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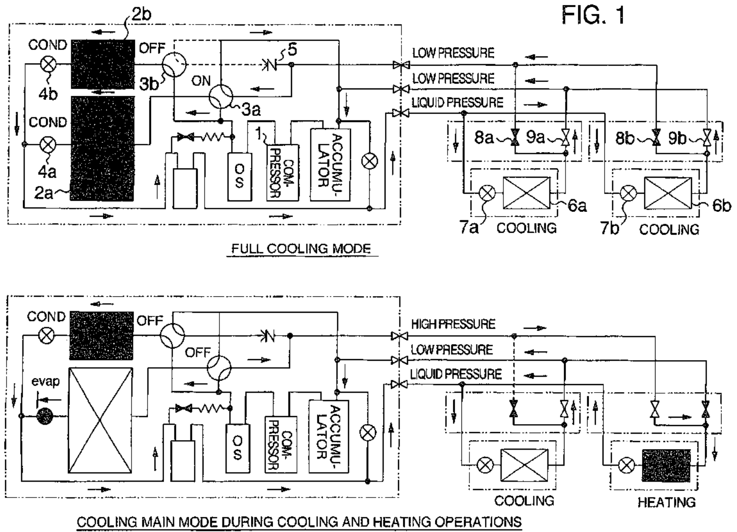
(54) Air conditioner

(57) In an air conditioner comprising an exterior heat exchanger (2a, 2b) usable as desired one of an evaporator and a condenser, a first interior heat exchanger (6a) usable as another evaporator, a second interior heat exchanger (6b) usable as another condenser, and a compressor (1) for pressurizing the refrigerant, a valve means (3a, 3b, 4a, 4b, 5, 8a, 8b, 9a, 9b) is capable of changing a flow course of refrigerant between a cooling main course using the exterior heat exchanger as the condenser and a heating main course using the exterior heat exchanger as the evaporator.



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Description

Background of the Invention

[0001] The present invention relates to an air conditioner including a first interior heat exchanger for heating an air with a refrigerant, a second interior heat exchanger for cooling the air with the refrigerant, and an exterior heat exchanger for required one of taking a heat energy into the refrigerant and radiating the heat energy from the refrigerant as occasion demands.

[0002] In a prior art air conditioner as disclosed by JP-A-2003-130492, a gaseous refrigerant pressurized by a compressor is fed to an interior heat exchanger for heating a room air so that the gaseous refrigerant is condensed to change to a liquid refrigerant, and a gaseous refrigerant pressurized by another compressor is fed to an exterior heat exchanger to be condensed and subsequently fed to another interior heat exchanger for cooling the room air so that the refrigerant condensed to be liquefied by the exterior heat exchanger is evaporated in the another interior heat exchanger.

Brief Summary of the Invention

[0003] An object of the present invention is to provide an air conditioner by which an operating efficiency is improved with preventing or restraining an excessive cooling capacity or performance of the first interior heat exchanger and an insufficient heating capacity or performance of the second interior heat exchanger when a temperature of an exterior air is deemed to be not more than a predetermined temperature to cause an excessive heating performance for the exterior air of the exterior heat exchanger with decreasing the heating capacity or performance of the second interior heat exchanger.

[0004] According to the invention, in an air conditioner comprising, an exterior heat exchanger capable of performing a heat exchange between a refrigerant and an exterior air and including an adjustable valve whose opening area (for passing the refrigerant through the adjustable valve) is variable so that the adjustable valve is usable as desired (or selected) one of an expansion valve for the refrigerant to use the exterior heat exchanger as an evaporator and a passage for the refrigerant to use the exterior heat exchanger as a condenser, a first interior heat exchanger capable of performing a heat exchange between the refrigerant and an interior air to be cooled (in such a manner that a difference between an actual temperature of the interior air to be cooled and a desirable temperature of the interior air to be cooled is automatically or manually decreased, minimized or kept within a desirable range, with a change of a rate of heat exchange energy amount for cooling with respect to a time proceeding, that is, a change of the heat exchange energy amount for cooling per every unit time in accordance with the difference between the actual temperature of the interior air to be cooled and the desirable temperature of the interior air to be cooled so that the greater the difference between the actual temperature of the interior air to be cooled and the desirable temperature of the interior air to be cooled is, the greater the rate of heat exchange energy amount for cooling with respect to the time proceeding or the heat exchange energy amount for cooling per every unit time is) and including another expansion valve for the refrigerant enabling the first interior heat exchanger to be used as another evaporator, a second interior heat exchanger capable of performing as another condenser a heat exchange between the refrigerant and an interior air to be heated(in such a manner that a difference between an actual temperature of the interior air to be heated and a desirable temperature of the interior air to be heated is automatically or manually decreased, minimized or kept within a desirable range, with a change of the rate of heat exchange energy amount for heating with respect to the time proceeding, that is, a change of the heat exchange energy amount for heating per every unit time in accordance with the difference between the actual temperature of the interior air to be heated and the desirable temperature of the interior air to be heated so that the greater the difference between the actual temperature of the interior air to be heated and the desirable temperature of the interior air to be heated is, the greater the rate of heat exchange energy amount for heating with respect to the time proceeding or the heat exchange energy amount for heating per every unit time is), and a compressor for pressurizing the refrigerant, since a valve means is capable of changing a flow course of the refrigerant between a cooling main course in which the pressurized refrigerant discharged from the compressor flows into each of the second interior heat exchanger (as the another condenser) and the exterior heat exchanger including the adjustable valve used as the passage to use the exterior heat exchanger as the condenser, subsequently the condensed refrigerant discharged from each of the second interior heat exchanger and the exterior heat exchanger flows into the first interior heat exchanger (as the another evaporator), and finally the evaporated refrigerant discharged from the first interior heat exchanger returns to the compressor, and a heating main course in which the pressurized refrigerant discharged from the compressor flows into the second interior heat exchanger (as the another condenser), subsequently the condensed refrigerant discharged from the second interior heat exchanger flows into each of the first interior heat exchanger (as the another evaporator) and the exterior heat exchanger including the adjustable valve used as the expansion valve to use the exterior heat exchanger as the evaporator, and finally the evaporated refrigerant discharged from each of the first interior heat exchanger and the exterior heat exchanger returns to the compressor, an operating efficiency is improved when a temperature of an exterior air is deemed to be not more than a predetermined temperature causing an excessive cooling capacity of the first interior heat exchanger.

[0005] The below mentioned various controls does not need necessarily to be performed with calculation in the absolute values(s), and may be performed when the physical conditions or situations defined with using the absolute values(s) are actually satisfied or fulfilled, irrespective of whether or not the calculation in the absolute values(s) is performed. That is, the absolute values(s) is used to definitely clarify the physical conditions or situations on which the control is performed, but is not used to restrict the scopes of the below mentioned various controls to respective calculating manners with using the absolute values(s).

[0006] It is preferable for using the exterior heat exchanger to obtain securely desirable performance of heat exchange in each of the first and second interior heat exchangers that the valve means sets the flow course of the refrigerant at the cooling main course when a desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger is greater than a desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger, and sets the flow course of the refrigerant at the heating main course when the desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger is greater than the desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger.

[0007] It is preferable for improving an operating efficiency of the air conditioner with preventing or restraining an excessive cooling capacity or performance of the first interior heat exchanger and an insufficient heating capacity or performance of the second interior heat exchanger that the valve means changes the flow course of the refrigerant from the cooling main course to the heating main course when a temperature of the exterior air is not more than a predetermined temperature, and a difference in absolute value between a desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger and a desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger is not more than a predetermined value.

[0008] It is preferable for improving an operating efficiency of the air conditioner with preventing or restraining an excessive cooling capacity or performance of the first interior heat exchanger and an insufficient heating capacity or performance of the second interior heat exchanger that the valve means changes the flow course of the refrigerant from the cooling main course to the heating main course when a difference in absolute value between a desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger and a desirable amount in absolute value of heat energy per unit time to be exchanged by the second interior heat exchanger is not more than a predetermined value, and a difference in absolute value between an amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger and an amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger less than the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger is more than a predetermined reference value.

[0009] It is preferable for easily and appropriately estimating the desirable amount in absolute value of thermal energy per unit time to be exchanged by each of the first and second interior heat exchangers that a difference in absolute value between an actual temperature of the interior air to be cooled by the first interior heat exchanger and a desirable temperature of the interior air to be cooled by the first interior heat exchanger lower than the actual temperature of the interior air to be cooled by the first interior heat exchanger is a value corresponding to the desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger, and a difference in absolute value between a desirable temperature of the interior air to be heated by the second interior heat exchanger and an actual temperature of the interior air to be heated by the second interior heat exchanger lower than the desirable temperature of the interior air to be heated by the second interior heat exchanger is a value corresponding to the desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger.

[0010] It is preferable for easily and appropriately estimating the desirable amount in absolute value of thermal energy per unit time to be exchanged by each of the first and second interior heat exchangers that a product of a flow rate of the interior air flowing through the first interior heat exchanger and a difference in absolute value between an actual temperature of the interior air to be cooled by the first interior heat exchanger and a desirable temperature of the interior air to be cooled by the first interior heat exchanger lower than the actual temperature of the interior air to be cooled by the first interior heat exchanger is a value corresponding to the desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger, and a product of a flow rate of the interior air flowing through the second interior heat exchanger and a difference in absolute value between an actual temperature of the interior air to be heated by the second interior heat exchanger and a desirable temperature of the interior air to be heated by the second interior heat exchanger higher than the actual temperature of the interior air to be heated by the second interior heat exchanger is a value corresponding to the desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger.

[0011] When at least one of the first and second interior heat exchangers has a plurality of interior sub-heat exchangers connected fluidly in parallel to each other, the desirable amount in absolute value of thermal energy per unit time to be exchanged by the at least one of the first and second interior heat exchangers is a total amount of desirable amounts in absolute value of thermal energy per unit time to be exchanged by the interior sub-heat exchangers respectively.

[0012] For easily and appropriately judging the condition or situation on which the control of the air conditioner is performed, it is deemed when a difference in absolute value in temperature between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger is more than a first reference degree and a difference in absolute value in temperature between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is less than a second reference degree, that the difference in absolute value between the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger and the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger less than the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger is more than the predetermined reference value.

[0013] For easily and appropriately judging the condition or situation on which the control of the air conditioner is performed, it is deemed when a pressure of the refrigerant evaporated by the first interior heat exchanger is less than a first comparison value and a pressure of the refrigerant condensed by the second interior heat exchanger is less than a second comparison value, that the difference in absolute value between the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger and the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger less than the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger is more than the predetermined reference value.

[0014] For easily and appropriately judging the condition or situation on which the control of the air conditioner is performed, it is deemed when a difference in absolute value in temperature between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger / a difference in absolute value in temperature between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is more than a reference degree, that the difference in absolute value between the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger and the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger less than the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger is more than the predetermined reference value.

[0015] For correctly and easily detecting the excessive cooling performance of the first interior heat exchanger, it is preferable that when the first interior heat exchanger has a plurality of first interior sub-heat exchangers connected fluidly in parallel to each other, the difference in absolute value in temperature between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger is the smallest one of differences in absolute value in temperature between the interior airs to be taken into the respective first interior sub-heat exchangers and the interior airs discharged from the respective first interior sub-heat exchangers.

[0016] For correctly and easily detecting the insufficient heating performance of the second interior heat exchanger, it is preferable that when the second interior heat exchanger has a plurality of second interior sub-heat exchangers connected in parallel to each other, and the difference in absolute value in temperature between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is the greatest one of differences in absolute value in temperature between the interior airs to be taken into the respective second interior sub-heat exchangers and the interior airs discharged from the respective second interior sub-heat exchangers.

[0017] It is preferable for easily and appropriately estimating the amount in absolute value of thermal energy per unit time actually exchanged by each of the first and second interior heat exchangers that a difference in temperature in absolute value between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger, and a difference in temperature in absolute value between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger.

[0018] It is preferable for easily and appropriately estimating the amount in absolute value of thermal energy per unit time actually exchanged by each of the first and second interior heat exchangers that a product of a flow rate of the interior air flowing through the first interior heat exchanger and a difference in temperature in absolute value between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger, and a product of a flow rate of the interior air flowing through the second interior heat exchanger and a difference in temperature in absolute value between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger.

[0019] It is preferable for easily and appropriately estimating the amount in absolute value of thermal energy per unit time actually exchanged by each of the first and second interior heat exchangers that a difference in temperature in absolute value between the refrigerant taken into the first interior heat exchanger and the refrigerant discharged from the first interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger, and a difference in temperature in absolute value between the refrigerant taken into the second interior heat exchanger and the refrigerant discharged from the second interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger.

[0020] It is preferable for easily and appropriately estimating the amount in absolute value of thermal energy per unit time actually exchanged by each of the first and second interior heat exchangers that a product of a mass flow rate of the refrigerant flowing through the first interior heat exchanger and a difference in temperature in absolute value between the refrigerant taken into the first interior heat exchanger and the refrigerant discharged from the first interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger, and a product of a mass flow rate of the refrigerant flowing through the second interior heat exchanger and a difference in temperature in absolute value between the refrigerant taken into the second interior heat exchanger and the refrigerant discharged from the second interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger.

[0021] It is preferable for correctly and stably detecting at least one of actual and desirable amounts of heat energy exchanged by each of the first and second interior heat exchanger that at least one of actual and desirable amounts of heat energy exchanged by each of the first and second interior heat exchanger is detected by the air conditioner after at least a predetermined time period elapse from a change between the cooling main course and heating main course.

[0022] For easily and appropriately judging the condition or situation on which the control of the air conditioner is performed when the valve means has a four-way valve (3a, 3b), it is preferable that at which the four-way valve is set ON condition or OFF condition is detected from a value of electric current applied to the four-way valve, the exterior heat exchanger has a thermistor for measuring a temperature of the refrigerant in the exterior heat exchanger, and at which the exterior heat exchanger is used the evaporator condition or condenser condition is detected from the temperature of the refrigerant measured by the thermistor so that when the measured temperature of the refrigerant is lower than a predetermined temperature, the exterior heat exchanger is deemed to be used as the evaporator, and when the measured temperature of the refrigerant is not lower than the predetermined temperature, the exterior heat exchanger is deemed to be used as the condenser. It is preferable that the detected conditions of the four-way valve and exterior heat exchanger are indicated on at least one of a remote controller for controlling the air conditioner and the exterior heat exchanger.

[0023] An air conditioner may comprise an exterior unit having a compressor (1), a plurality of four-way valves (3a, 3b) connected to the compressor to change a flow direction of a refrigerant, a plurality of exterior heat exchangers (2a, 2b), and exterior electronic expansion valves (4a, 4b) connected to the exterior heat exchangers respectively, and a plurality of interior units having respective interior heat exchangers, respective interior electronic expansion valves and respective shut-off valves and connected to the exterior heat exchangers through a pipe for refrigerant of gas state and a pipe for refrigerant of liquid state wherein a refrigerant cycle having one of the interior units operable to cool an interior air and the other one of the interior units operable to heat the interior air is formed, and an operation of the air conditioner is changed to a cooling main mode with using the exterior heat exchanger as a condenser when a cooling load is greater than a heating load, and to a heating main mode with using the exterior heat exchanger as an evaporator when the heating load is greater than the cooling load,
wherein the operation of the air conditioner is changed from the cooling main mode to the heating main mode when a temperature of an exterior air is not more than a predetermined temperature, and a difference between the cooling load and the heating load is not more than a predetermined value.

[0024] Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

Brief Description of the Several Views of the Drawings

[0025]

Fig. 1 is a block diagram showing a refrigerating cycle as an embodiment capable of simultaneously heating an air and cooling the air.
Fig. 2 is a block diagram showing a flow route of a refrigerant and operations of elements in the refrigerating cycle in various operating modes.
Fig. 3 is a flow chart for changing the operating mode from a cooling main mode to a heating main mode.
Fig. 4 includes diagrams showing relationships between a capacity (thermal energy) and a refrigerant pressure in cooling main mode and heating main mode.

Fig. 5 includes diagrams showing relationships between the capacity (thermal energy) and an ambient temperature in cooling main mode and heating main mode.

Fig. 6 is a diagram showing a relationship between the cooling and heating capacities and the ambient temperature in cooling main mode and heating main mode.

Detailed Description of the Invention

[0026] Hereafter, an air conditioner as an embodiment of the invention will be described with making reference to the drawings.

[0027] Figs. 1 and 2 show a refrigerating cycle capable of simultaneously heating and cooling, an upper drawing of fig. 1 shows a full cooling mode, a lower drawing thereof shows a cooling main mode during simultaneous heating and cooling operations, an upper drawing of fig. 2 shows a heating main mode during simultaneous heating and cooling operations, a lower drawing thereof shows a full heating mode, and an arrow mark shows a flow of a refrigerant.

[0028] The refrigerating cycle is constituted by a compressor 1, a plurality of exterior heat exchangers 2a and 2b, exterior electronically controlled expansion valves 4a and 4b attached to the exterior heat exchangers 2a and 2b, a check valve 5, an exterior unit including four-way valves 3a and 3b for changing a refrigerant flowing route, and at least two, for example, k interior units which are connected to the exterior unit through gas and liquid pipes and include respective interior heat exchangers 6a and 6b with respective interior electronically controlled expansion valves 7a and 7b and respective pairs of valves 8a and 9a and valves 8b and 9b (one filled with black is closed, and one filled with white is opened).

[0029] Next, the cooling main mode and heating main mode will be described in detail.

[0030] In the cooling main mode (during simultaneously heating and cooling), the gas refrigerant discharged from the compressor 1 is fed to the exterior heat exchanger 2b and interior heat exchanger 6b as condensers so that it is changed to the liquid refrigerant through the heat exchange, and subsequently the liquid refrigerant is fed to the interior heat exchanger 6a as an evaporator. The liquid refrigerant is vaporized in the interior heat exchanger 6a, and the vaporized refrigerant is recovered into the compressor 1. When a heat energy amount of absolute value exchanged through the interior heat exchanger 6b as the condenser is smaller than a heat energy amount of absolute value exchanged through the interior heat exchanger 6a as the evaporator, a difference therebetween is radiated from the exterior heat exchanger 2b as the condenser.

[0031] In the heating main mode (during simultaneously heating and cooling), the refrigerant discharged from the compressor 1 flows into the interior heat exchanger 6b as the condenser to perform the heat exchange, and the liquefied refrigerant is fed to the exterior heat exchanger 2a and interior heat exchanger 6a as the evaporator, and the refrigerant vaporized by the heat exchange by them returns to the compressor 1. A heat exchange energy amount thermally exchanged by the interior heat exchanger 6b as the condenser is balanced with a heat exchange energy amount thermally exchanged by the interior heat exchanger 6a and exterior heat exchanger 2a as the evaporator.

[0032] As mentioned above, in the air conditioner for simultaneously heating and cooling, an intended purpose and/or capacity of the exterior heat exchanger is changed to drive both the interior room heater and interior room cooler, and a difference in amount of exchanged thermal energy between the interior cooling and the interior heating is compensated by the exterior heat exchanger to form the refrigerating cycle. Incidentally, when an interior cooling load Qei and an interior heating load Qci are substantially equal to each other, an exterior heat exchange amount Qo for other than a thermal input from the compressor is not necessary, and may be zero, so that if the exterior heat exchange amount Qo by the exterior heat exchanger is more than zero as performed in the prior art, the heat exchange amount Qci of the interior heat exchanger as the condenser is decreased by the heat exchange amount Qco of the exterior heat exchanger as the condenser when the cooling main mode. Further, in the heating main mode, the heat exchange amount Qei of the interior heat exchanger as the evaporator is decreased by the heat exchange amount Qeo of the exterior heat exchanger as the evaporator. When the exterior temperature is significantly low or high to increase the heat exchange amount by the exterior heat exchanger, an effect thereby increases.

[0033] In the cooling main mode and the heating main mode, it is difficult for the cooling capacity to be sufficient and it is easy for the heating capacity to be sufficient when the ambient temperature is high, it is easy for the cooling capacity to be sufficient and it is difficult for the heating capacity to be sufficient when the ambient temperature is low, and these relationships during simultaneously heating and cooling will be explained in detail with making reference to fig. 4 showing a relationship in the refrigerating cycle (a diagram whose ordinate corresponds to the pressure and whose abscissa corresponds to the capacity (thermal energy amount)) and fig. 5 showing a relationship between the ambient (exterior) temperature and the capacity (thermal energy amount) of each part.

(in cooling main mode)

[0034] When the heat exchange amount of the interior heat exchanger for cooling the room air and the heat exchange amount of the interior heat exchanger for heating the room air are balanced with each other except for the power Pc applied by the compressor to the refrigerant, an enthalpy necessary for the required cooling capacity is supplied from the interior heat exchanger 6b for heating the room air. However, if the refrigerant flows through the exterior unit, the high pressure and high temperature gas refrigerant flows through the exterior heat exchanger 2b to generate the heat exchange amount Qco radiated from the exterior heat exchanger as the condenser. Therefore, when the heat exchange amount Qt of the heat energy absorbing side in the refrigerating cycle is kept unchanged, since the enthalpy necessary for the required cooling capacity is a total amount of the heat exchange amount Qco of the exterior heat exchanger as the condenser and the heat exchange amount Qci of the interior heat exchanger as the condenser, the heat exchange amount Qci of the interior heat exchanger as the condenser is smaller than the heat exchange amount Qt of the heat energy absorbing side by the heat exchange amount Qco of the exterior heat exchanger as the condenser.

[0035] Therefore, the greater the heat exchange amount Qco of the exterior heat exchanger as the condenser is, the smaller the heat exchange amount Qci of the interior heat exchanger as the condenser (that is, the capacity of the heat exchanger for heating the room air) is. This situation occurs when the ambient temperature is low to accelerate the heat radiation of the exterior heat exchanger 2b as the condenser. Therefore, an efficiency of operation for simultaneous heating and cooling is low.

[0036] On the contrary, when the ambient temperature is high to decelerate the heat exchange amount Qco of the exterior heat exchanger 2b as the condenser, the heat exchange amount Qci of the interior heat exchanger as the condenser becomes great. Regarding the input power Pc from the compressor, when Qt is kept unchanged, the heat exchange amount Qei of the interior heat exchanger as the evaporator and the input power Pc from the compressor change inversely with respect to each other, so that the heat exchange amount Qei of the interior heat exchanger as the evaporator is decreased by the input power Pc from the compressor.

(in heating main mode)

[0037] When the heat exchange amount of the interior heat exchanger for cooling the room air and the heat exchange amount of the interior heat exchanger for heating the room air are balanced with each other in the heating main mode, an enthalpy necessary for the required heating capacity is supplied from the heat exchange amount Qei of the interior heat exchanger as the evaporator and the input power Pc from the compressor. However, if the heat exchange amount Qeo of the exterior heat exchanger as the evaporator exists and the heat exchange amount Qt of the heat energy emitting side in the refrigerating cycle is kept unchanged, since the enthalpy difference necessary for the required heating capacity is a total amount of the heat exchange amount Qeo of the exterior heat exchanger as the evaporator, the heat exchange amount Qei of the interior heat exchanger as the evaporator and the input power Pc from the compressor, the heat exchange amount Qei of the interior heat exchanger as the evaporator is smaller than the heat exchange amount Qt of the heat energy emitting side by the heat exchange amount Qeo of the exterior heat exchanger as the evaporator.

[0038] Therefore, the heat exchange amount Qeo of the exterior heat exchanger as the evaporator and the heat exchange amount Qei of the interior heat exchanger as the evaporator change inversely with respect to each other, so that the heat exchange amount Qei of the interior heat exchanger as the evaporator is decreased by the heat exchange amount Qeo of the exterior heat exchanger as the evaporator, This situation occurs when the ambient temperature is high to accelerate the heat absorption of the exterior heat exchanger as the evaporator, and increase the heat exchange amount Qeo of the exterior heat exchanger as the evaporator, the heat exchange amount Qei of the interior heat exchanger as the evaporator is decreased. Therefore, an efficiency of operation for simultaneous heating and cooling is low.

[0039] As mentioned above, the heating capacity is insufficient at the low ambient temperature in the cooling main mode, and cooling capacity is insufficient at the high ambient temperature in the heating main mode, so that an input power for the compressor needs to be increased to compensate this insufficiency of the capacity, and an operating efficiency during simultaneous heating and cooling is decreased.

[0040] In the embodiment, the operating mode is changed between the heating main mode and cooling main mode in accordance with a detection of insufficiency of the heating or cooling capacity on the basis of a decision value for each of the capacity of the interior heat exchanger for cooling the room air and the capacity of the interior heat exchanger for heating the room air, in addition to a judgment on the basis of a rate between the cooling load and heating load.

[0041] That is, when the load of cooling the room air and the load of heating the room air are substantially equal to each other, and the ambient temperature is low, the insufficiency of the heating capacity is detected so that the cooling main mode is replaced by the heating main mode in which the exterior heat exchanger is used as the evaporator forming the refrigerating cycle. Whereby, the heat exchange amount of the exterior heat exchanger is decreased to prevent the condensing pressure from decreasing, so that the capacity for heating the room air is maintained, and an excessive decrease of the evaporating pressure is prevented. Therefore, the cooling capacity is restrained from becoming excessive when the ambient temperature is low, and the efficiency for simultaneous heating and cooling is increased.

[0042] In the cooling main mode, when the heat exchange amount Qco of the exterior heat exchanger as the condenser is zero, the heat exchange is performed only by the interior heat exchanger as the evaporator and the interior heat exchanger as the condenser, so that the heat radiation or heat absorption added by the exterior heat exchanger does not exist and the whole of the heat energy circulates between the interior heat exchangers to increase the operating efficiency. As an indicator showing the operating efficiency in simultaneous heating and cooling, the operating efficiency in simultaneous heating and cooling is indicated by $COP^{(5)}$ calculated by formula 1, and the heat exchange amounts in the modes are calculated by formula 2 and 3 respectively.

$$\text{operating efficiency : } COP^{(s)} = \frac{Qci + Qei}{Pc} \qquad \text{(formula 1)}$$

$$\text{cooling main mode : } Qco + Qci = Qei + Pc \qquad \text{(formula 2)}$$

$$\text{heating main mode : } Qci = Qeo + Qei + Pc \qquad \text{(formula 3)}$$

$$\text{operating efficiency (cooling main)}$$
$$: COP^{(s)} = \frac{(Qei + Pc - Qco) + Qei}{Pc} = \frac{2Qei + Pc - Qco}{Pc} \qquad \text{(formula 4)}$$

$$\text{operating efficiency (heating main)}$$
$$: COP^{(s)} = \frac{Qci + (Qci - Qeo - Pc)}{Pc} = \frac{2Qci - Pc - Qeo}{Pc} \qquad \text{(formula 5)}$$

[0043] Therefore, the operating efficiency (the cooling main mode) and the operating efficiency (the heating main mode) are calculated along the formulas 4 and 5.

[0044] As mentioned above, when Qei + Pc = constant = Qt (in the cooling main mode) or Qci = Qt (in the heating main mode), the smaller the heat exchange amount Qco of the exterior heat exchanger as the condenser is or the smaller the heat exchange amount Qeo of the exterior heat exchanger as the evaporator is, the higher COP for simultaneous heating and cooling is.

[0045] Incidentally, in fig. 6, the cooling and heating capacities in the cooling main mode as shown in fig. 5 and the cooling and heating capacities in the heating main mode overlap with each other, the cooling capacity Qei is excessive while the heating capacity Qci is insufficient during the cooling main mode in the ambient temperature shown in fig. 6, and a condition shown by O mark is changed to a condition shown by ☆ mark by changing to the heating main mode so that the balancing situation is obtained for the high operating efficiency of simultaneous heating and cooling.

[0046] A change from the cooling main mode to the heating main mode is brought about in the following condition.

condition (c1) : $L_H > 0$ and a number of interior heat exchanger(s) in cooling operation = 0,
or
condition (c2): a number of interior heat exchanger(s) in heating operation > 0 and $L_H > 1.25\ L_R$ and at least one minute elapse after increase of the number of the interior heat exchanger(s),
or
condition (c3): a number of interior heat exchanger(s) in heating operation > 0 and $L_H > 0.9\ L_R$ and $\Delta Thm - \Delta Tcm \leqq 1$ and at least one minute elapse after increase of the number of the interior heat exchanger(s).

[0047] A change from the heating main mode to the cooling main mode is brought about in the following condition.

condition (c4): a number of interior heat exchanger(s) in heating operation = 0,
or

condition (c5): a number of interior heat exchanger(s) in cooling operation > 0 and $L_R > 1.25\ L_H$ and at least one minute elapse after increase of the number of the interior heat exchanger(s),
or

condition (c6): a number of interior heat exchanger(s) in cooling operation > 0 and $L_R > 0.9\ L_H$ and ΔThm - ΔTcm $\leqq$ 1 and at least one minute elapse after increase of the number of the interior heat exchanger(s).

[0048] Here, the notes are as follows.

$$L_R = \sum_k l_R \qquad \text{(formula 6)}$$

$$l_R = \frac{hp^{(R)}}{HP} \bullet V \bullet \left\{ \frac{1}{2} + \frac{\Delta Tc}{8} \right\} \bullet K$$

$$\Delta T_c = T_i - T_S$$

$$L_H = \sum_k l_H \qquad \text{(formula 7)}$$

$$l_H = \frac{hp^{(H)}}{HP} \bullet V \bullet \left\{ \frac{1}{2} + \frac{\Delta T_h}{8} \right\} \bullet K$$

$$\Delta T_h = T_S - T_i$$

L_R : a total amount of heating loads of interior heat exchanger(s) for heating, L_H , a total amount of cooling loads of interior heat exchanger(s) for cooling, T_s : set temperature, Ti: air temperature in room, ΔTc : a difference between the air temperature in room and the set temperature for cooling operation, ΔTh : a difference between the air temperature in room and the set temperature for heating operation, $hp^{(R)}$: capacity of interior heat exchanger for cooling, $hp^{(H)}$: capacity of interior heat exchanger for heating, HP: capacity of exterior heat exchanger,
Δ Thm : a maximum value of ΔTh, ΔTcm : a maximum value of ΔTc,
K : correction coefficient has a value of 1.0 when thermo on, a value of 0.1 when thermo off, and a value of 0 when stopping,
V : correction coefficient has a value of 1.0 when an air flow is high, a value of 7/8 when the air flow is medium, and has a value 3/4 when the air flow is low.

[0049] In these conditions (c1)-(c6) for changing the operating mode, since only a rate between the heating and cooling loads is considered, at least one of the following conditions (C7-1), (C7-2) and (C7-3) is considered for change from the cooling main mode to the heating main mode when the ambient temperature is low to increase the capacity of the heat exchanger for cooling the room air.
condition (C7-1)
Δ Tcmin > a and ΔThmax < b (and at least four minutes elapse after changing the operating mode) and preferably a = 12 with b = 15
Δ Tcmin is a minimum value of (Ti - Tio), ΔThmax is a maximum value of (Tio - Ti), and Tio is a temperature of the air after passing through the interior heat exchanger. That is, during the cooling main mode, when the minimum one ΔTc of the differences in temperature between the airs taken into and flowing out of the respective interior heat exchangers for cooling the air is more than a while the maximum one ΔTh of the differences in temperature between the airs taken into and flowing out of the respective interior heat exchangers for heating the air is less than b, the operating mode is

changed to the heating main mode.

condition (C7-2)

$Ps \leqq Pso - \gamma$ ($\gamma = 0.17$) and $Pd \leqq Pdo - \xi$ ($\xi = 0.15$) (and preferably $Pd/(Ps+0.13) \leqq \varepsilon$($\varepsilon = 2.4$))

Ps : refrigerant pressure at low pressure side (evaporating pressure), Pd : refrigerant pressure at high pressure side (condensing pressure), Pso : desired evaporating pressure for cooling, Pdo : desired condensing pressure for heating. That is, at least during the cooling main mode, when the detected evaporating pressure in the interior heat exchanger for cooling the room air is smaller than (the desired evaporating pressure - the predetermined value γ) and the detected condensing pressure in the interior heat exchanger for heating the room air is smaller than (the desired dendensing pressure - the predetermined value ξ), the operating mode is changed to the heating main mode.

(condition C7-3)

Δ Tcmin / ΔThmax > 2.3 (and preferably at least four minute elapse after changing the operating mode)

[0050] Whereby when the cooling capacitance is excessive and the heating capacitance is insufficient, the operating mode is changed from the cooling main mode to the heating main mode to improve a margin or spare operating capacity, an amenity and the operating efficiency. On the other hand, when the cooling capacitance is insufficient and the heating capacitance is excessive, the operating mode is changed from the heating main mode to the cooling main mode.

[0051] Fig. 3 shows a control flow chart for change from the cooling main mode to the heating main mode on the basis of the condition (C7-1), and at first, during the cooling main mode, a number of the interior heat exchanger(s) being operating to cool the air is detected, and when the number of the interior heat exchanger(s) being operating to cool the air is zero, the operating mode is changed to the heating main mode. When the number of the interior heat exchanger (s) being operating to cool the air is not zero and the number of the interior heat exchanger(s) being operating to heat the air is zero, the load for cooling the room air and the load for heating the room air are measured. On the other hand, when the number of the interior heat exchanger(s) being operating to heat the air is more than zero, after one minute elapse for making the refrigerating cycle stable from an increase of the number of the operated interior heat exchanger (s), the load for cooling the room air and the load for heating the room air are measured, and subsequently when the load for cooling the room air is smaller the load for heating the room air, that is, L_H (the total amount of the heat exchange amounts of the cooling loads of the interior heat exchanger(s) for cooling the air) - L_R (the total amount of the heat exchange amounts of the heating loads of the interior heat exchanger(s) for heating the air) is smaller than a predetermined value B, the operating mode is changed to the heating main mode.

[0052] When the number of the interior heat exchanger(s) being operating to heat the air is more than zero, and one minute has not elapsed from the increase of the number of the operated interior heat exchanger(s), the load for cooling the room air and the load for heating the room air are measured, and when the the load for cooling the room air and the load for heating the room air are substantially equal to each other and ΔTcmin > 12 and ΔThmax < 15, the operating mode is changed from the cooling main mode to the heating main mode.

[0053] By switching the operating mode as described above, the operating efficiency for simultaneous heating and cooling is improved, and the performed operating mode is indicated on a remote controller for controlling the exterior heat exchanger and/or the interior heat exchangers. A detection of the operating mode to be indicated is performed from conditions of the four-way valves 3a and 3b and the exterior heat exchangers (evaporators or condensers) 2a and 2b. Regarding the four-way valves 3a and 3b, ON/OFF situations thereof are detected from electric currents of the four-way valve coils, and regarding the exterior heat exchangers 2a and 2b, the refrigerant temperatures are measured by thermistors attached to inlets of the exterior heat exchangers, so that when the temperature is high, they are deemed to be the condensers and when the temperature is low, they are deemed to be the evaporators. From a combination of the using purposes of these four-way valves and the exterior heat exchangers, which operating mode is selected is detected.

[0054] As mentioned above, the efficiency of simultaneous heating and cooling is increased to improve an yearly power consumption efficiency such as an year-round power consumption efficiency determined along JIS C 9612 and JRA4055 so that CO_2 discharge is decreased and an amount of the refrigerant used in the air conditioner is decreased.

[0055] It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

Claims

1. An air conditioner comprising,

an exterior heat exchanger (2a, 2b) capable of performing a heat exchange between a refrigerant and an exterior air and including an adjustable valve (4a, 4b) whose opening area is variable so that the adjustable valve is usable as desired one of an expansion valve for the refrigerant to use the exterior heat exchanger as an evaporator and a passage for the refrigerant to use the exterior heat exchanger as a condenser,

a first interior heat exchanger (6a) capable of performing a heat exchange between the refrigerant and an interior

air to be cooled and including another expansion valve (7a) for the refrigerant enabling the first interior heat exchanger to be used as another evaporator,
a second interior heat exchanger (6b) capable of performing as another condenser a heat exchange between the refrigerant and an interior air to be heated, and
a compressor (1) for pressurizing the refrigerant,
wherein a valve means (3a, 3b, 4a, 4b, 5, 8a, 8b, 9a, 9b) is capable of changing a flow course of the refrigerant between a cooling main course in which the pressurized refrigerant discharged from the compressor flows into each of the second interior heat exchanger and the exterior heat exchanger including the adjustable valve used as the passage to use the exterior heat exchanger as the condenser, subsequently the condensed refrigerant discharged from each of the second interior heat exchanger and the exterior heat exchanger flows into the first interior heat exchanger, and finally the evaporated refrigerant discharged from the first interior heat exchanger returns to the compressor, and a heating main course in which the pressurized refrigerant discharged from the compressor flows into the second interior heat exchanger, subsequently the condensed refrigerant discharged from the second interior heat exchanger flows into each of the first interior heat exchanger and the exterior heat exchanger including the adjustable valve used as the expansion valve to use the exterior heat exchanger as the evaporator, and finally the evaporated refrigerant discharged from each of the first interior heat exchanger and the exterior heat exchanger returns to the compressor.

2. An air conditioner according to claim 1,
wherein the valve means sets the flow course of the refrigerant at the cooling main course when a desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger is greater than a desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger, and sets the flow course of the refrigerant at the heating main course when the desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger is greater than the desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger.

3. An air conditioner according to claims 1 or 2, wherein the valve means changes the flow course of the refrigerant from the cooling main course to the heating main course when a temperature of the exterior air is not more than a predetermined temperature, and a difference in absolute value between a desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger and a desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger is not more than a predetermined value.

4. An air conditioner according to claim 1 or 2, wherein the valve means changes the flow course of the refrigerant from the cooling main course to the heating main course when a difference in absolute value between a desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger and a desirable amount in absolute value of heat energy per unit time to be exchanged by the second interior heat exchanger is not more than a predetermined value, and a difference in absolute value between an amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger and an amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger less than the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger is more than a predetermined reference value.

5. An air conditioner according to any one of claims 2-4, wherein a difference in absolute value between an actual temperature of the interior air to be cooled by the first interior heat exchanger and a desirable temperature of the interior air to be cooled by the first interior heat exchanger lower than the actual temperature of the interior air to be cooled by the first interior heat exchanger is a value corresponding to the desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger, and a difference in absolute value between a desirable temperature of the interior air to be heated by the second interior heat exchanger, and an actual temperature of the interior air to be heated by the second interior heat exchanger lower than the desirable temperature of the interior air to be heated by the second interior heat exchanger is a value corresponding to the desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger.

6. An air conditioner according to any one of claims 2-4, wherein a product of a flow rate of the interior air flowing through the first interior heat exchanger and a difference in absolute value between an actual temperature of the interior air to be cooled by the first interior heat exchanger and a desirable temperature of the interior air to be cooled by the first interior heat exchanger lower than the actual temperature of the interior air to be cooled by the first interior heat exchanger is a value corresponding to the desirable amount in absolute value of thermal energy per unit time to be exchanged by the first interior heat exchanger, and a product of a flow rate of the interior air flowing through the second interior heat exchanger and a difference in absolute value between an actual temperature of the interior air to be heated by the second interior heat exchanger and a desirable temperature of the interior air to be heated by the second interior heat exchanger higher than the actual temperature of the interior air to be heated by the second interior heat exchanger is a value corresponding to the desirable amount in absolute value of thermal energy per unit time to be exchanged by the second interior heat exchanger.

7. An air conditioner according to any one of claims 2-6, wherein at least one of the first and second interior heat exchangers has a plurality of interior sub-heat exchangers connected fluidly in parallel to each other so that the desirable amount in absolute value of thermal energy per unit time to be exchanged by the at least one of the first and second interior heat exchangers is a total amount of desirable amounts in absolute value of thermal energy per unit time to be exchanged by the interior sub-heat exchangers respectively.

8. An air conditioner according to any one of claims 4-7, wherein it is deemed when a difference in absolute value in temperature between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger is more than a first reference degree and a difference in absolute value in temperature between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is less than a second reference degree, that the difference in absolute value between the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger and the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger less than the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger is more than the predetermined reference value.

9. An air conditioner according to any one of claims 4-7, wherein it is deemed when a pressure of the refrigerant evaporated by the first interior heat exchanger is less than a first comparison value and a pressure of the refrigerant condensed by the second interior heat exchanger is less than a second comparison value, that the difference in absolute value between the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger and the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger less than the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger is more than the predetermined reference value.

10. An air conditioner according to any one of claims 4-7, wherein it is deemed when a difference in absolute value in temperature between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger / a difference in absolute value in temperature between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is more than a reference degree, that the difference in absolute value between the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger and the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger less than the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger is more than the predetermined reference value.

11. An air conditioner according to claim 8 or 10, wherein the first interior heat exchanger has a plurality of first interior sub-heat exchangers connected fluidly in parallel to each other, and the difference in absolute value in temperature between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger is the smallest one of differences in absolute value in temperature between the interior airs to be taken into the respective first interior sub-heat exchangers and the interior airs discharged from the respective first interior sub-heat exchangers.

12. An air conditioner according to any one of claims 8, 10 and 11, wherein the second interior heat exchanger has a plurality of second interior sub-heat exchangers connected in parallel to each other, and the difference in absolute value in temperature between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is the greatest one of differences in absolute value in temperature between the interior airs to be taken into the respective second interior sub-heat exchangers and the interior airs discharged from the respective second interior sub-heat exchangers.

13. An air conditioner according to any one of claims 4-12, wherein a difference in temperature in absolute value between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger, and a difference in temperature in absolute value between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger.

14. An air conditioner according to any one of claims 4-12, wherein a product of a flow rate of the interior air flowing through the first interior heat exchanger and a difference in temperature in absolute value between the interior air to be taken into the first interior heat exchanger and the interior air discharged from the first interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger, and a product of a flow rate of the interior air flowing through the second interior heat exchanger and a difference in temperature in absolute value between the interior air to be taken into the second interior heat exchanger and the interior air discharged from the second interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger.

15. An air conditioner according to any one of claims 4-12, wherein a difference in temperature in absolute value between the refrigerant taken into the first interior heat exchanger and the refrigerant discharged from the first interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger, and a difference in temperature in absolute value between the refrigerant taken into the second interior heat exchanger and the refrigerant discharged from the second interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger.

16. An air conditioner according to any one of claims 4-12, wherein a product of a mass flow rate of the refrigerant flowing through the first interior heat exchanger and a difference in temperature in absolute value between the refrigerant taken into the first interior heat exchanger and the refrigerant discharged from the first interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the first interior heat exchanger, and a product of a mass flow rate of the refrigerant flowing through the second interior heat exchanger and a difference in temperature in absolute value between the refrigerant taken into the second interior heat exchanger and the refrigerant discharged from the second interior heat exchanger is a value corresponding to the amount in absolute value of heat energy per unit time actually exchanged by the second interior heat exchanger.

17. An air conditioner according to any one of claims 1-16, wherein at least one of actual and desirable amounts of heat energy exchanged by each of the first and second interior heat exchanger is detected by the air conditioner after at least a predetermined time period elapse from a change between the cooling main course and heating main course.

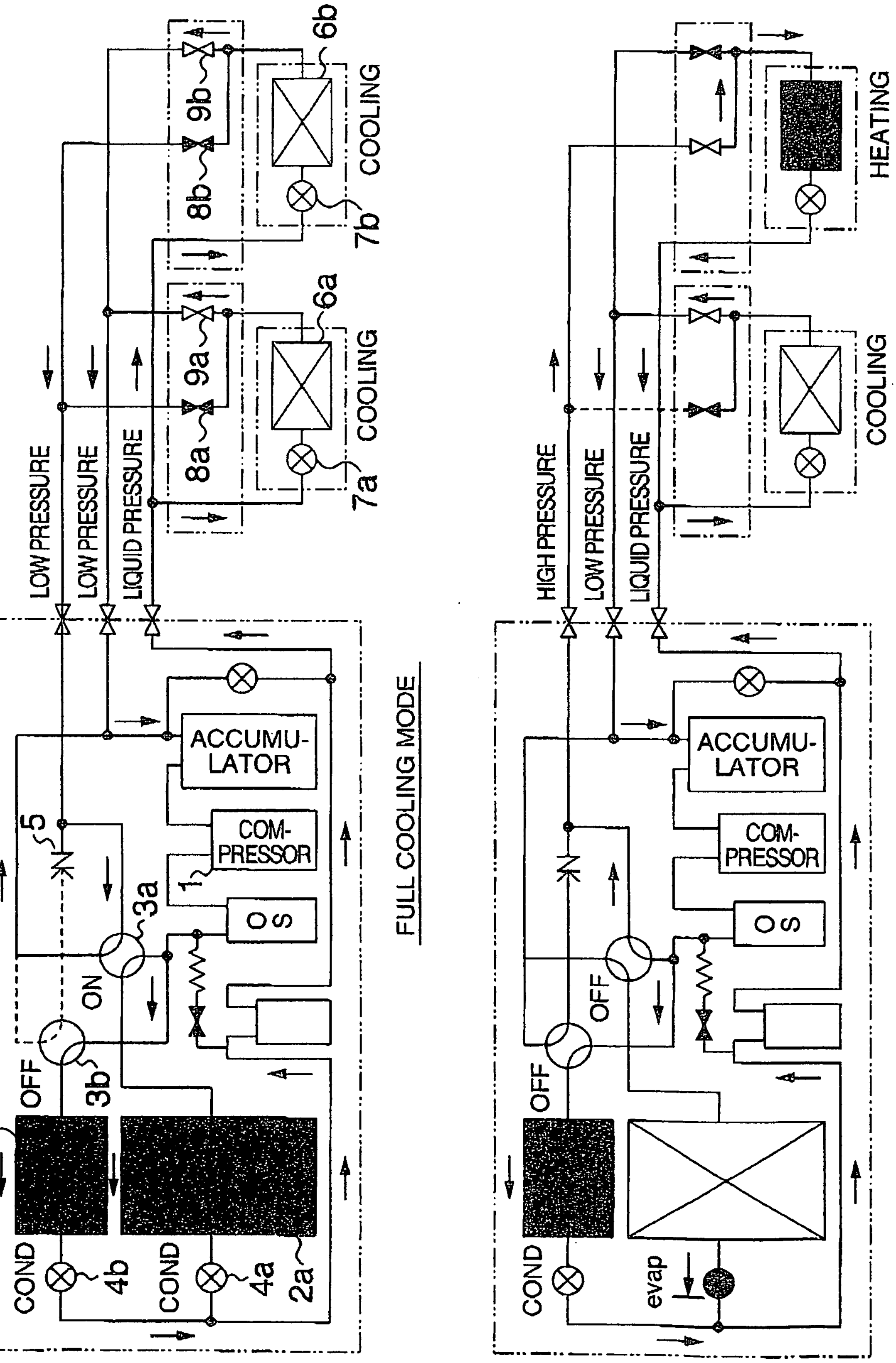
18. An air conditioner according to any one of claims 1-17, wherein the valve means has a four-way valve (3a, 3b), at which the four-way valve is set ON condition or OFF condition is detected from a value of electric current applied to the four-way valve, the exterior heat exchanger has a thermistor for measuring a temperature of the refrigerant in the exterior heat exchanger, and at which the exterior heat exchanger is used the evaporator condition or condenser condition is detected from the temperature of the refrigerant measured by the thermistor so that when the measured temperature of the refrigerant is lower than a predetermined temperature, the exterior heat exchanger is deemed to be used as the evaporator, and when the measured temperature of the refrigerant is not lower than the predetermined temperature, the exterior heat exchanger is deemed to be used as the condenser.

19. An air conditioner according to claim 18, wherein the detected conditions of the four-way valve and exterior heat exchanger are indicated on at least one of a remote controller for controlling the air conditioner and the exterior heat exchanger.

20. An air conditioner comprising an exterior unit having a compressor (1), a plurality of four-way valves (3a, 3b) connected to the compressor to change a flow direction of a refrigerant, a plurality of exterior heat exchangers (2a, 2b), and exterior electronic expansion valves (4a, 4b) connected to the exterior heat exchangers respectively, and a plurality of interior units having respective interior heat exchangers, respective interior electronic expansion valves and respective shut-off valves and connected to the exterior heat exchangers through a pipe for refrigerant of gas state and a pipe for refrigerant of liquid state wherein a refrigerant cycle having one of the interior units operable to cool an interior air and the other one of the interior units operable to heat the interior air is formed, and an operation of

the air conditioner is changed to a cooling main mode with using the exterior heat exchanger as a condenser when a cooling load is greater than a heating load, and to a heating main mode with using the exterior heat exchanger as an evaporator when the heating load is greater than the cooling load,
wherein the operation of the air conditioner is changed from the cooling main mode to the heating main mode when a temperature of an exterior air is not more than a predetermined temperature, and a difference between the cooling load and the heating load is not more than a predetermined value.

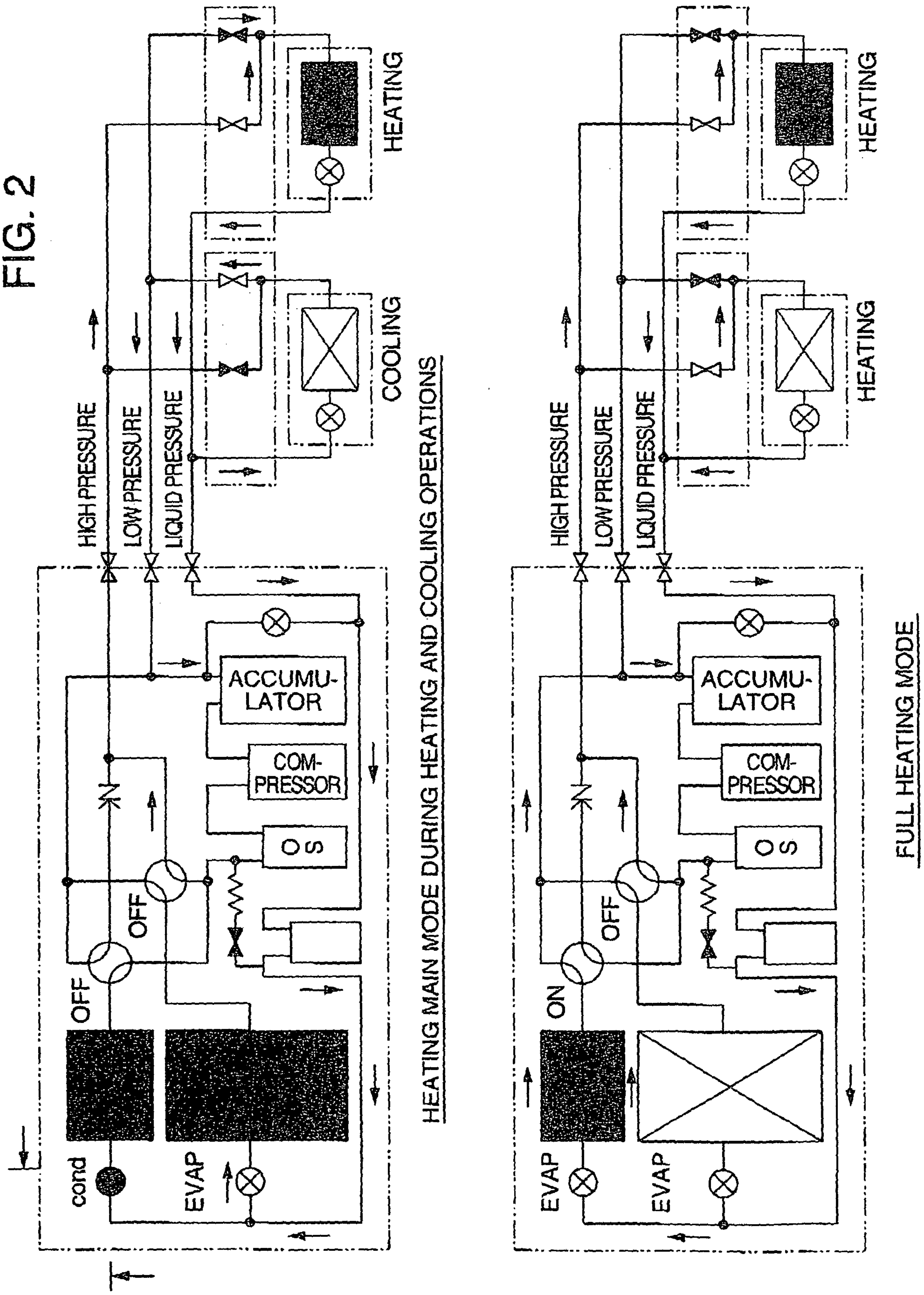
FIG. 1



FULL COOLING MODE

COOLING MAIN MODE DURING COOLING AND HEATING OPERATIONS

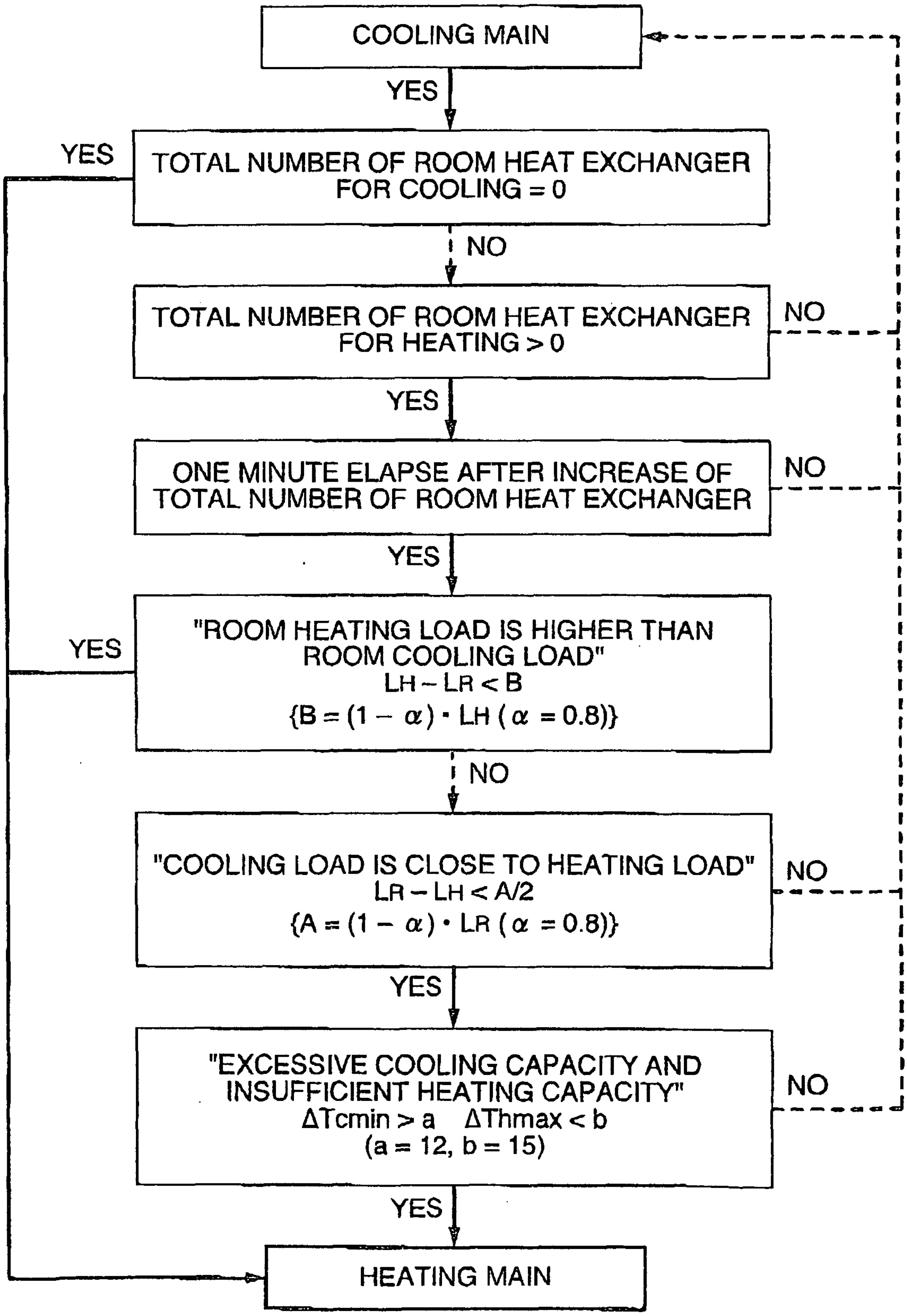
FIG. 2



HEATING MAIN MODE DURING HEATING AND COOLING OPERATIONS

FULL HEATING MODE

FIG. 3



COOLING MAIN
YES
TOTAL NUMBER OF ROOM HEAT EXCHANGER FOR COOLING = 0
YES
NO
TOTAL NUMBER OF ROOM HEAT EXCHANGER FOR HEATING > 0
NO
YES
ONE MINUTE ELAPSE AFTER INCREASE OF TOTAL NUMBER OF ROOM HEAT EXCHANGER
NO
YES
"ROOM HEATING LOAD IS HIGHER THAN ROOM COOLING LOAD"
LH − LR < B
{B = (1 − α) • LH (α = 0.8)}
YES
NO
"COOLING LOAD IS CLOSE TO HEATING LOAD"
LR − LH < A/2
{A = (1 − α) • LR (α = 0.8)}
NO
YES
"EXCESSIVE COOLING CAPACITY AND INSUFFICIENT HEATING CAPACITY"
ΔTcmin > a ΔThmax < b
(a = 12, b = 15)
NO
YES
HEATING MAIN

FIG. 4

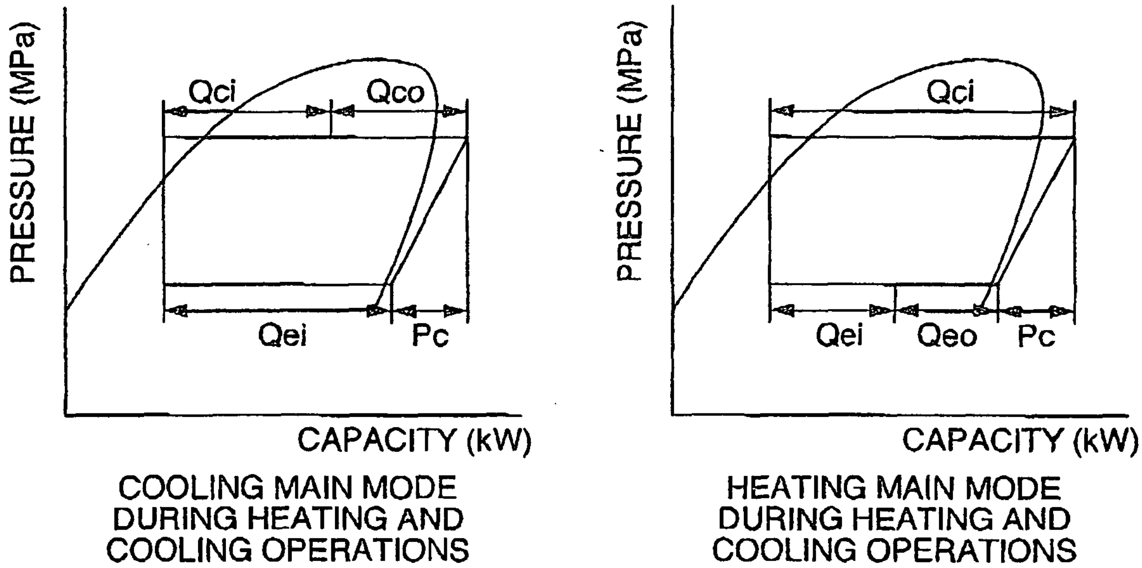

PRESSURE (MPa)
Qci
Qco
Qei
Pc
CAPACITY (kW)
COOLING MAIN MODE
DURING HEATING AND
COOLING OPERATIONS
PRESSURE (MPa)
Qci
Qei
Qeo
Pc
CAPACITY (kW)
HEATING MAIN MODE
DURING HEATING AND
COOLING OPERATIONS

FIG. 6

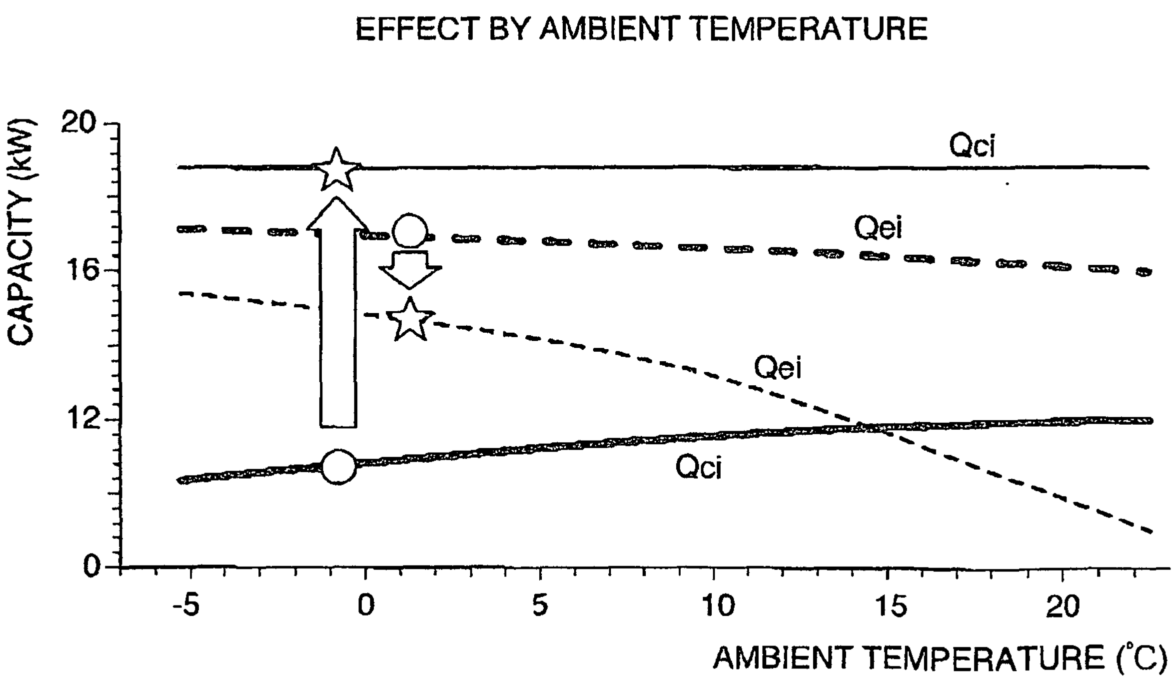
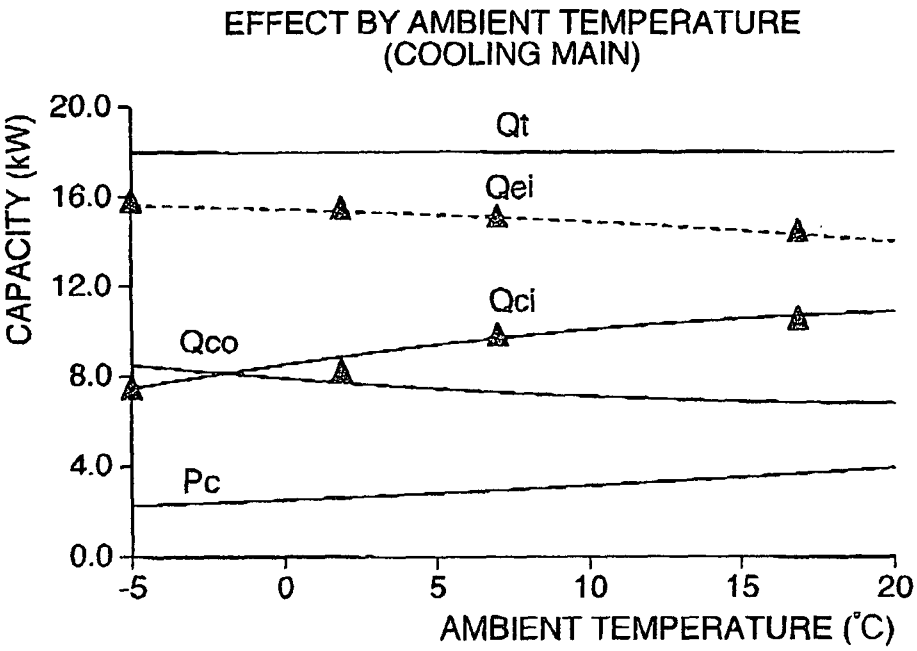
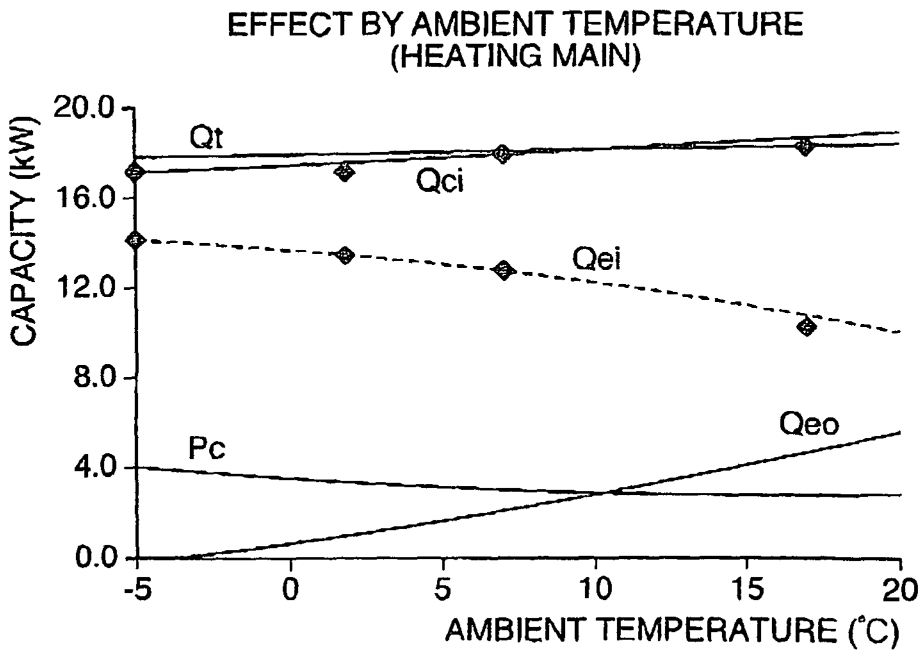

EFFECT BY AMBIENT TEMPERATURE
CAPACITY (kW)
20
16
12
0
Qci
Qei
Qei
Qci
-5
0
5
10
15
20
AMBIENT TEMPERATURE (°C)

FIG. 5


EFFECT BY AMBIENT TEMPERATURE
(COOLING MAIN)
CAPACITY (kW)
20.0
16.0
12.0
8.0
4.0
0.0
Qt
Qei
Qci
Qco
Pc
-5
0
5
10
15
20
AMBIENT TEMPERATURE (°C)


EFFECT BY AMBIENT TEMPERATURE
(HEATING MAIN)
CAPACITY (kW)
20.0
16.0
12.0
8.0
4.0
0.0
Qt
Qci
Qei
Qeo
Pc
-5
0
5
10
15
20
AMBIENT TEMPERATURE (°C)