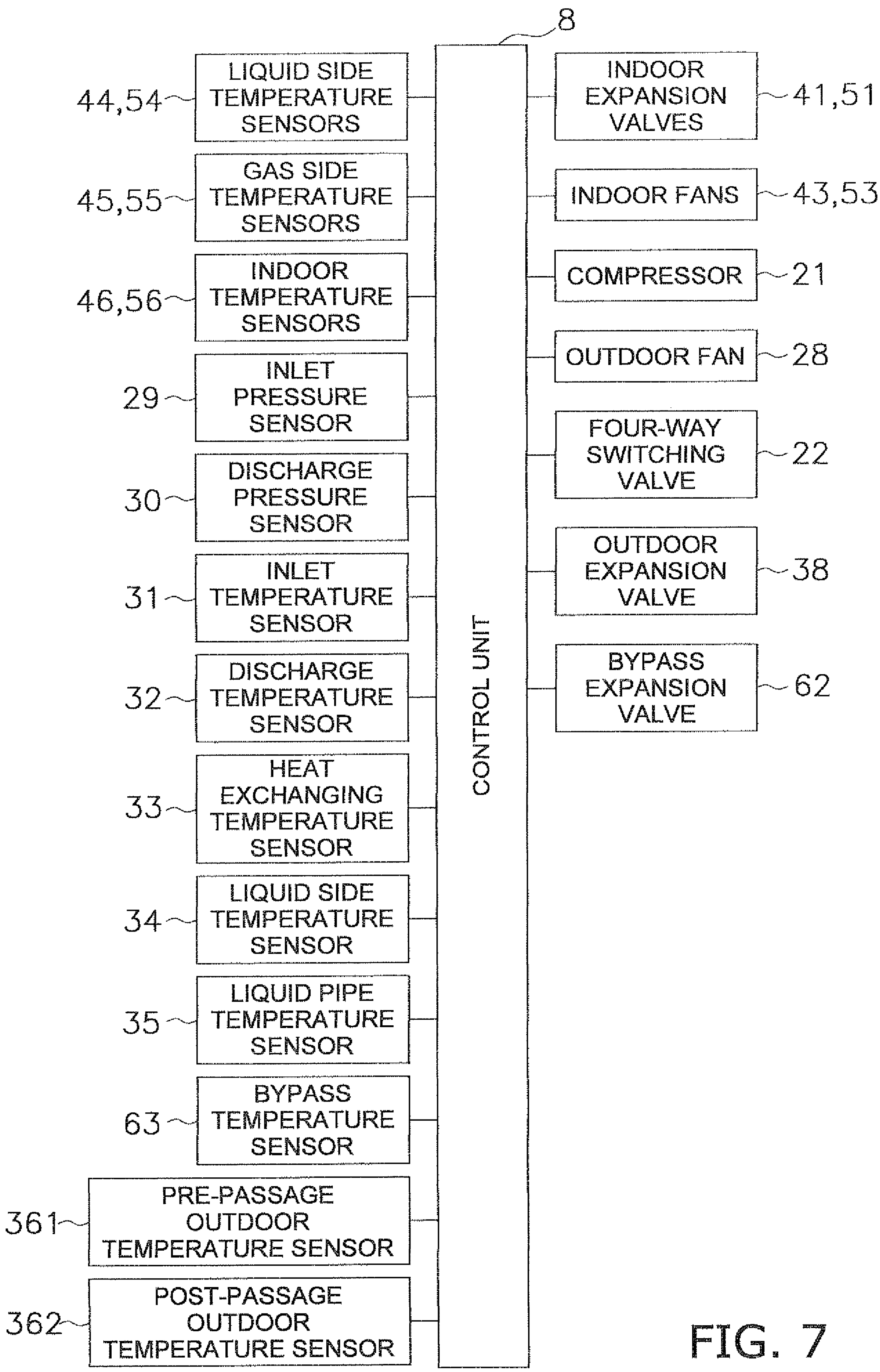
8
44,54
LIQUID SIDE TEMPERATURE SENSORS
45,55
GAS SIDE TEMPERATURE SENSORS
46,56
INDOOR TEMPERATURE SENSORS
29
INLET PRESSURE SENSOR
30
DISCHARGE PRESSURE SENSOR
31
INLET TEMPERATURE SENSOR
32
DISCHARGE TEMPERATURE SENSOR
33
HEAT EXCHANGING TEMPERATURE SENSOR
34
LIQUID SIDE TEMPERATURE SENSOR
35
LIQUID PIPE TEMPERATURE SENSOR
63
BYPASS TEMPERATURE SENSOR
361
PRE-PASSAGE OUTDOOR TEMPERATURE SENSOR
362
POST-PASSAGE OUTDOOR TEMPERATURE SENSOR
CONTROL UNIT
INDOOR EXPANSION VALVES
41,51
INDOOR FANS
43,53
COMPRESSOR
21
OUTDOOR FAN
28
FOUR-WAY SWITCHING VALVE
22
OUTDOOR EXPANSION VALVE
38
BYPASS EXPANSION VALVE
62

FIG. 7

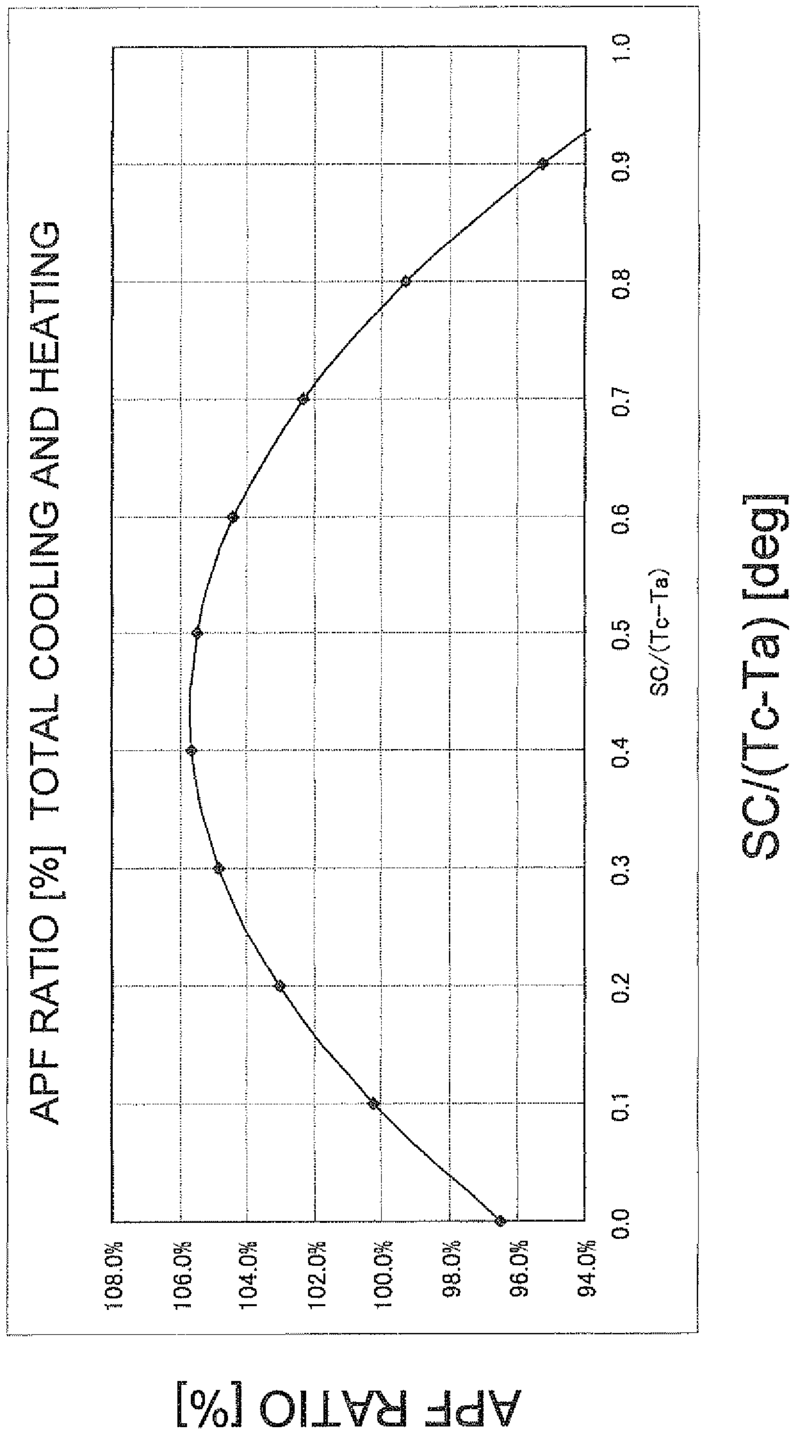
APF RATIO [%] TOTAL COOLING AND HEATING
108.0%
106.0%
104.0%
102.0%
100.0%
98.0%
96.0%
94.0%
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
SC/(Tc-Ta)
SC/(Tc-Ta) [deg]
APF RATIO [%]

FIG. 8

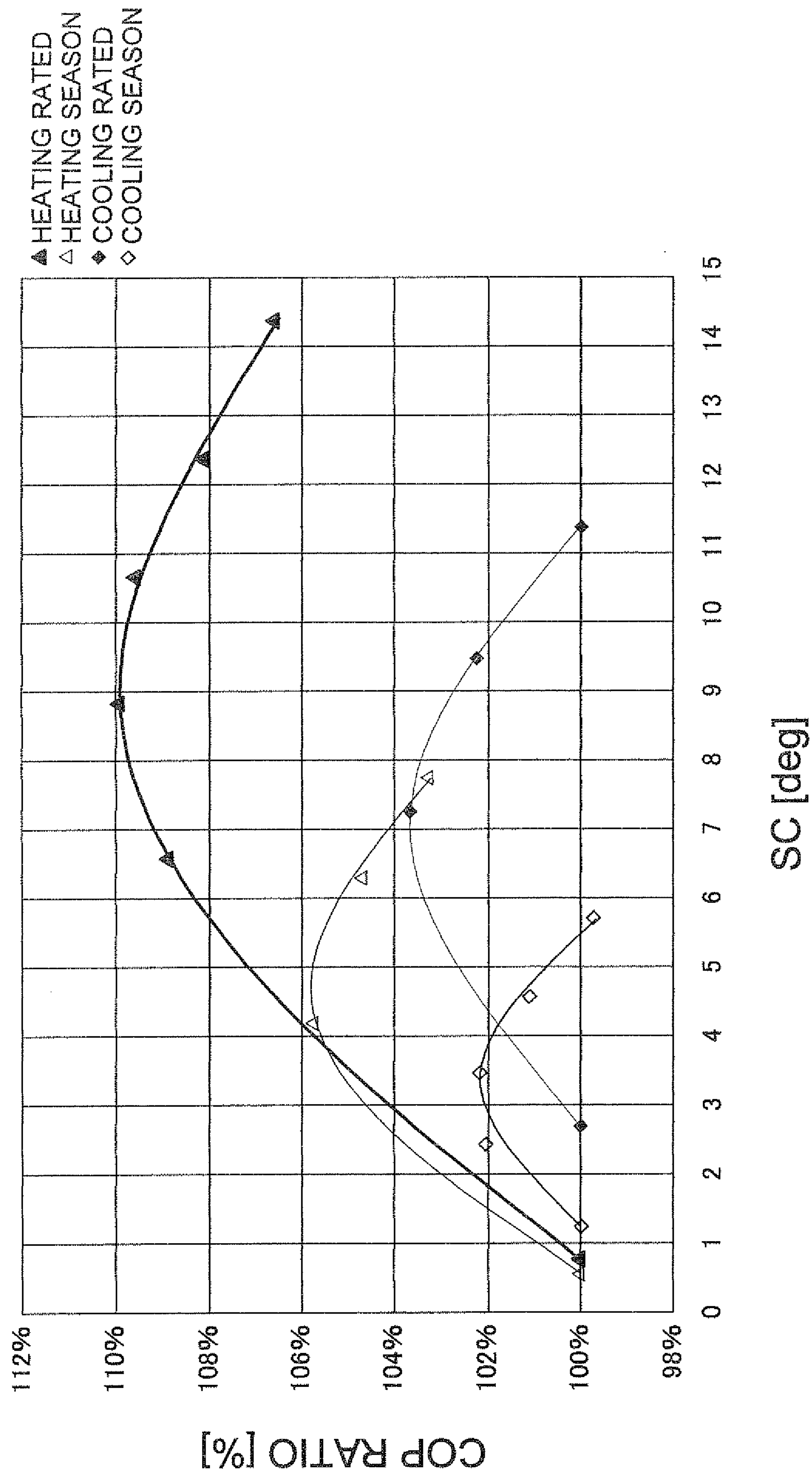
HEATING RATED
HEATING SEASON
COOLING RATED
COOLING SEASON
COP RATIO [%]
112%
110%
108%
106%
104%
102%
100%
98%
SC [deg]
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/002865

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i, *F24F11/02*(2006.01)i, *F24F11/053*(2006.01)i, *F25B13/00*(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)
F25B1/00, F24F11/02, F24F11/053, F25B13/00

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	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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.
X Y	JP 9-14780 A (Denso Corp.), 17 January, 1997 (17.01.97), Claim 2; Par. Nos. [0021] to [0022], [0058] to [0059]; Fig. 8 & US 5701753 A & EP 751356 A2 & DE 69626069 D	1,3-6 2
Y	JP 1-212867 A (Sanyo Electric Co., Ltd.), 25 August, 1989 (25.08.89), Page 3, lower right column, lines 1 to 4 (Family: none)	2-6
Y	JP 2006-105554 A (Mitsubishi Electric Corp.), 20 April, 2006 (20.04.06), Par. No. [0015] (Family: none)	2-6

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search 21 November, 2008 (21.11.08)	Date of mailing of the international search report 09 December, 2008 (09.12.08)
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/002865

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 8-28985 A (Toshiba AVE Co., Ltd.), 02 February, 1996 (02.02.96), Par. Nos. [0035] to [0036] & EP 692683 A2 & CN 1128340 A	1-6
A	JP 2001-280735 A (Tokyo Gas Co., Ltd.), 10 October, 2001 (10.10.01), Claim 2 (Family: none)	1-6

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2001263831 A **[0003]**