(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 526 341 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.04.2005 Bulletin 2005/17

(51) Int Cl.[7]: **F24F 11/00**, F25B 13/00, F24F 3/06

(21) Application number: **04250231.0**

(22) Date of filing: **17.01.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(30) Priority: **21.10.2003 KR 2003073328**

(71) Applicant: **Samsung Electronics Co., Ltd.**
Suwon-si, Gyeonggi-do (KR)

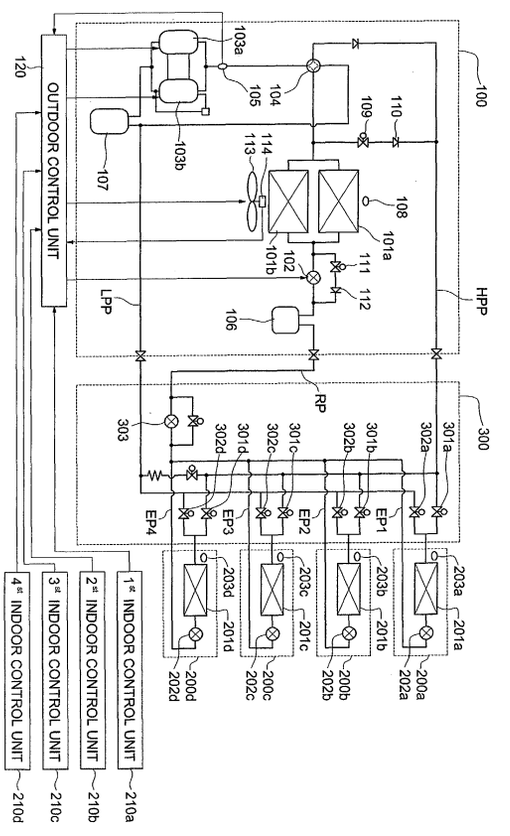
(72) Inventors:
- **Kim, Woo Hyun**
  Kangnam-Gu Seoul (KR)
- **Jung, Gyoo Ha, No. 244-303 Shinan Apt.**
  Suwon-Si Gyeonggi-Do (KR)
- **Jung, Hyun Seok,**
  No. 122-501, Sin Maetan Jookong
  Paldal-Gu Suwon-Si Gyeonggi-Do (KR)

(74) Representative: **Waddington, Richard et al**
Appleyard Lees,
15 Clare Road
Halifax HX1 2HY (GB)

(54) Multi-unit air conditioner and method for controlling the same

(57) An air conditioner having an outdoor unit (100) and a plurality of indoor units (200a-d) connected to the outdoor unit (100), and a method of controlling an operation of the air conditioner. The air conditioner includes an outdoor control unit (120) and a plurality of indoor control units (210a-d). The indoor control units (210a-d) output operational loads to be borne by the indoor units (200a-d), and the outdoor control unit (120) controls an opening ratio of an outdoor expansion valve (102) in response to the operational loads to be borne by the indoor units (200a-d), thus appropriately controlling the amounts of refrigerant fed from compressors (103a/b) to indoor units (200a-d) operating in a cooling mode and indoor units (200a-d) operating in a heating mode. The outdoor control unit (120) further determines a desired compression capacity of the compressors (103a/b) according to outdoor air temperatures, and controls the rpm of an outdoor fan (113) according to an output refrigerant pressure of the compressors (103a/b), thus optimally operating the compressors (103a/b) in response to variations in the outdoor air temperatures.

FIG 1



EP 1 526 341 A1

Description

[0001] The present invention relates, in general, to air conditioners and methods of controlling the air conditioners and, more particularly, to an air conditioner which has an outdoor unit and a plurality of indoor units connected to the outdoor unit such that some indoor units may operate in a cooling mode and some other indoor units may operate in a heating mode, at the same time, and to a method of controlling an operation of the air conditioner.

[0002] Generally, conventional multiunit-type air conditioners include one outdoor unit and a plurality of indoor units connected to the outdoor unit to operate in a cooling mode and/or a heating mode to cool and/or heat indoor air, thus controlling the atmosphere of indoor spaces. In the conventional multiunit-type air conditioners, the outdoor unit includes a plurality of compressors, a plurality of outdoor heat exchangers and an outdoor expansion valve, while each of the plurality of indoor units includes an indoor heat exchanger and an indoor expansion valve. The outdoor and indoor expansion valves are automatic expansion valves.

[0003] Users presenting in rooms having the indoor units of a conventional multiunit-type air conditioner may differently select the operating modes of the indoor units between the cooling mode and the heating mode, as desired.

[0004] For example, because the users presenting in the rooms differently sense temperatures of indoor air, according to a variation in the temperatures of the indoor air during a change of season or to a variation in the environmental conditions of the indoor spaces, the conventional multiunit-type air conditioner may operate in a combined mode in which some indoor units operate in the cooling mode to cool the indoor air and, at the same time, some other indoor units operate in the heating mode to heat the indoor air, according to selections of the users.

[0005] During a combined-mode operation, the conventional multiunit-type air conditioner may operate in a cooling major mode in which the major part of the indoor units operates in the cooling mode and the minor part operates in the heating mode, or in a heating major mode in which the major part of the indoor units operates in the heating mode and the minor part operates in the cooling mode. In the following description, the combined mode with the cooling major mode is referred to as a cooling major combined-mode, while the combined mode with the heating major mode is referred to as a heating major combined-mode.

[0006] During the combined-mode operation of the conventional multiunit-type air conditioner, an output refrigerant discharged from the compressors is divided into two parts which are respectively fed to a first group of indoor units which operate in the cooling mode and to a second group of indoor units which operate in the heating mode. In other words, some of the output refrigerant discharged from the compressors of the outdoor unit is fed to the outdoor heat exchangers acting as condensers, while a remaining part of the output refrigerant is fed to the indoor heat exchangers of some indoor units which operate in the heating mode, without passing through the outdoor heat exchangers.

[0007] When an indoor unit operates in the cooling mode or the heating mode, an operational load to be borne by the indoor unit frequently varies. Therefore, even when the number of the indoor units operating in the heating mode is less than that of the indoor units operating in the cooling mode, the total operational load to be borne by the indoor units operating in the heating mode may increase much higher than the total operational load to be borne by the indoor units operating in the cooling mode. During the combined-mode operation of the conventional multiunit-type air conditioner, the output refrigerant discharged from the compressors must be appropriately divided into two parts which meet the total operational loads to be borne by the two groups of indoor units which respectively operate in the cooling mode and the heating mode.

[0008] However, the conventional multiunit-type air conditioner controls amounts of divided parts of the output refrigerant, according to only the numbers of the two groups of the indoor units which respectively operate in the cooling mode and the heating mode. Therefore, the conventional multiunit-type air conditioner cannot precisely control the amounts of the divided parts of the output refrigerant, which meet the total operational loads to be borne by the two groups of the indoor units which respectively operate in the cooling mode and the heating mode.

[0009] Thus, the conventional multiunit-type air conditioner may supply an excessive amount of output refrigerant to the first group of indoor units that operates in the cooling mode, while the amount of the refrigerant fed to the second group of indoor units operating in the heating mode may be deficient. In the above state, the heating-mode performances of the indoor units that operate in the heating mode, as well as the cooling-mode performances of the indoor units that operate in the cooling mode, may be reduced.

[0010] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0011] Accordingly, it is an aspect of the present invention to provide an air conditioner and a method of controlling the air conditioner, in which an output refrigerant discharged from the compressors during a combined-mode operation of the air conditioner, is appropriately controlled in consideration of operational loads to be borne by two groups of indoor units respectively operating in a cooling mode and a heating mode, thus the output refrigerant is accurately divided into two parts that are respectively fed to the two groups of indoor units.

[0012] The above and/or other aspects are achieved by providing an air conditioner, including: an outdoor unit having a compressor, an outdoor heat exchanger, an outdoor expansion valve and an ON/OFF valve; a plurality of indoor units respectively having a plurality of indoor heat exchangers; a first refrigerant line through which a refrigerant discharged from the compressor flows from the compressor to the plurality of indoor units while passing through the ON/OFF valve; a second refrigerant line through which the refrigerant discharged from the compressor flows from the compressor to the plurality of indoor units while passing through the outdoor heat exchanger and the outdoor expansion valve; and a control unit to control an amount of the refrigerant flowing through the first refrigerant line and an amount of the refrigerant flowing through the second refrigerant line, according to operational loads to be borne by the plurality of indoor units.

[0013] The ON/OFF valve may be connected at an inlet thereof to a position between the compressor and the outdoor heat exchanger, and may be connected at an outlet thereof to the plurality of indoor units.

[0014] The outdoor expansion valve may be connected to an outlet of the outdoor heat exchanger.

[0015] The control unit may control the ON/OFF valve and the outdoor expansion valve so as to control the amount of the refrigerant flowing through the first refrigerant line and the amount of the refrigerant flowing through the second refrigerant line.

[0016] The control unit may include: an indoor control unit to provide the operational loads to be borne by the plurality of indoor units operating in a cooling mode or a heating mode; and an outdoor control unit to control the ON/OFF valve and an opening ratio of the outdoor expansion valve, in response to the operational loads provided by the indoor control unit.

[0017] The outdoor control unit may determine the opening ratio of the outdoor expansion valve, so as to optimize operational performances of the indoor units operating in the cooling mode and operational performances of all the indoor units which include the indoor units operating in the cooling mode and the. indoor units operating in the heating mode, during a cooling major combined-mode operation in which a major part of the indoor units operates in the cooling mode and a minor part of the indoor units operates in the heating mode.

[0018] The plurality of indoor units may further include a plurality of indoor temperature sensors, respectively, and the indoor control unit may provide the operational loads, which are borne by the plurality of indoor units, according to differences between indoor temperatures around the indoor units and preset reference temperatures.

[0019] The outdoor control unit may compare a total operational load to be borne by the indoor units operating in the heating mode to a total operational load to be borne by the indoor units operating in the cooling mode, prior to determining the opening ratio of the outdoor expansion valve according to a result of the total operational load comparison.

[0020] The above and/or other aspects are achieved by providing an air conditioner, including: an outdoor unit having a compressor, an outdoor heat exchanger, an outdoor expansion valve, an ON/OFF valve, an outdoor fan, an outdoor temperature sensor and a pressure sensor; a plurality of indoor units each having an indoor temperature sensor and an indoor heat exchanger; a first refrigerant line through which a refrigerant discharged from the compressor flows from the compressor to the plurality of indoor units while passing through the ON/OFF valve; a second refrigerant line through which the refrigerant discharged from the compressor flows from the compressor to the plurality of indoor units while passing through the outdoor heat exchanger and the outdoor expansion valve; an indoor control unit to provide operational loads, which are borne by the plurality of indoor units, according to differences between indoor temperatures sensed by the indoor temperature sensors of the indoor units and preset reference temperatures; and an outdoor control unit to control the ON/OFF valve and an opening ratio of the outdoor expansion valve in response to the operational loads provided by the indoor control unit, and to determine a desired compression capacity of the compressor according to an outdoor temperature sensed by the outdoor temperature sensor, and to control a rotating speed of the outdoor fan according to an output refrigerant pressure of the compressor which is sensed by the pressure sensor when the compressor operates according to the desired compression capacity.

[0021] The outdoor control unit may determine the desired compression capacity of the compressor to be higher as the outdoor temperature, sensed by the outdoor temperature sensor, is higher.

[0022] The outdoor control unit may increase the rotating speed of the outdoor fan to reduce the output refrigerant pressure of the compressor, and may reduce the rotating speed of the outdoor fan to increase the output refrigerant pressure of the compressor.

[0023] The outdoor unit may further include a speed sensor to sense the rotating speed of the outdoor fan, and the outdoor control unit may control the outdoor fan according to the rotating speed of the outdoor fan which is sensed by the speed sensor.

[0024] The above and/or other aspects are achieved by providing a method of controlling an air conditioner, the air conditioner having an outdoor unit having a compressor, an outdoor heat exchanger, an outdoor expansion valve and an ON/OFF valve; a plurality of indoor units respectively having a plurality of indoor heat exchangers; a first refrigerant line through which a refrigerant discharged from the compressor flows from the compressor to the plurality of indoor units while passing through the ON/OFF valve; and a second refrigerant line through which the refrigerant discharged from the compressor flows from the compressor to the plurality of in-

door units while passing through the outdoor heat exchanger and the outdoor expansion valve, the method including: calculating operational loads to be borne by the plurality of indoor units; and controlling an amount of the refrigerant flowing through the first refrigerant line and an amount of the refrigerant flowing through the second refrigerant line, according to the operational loads to be borne by the plurality of indoor units.

[0025] In the method, the operational loads to be borne by the plurality of indoor units may be calculated according to differences between indoor temperatures around the indoor units and preset reference temperatures.

[0026] The calculating of the operational loads and the controlling of the amounts of the refrigerant may include: calculating a total operational load to be borne by indoor units operating in a cooling mode and a total operational load to be borne by indoor units operating in a heating mode during a cooling major combined-mode operation in which a major part of the plurality of indoor units operates in the cooling mode and a minor part of the plurality of indoor units operates in the heating mode; comparing the total operational load to be borne by the indoor units operating in the cooling mode to the total operational load to be borne by the indoor units operating in the heating mode; and controlling the ON/OFF valve and an opening ratio of the outdoor expansion valve according to a result of the comparing of the total operational loads.

[0027] The controlling of the opening ratio of the outdoor expansion valve may be executed to optimize operational performances of the indoor units operating in the cooling mode and operational performances of all the indoor units which include the indoor units operating in the cooling mode and the indoor units operating in the heating mode, during the cooling major combined-mode operation.

[0028] The method may further include: sensing an outdoor temperature by an outdoor temperature sensor provided in the outdoor unit, after the controlling of the amounts of the refrigerant; and determining a desired compression capacity of the compressor according to the outdoor temperature sensed by the outdoor temperature sensor.

[0029] The method may further include: sensing an output refrigerant pressure of the compressor when the compressor operates according to the desired compression capacity; and controlling a rotating speed of an outdoor fan provided in the outdoor unit, according to the output refrigerant pressure of the compressor.

[0030] The controlling of the rotating speed of the outdoor fan may include: comparing the output refrigerant pressure of the compressor to a preset reference pressure; and increasing the rotating speed of the outdoor fan when the output refrigerant pressure of the compressor is higher than the preset reference pressure, and reducing the rotating speed of the outdoor fan when the output refrigerant pressure of the compressor is lower than the preset reference pressure.

[0031] These and other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the preferred embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a diagram of a refrigeration circuit of an air conditioner, according to an embodiment of the present invention;

FIG. 2 is a diagram of the refrigeration circuit of FIG. 1, which shows a flowing direction of a refrigerant in the refrigeration circuit when the air conditioner operates in a cooling major combined-mode;

FIG. 3 is a graph showing an operational performance of indoor units of the air conditioner of the present invention as a function of an opening ratio of an outdoor expansion valve when a total operational load to be borne by indoor units operating in a heating mode is larger than a total operational load to be borne by indoor units operating in a cooling mode;

FIG. 4 is a graph showing the operational performance of the indoor units of the air conditioner of the present invention as a function of the opening ratio of the outdoor expansion valve when the total operational load to be borne by the indoor units operating in the heating mode is not larger than the total operational load to be borne by the indoor units operating in the cooling mode; and

FIGS. 5A and 5B are flowcharts of a method of controlling the air conditioner, according to the present invention.

[0032] Reference will now be made in detail to the present preferred embodiments of the present invention, an example of which is illustrated in the accompanying drawings, wherein the same reference numerals refer to the same elements throughout. The embodiment is described below in order to explain the present invention by referring to the figures.

[0033] In the embodiment, the present invention is adapted to a multiunit-type air conditioner that has an outdoor unit and a plurality of indoor units connected to the outdoor unit.

[0034] As shown in FIG. 1, a refrigeration circuit of the multiunit-type air conditioner according to the embodiment of the present invention includes one outdoor unit 100, and four indoor units which are first, second, third and fourth indoor units 200a, 200b, 200c and 200d connected to the outdoor unit 100, with a refrigerant switching unit 300 interposed between the outdoor unit 100 and the four indoor units 200a, 200b, 200c and 200d to switch a flow of a refrigerant in the refrigeration circuit.

[0035] The outdoor unit 100 includes a plurality of outdoor heat exchangers 101a and 101b, an outdoor fan 113, and an outdoor expansion valve 102 connected to outlets of the outdoor heat exchangers 101a and 101b. The outdoor unit 100 further includes a first ON/OFF valve 111 and a first check valve 112 connected to the outlet of the outdoor heat exchangers 101a and 101b in parallel to the outdoor expansion valve 102, a plurality of variable capacity compressors 103a and 103b, a four-way valve 104, a receiver 106 and an accumulator 107. The outdoor unit 100 further includes a second ON/OFF valve 109 and a second check valve 110 to bypass an output refrigerant discharged from the compressors 103a and 103b to indoor units that operate in a heating mode, without allowing the output refrigerant to pass through the outdoor heat exchangers 101a and 101b.

[0036] The outdoor unit 100 further includes an outdoor temperature sensor 108 to sense a temperature of outdoor air, a speed sensor which is an rpm sensor 114 to sense a rotating speed (rpm) of the outdoor fan 113, and a pressure sensor 105 to sense a pressure of the output refrigerant discharged from the compressors 103a and 103b.

[0037] The air conditioner of the present invention further includes an outdoor control unit 120 to control an operation of the outdoor unit 100.

[0038] The outdoor control unit 120 controls an opening ratio of the outdoor expansion valve 102, based on information data signals which are output from a plurality of indoor control units 210a, 210b, 210c and 210d and represent operational loads to be borne by the indoor units 200a, 200b, 200c and 200d, thus the outdoor control unit 120 appropriately controls the amounts of divided parts of the output refrigerant which are respectively fed to indoor units operating in the heating and cooling modes, respectively. The outdoor control unit 120 also controls the compressors 103a and 103b and the outdoor fan 113, based on information data signals output from the outdoor temperature sensor 108, rpm sensor 114 and the pressure sensor 105.

[0039] The first to fourth indoor units 200a, 200b, 200c and 200d each include an indoor heat exchanger 201a, 201b, 201c, 201d, an indoor expansion valve 202a, 202b, 202c, 202d, and an indoor temperature sensor 203a, 203b, 203c, 203d to sense a temperature of indoor air of each of the rooms in which the indoor units 200a, 200b, 200c and 200d are respectively installed. The outdoor and indoor expansion valves 102, 202a, 202b, 202c and 202d are automatic expansion valves.

[0040] The plurality of indoor control units which are the first, second, third and fourth indoor control units 210a, 210b, 210c and 210d, are provided in the air conditioner of the present invention to respectively independently control the first to fourth indoor units 200a, 200b, 200c and 200d.

[0041] The first to fourth indoor control units 210a, 210b, 210c and 210d respectively calculate operational loads to be borne by the first to fourth indoor units 200a, 200b, 200c and 200d, based on differences between the indoor air temperatures sensed by the indoor temperature sensors 203a, 203b, 203c and 203d and reference indoor temperatures preset by users with function keys of the indoor units 200a, 200b, 200c and 200d or remote controllers for the indoor units 200a, 200b, 200c and 200d. After the calculation of the operational loads to be borne by the indoor units 200a, 200b, 200c and 200d, the indoor control units 210a, 210b, 210c and 210d output the information data signals representing the operational loads to the outdoor control unit 120.

[0042] The first to fourth indoor control units 210a, 210b, 210c and 210d also control a plurality of indoor fans (not shown) and the indoor expansion valves 202a, 202b, 202c and 202d, in conjunction with the outdoor control unit 120.

[0043] The refrigerant switching unit 300 includes a plurality of high-pressure gas valves 301a, 301b, 301c and 301d, a plurality of low-pressure gas valves 302a, 302b, 302c and 302d, and an expansion valve 303. The plurality of high-pressure gas valves 301a, 301b, 301c and 301d are respectively mounted on a plurality of branch lines of a high-pressure pipe HPP extending between the outdoor unit 100 and the indoor units 200a, 200b, 200c and 200d. The plurality of low-pressure gas valves 302a, 302b, 302c and 302d are respectively mounted on a plurality of branch lines of a low-pressure pipe LPP extending between the outdoor unit 100 and the indoor units 200a, 200b, 200c and 200d. The expansion valve 303 which is an automatic expansion valve, is mounted on a common liquid pressure pipe which extends from and the indoor units 200a, 200b, 200c and 200d to the outdoor unit 100. The outdoor control unit 120 controls all the valves of the refrigerant switching unit 300.

[0044] The plurality of high-pressure gas valves 301a, 301b, 301c and 301d of the refrigerant switching unit 300 are connected to an end of the four-way valve 104 of the outdoor unit 100 via the high-pressure pipe HPP. The plurality of low-pressure gas valves 302a, 302b, 302c and 302d of the refrigerant switching unit 300 are connected to the accumulator 107 of the outdoor unit 100 via the low-pressure pipe LPP.

[0045] The refrigerant switching unit 300 is connected to the outdoor heat exchangers 101a and 101b of the outdoor unit 100 via a return pipe RP, with the outdoor expansion valve 102 mounted on the return pipe RP. The first ON/OFF valve 111 which is mounted on the return pipe RP in parallel to the outdoor expansion valve 102, is a valve to control a flow rate of the refrigerant.

[0046] The return pipe RP is connected to a plurality of pipes EP1, EP2, EP3 and EP4 extending from the indoor units 200a, 200b, 200c and 200d.

[0047] FIG. 2 is a diagram of the refrigeration circuit of FIG. 1, which shows a flowing direction of the refrigerant in the refrigeration circuit when the air conditioner operates in a cooling major combined-mode.

[0048] In FIG. 2, the air conditioner executes a cooling

major combined-mode operation, with the first indoor unit 200a operating in the heating mode and the second to fourth indoor units 200b, 200c and 200d operating in the cooling mode. To execute the cooling major combined-mode operation, the compressors 103a and 103b starts operations thereof. In the above state, the outdoor expansion valve 102 is opened at a predetermined opening ratio, the second ON/OFF valve 109 is opened, and the high-pressure gas valve 301a of the first indoor unit 200a operating in the heating mode is opened. Furthermore, the high-pressure gas valves 301b, 301c and 301d of the second to fourth indoor units 200b, 200c and 200d operating in the cooling mode are closed, the low-pressure gas valve 302a of the first indoor unit 200a is closed, and the low-pressure gas valves 302b, 302c and 302d of the second to fourth indoor units 200b, 200c and 200d are opened.

[0049] The output refrigerant discharged from the compressors 103a and 103b is thus divided into first and second parts of which the first part passes through the outdoor heat exchangers 101a and 101b, at which heat transfers between the output refrigerant and the outdoor air. Thereafter, the first part of the output refrigerant is fed to the second to fourth indoor units 200b, 200c and 200d operating in the cooling mode, via the outdoor expansion valve 102. The second part of the output refrigerant discharged from the compressors 103a and 103b is fed to the first indoor unit 200a operating in the heating mode, after sequentially passing through the second ON/OFF valve 109 and the second check valve 110.

[0050] In the above state, the outdoor control unit 120 determines the opening ratio of the outdoor expansion valve 102 while regarding the total operational load to be borne by the first indoor unit 200a operating in the heating mode and the total operational load to be borne by the second to fourth indoor units 200b, 200c and 200d operating in the cooling mode. The outdoor control unit 120 thus appropriately controls the amounts of first and second parts of the output refrigerant which are respectively fed to the second to fourth indoor units 200b, 200c and 200d operating in the cooling mode and the first indoor unit 200a operating in the heating mode.

[0051] The determination of the opening ratio of the outdoor expansion valve 102 to control the amounts of the first and second parts of the output refrigerant will be described in detail herein below, with reference to FIGS. 3 and 4.

[0052] The outdoor control unit 120 controls the opening ratio of the outdoor expansion valve 102, in consideration of the total operational load to be borne by the first indoor unit 100a operating in the heating mode and the total operational load to be borne by the second to fourth indoor units 100b, 100c and 100d operating in the cooling mode.

[0053] For an example, when the total operational load to be borne by the first indoor unit 100a operating in the heating mode is larger than the total operational load to be borne by the second to fourth indoor units 100b, 100c and 100d operating in the cooling mode, the opening ratio of the outdoor expansion valve 102 is set to a first level. In the air conditioner of the present invention, the first level of the opening ratio of the outdoor expansion valve 102 is stored, as data obtained from tests, in a memory of the outdoor control unit 120. The tests to determine the first level of the opening ratio of the outdoor expansion valve 102 were executed at an indoor air temperature of 20°C(dry-bulb temperature)/15°C(wet-bulb temperature) and an outdoor air temperature of -5°C. When the first level of the opening ratio of the outdoor expansion valve 102 is set to 50% in the tests, the operational performances of the second to fourth indoor units 100b, 100c and 100d operating in the cooling mode and the operational performances of all the indoor units 100a, 100b, 100c and 100d, which include the indoor unit operating in the heating mode and the indoor units operating in the cooling mode, are optimized, as shown by the points A of FIG. 3.

[0054] For another example, when the total operational load to be borne by the first indoor unit 100a operating in the heating mode is not larger than the total operational load to be borne by the second to fourth indoor units 100b, 100c and 100d operating in the cooling mode, the opening ratio of the outdoor expansion valve 102 is set to a second level. In the air conditioner of the present invention, the second level of the opening ratio of the outdoor expansion valve 102 is stored, as data obtained from tests, in the memory of the outdoor control unit 120. The tests to determine the second level of the opening ratio of the outdoor expansion valve 102 were executed at an indoor air temperature of 27°C(dry-bulb temperature)/19.5°C(wet-bulb temperature) and an outdoor air temperature of 15°C(dry-bulb temperature)/10°C(wet-bulb temperature). When the second level of the opening ratio of the outdoor expansion valve 102 is set to 35% in the tests, the operational performances of the second to fourth indoor units 100b, 100c and 100d operating in the cooling mode and the operational performances of all the indoor units 100a, 100b, 100c and 100d, which include the indoor unit operating in the heating mode and the indoor units operating in the cooling mode, are optimized, as shown by the points B of FIG. 4.

[0055] After controlling the amounts of the first and second parts of the output refrigerant to be respectively fed to the second to fourth indoor units 200b, 200c and 200d operating in the cooling mode and the first indoor unit 200a operating in the heating mode, the outdoor control unit 120 compares a sensed outdoor air temperature to a preset reference outdoor temperature. Thereafter, the outdoor control unit 120 determines a desired compression capacity of the compressors 103a and 103b according to a temperature comparison result, and drives the compressors 103a and 103b based on the desired compression capacity. For example, when the sensed outdoor air temperature is higher than the reference outdoor temperature, the outdoor control unit 120 drives the compressors 103a and 103b to provide a first

compression capacity. However, when the sensed outdoor air temperature is not higher than the reference outdoor temperature, the outdoor control unit 120 drives the compressors 103a and 103b to provide a second compression capacity smaller than the first compression capacity. The outdoor control unit 120 thus controls the desired compression capacity of the compressors 103a and 103b according to a variation in the outdoor air temperature.

[0056] After the desired compression capacity of the compressors 103a and 103b is determined, the outdoor control unit 120 compares the pressure of the output refrigerant discharged from the compressors 103a and 103b to a preset reference pressure while driving the compressors 103a and 103b to provide the desired compression capacity, and controls the rpm of the outdoor fan 113, based on the pressure comparison result. For example, when the output refrigerant pressure is included between the upper and lower limits of the reference pressure, the outdoor control unit 120 continues the operations of the compressors 103a and 103b without change. However, when the output refrigerant pressure is higher than the upper limit of the reference pressure, the outdoor control unit 120 increases the rpm of the outdoor fan 113, thus enhancing the heat exchanging efficiency of the outdoor heat exchangers 101a and 101b and thereby reducing the output refrigerant pressure. When the output refrigerant pressure is lower than the lower limit of the reference pressure, the outdoor control unit 120 reduces the rpm of the outdoor fan 113, thus reducing the heat exchanging efficiency of the outdoor heat exchangers 101a and 101b and thereby increasing the output refrigerant pressure. The outdoor control unit 120 thus controls the pressure of the output refrigerant discharged from the compressors 103a and 103b to meet the reference pressure.

[0057] A method of controlling the air conditioner having the above-mentioned construction will be described herein below, with reference to FIGS. 5A and 5B.

[0058] FIGS. 5A and 5B are flowcharts of the method of controlling the air conditioner, when the air conditioner operates in the cooling major combined-mode, with the first indoor unit 200a operating in the heating mode and the second to fourth indoor units 200b, 200c and 200d operating in the cooling mode. In the following description, the indoor unit(s) operating in the heating mode are referred to simply as the heating-mode indoor unit(s), and the indoor unit(s) operating in the cooling mode are referred to as the cooling-mode indoor unit(s), for ease of description.

[0059] When the air conditioner is powered on, the outdoor control unit 120 initializes the air conditioner in operation 10, to drive the compressors 103a and 103b and control a variety of valves, according to a preset control program.

[0060] After the initialization in operation 10, the first to fourth indoor control units 210a, 210b, 210c and 210d respectively output mode signals to the outdoor control unit 120, in operation 12. In the above state, the mode signals respectively represent designated operating modes of the first to fourth indoor units 200a, 200b, 200c and 200d, thus the outdoor control unit 120 recognizes the designated operating modes of the first to fourth indoor units 200a, 200b, 200c and 200d, based on the mode signals.

[0061] Thereafter, the outdoor control unit 120 determines, in operation 14, whether a number Nc of the cooling-mode indoor units is larger than a number Nh of the heating-mode indoor units.

[0062] When the number Nc of the cooling-mode indoor units is not larger than the number Nh of the heating-mode indoor units, the air conditioner operates in a designated operating mode which is a heating major combined-mode, in operation 15. The operation of the air conditioner in the heating major combined-mode is not described in the following.

[0063] However, when the number Nc of the cooling-mode indoor units is larger than the number Nh of the heating-mode indoor units, the outdoor control unit 120 controls the four-way valve 104 and opens the second ON/OFF valve 109, in operation 16, to execute the cool major combined-mode operation of the air conditioner. Therefore, the output refrigerant discharged from the compressors 103a and 103b is divided into first and second parts of which the first part sequentially passes through the outdoor heat exchangers 101a and 101b acting as condensers, and the outdoor expansion valve 102, prior to being fed to the cooling-mode indoor units 200b, 200c and 200d. The second part of the output refrigerant discharged from the compressors 103a and 103b is bypassed to reach the heating-mode indoor unit 200a, without passing through the outdoor heat exchangers 101a and 101b.

[0064] The first to fourth indoor control units 210a, 210b, 210c and 210d respectively calculate operational loads to be borne by the first to fourth indoor units 200a, 200b, 200c and 200d, based on differences between the indoor air temperatures sensed by the indoor temperature sensors 203a, 203b, 203c and 203d and the reference indoor temperatures, and respectively output information data signals representing the operational loads to be borne by the first to fourth indoor units 200a, 200b, 200c and 200d to the outdoor control unit 120, in operation 18.

[0065] The outdoor control unit 120 determines, in operation 20, whether the total operational load LTh to be borne by the heating-mode indoor unit 200a is larger than the total operational load LTc to be borne by the cooling-mode indoor units 200b, 200c and 200d. When the total operational load LTh to be borne by the heating-mode indoor unit 200a is larger than the total operational load LTc to be borne by the cooling-mode indoor units 200b, 200c and 200d, the outdoor control unit 120 sets the opening ratio V0 of the outdoor expansion valve 102 to the first level V1, in operation 22. However, when the total operational load LTh to be borne by the heating-

mode indoor unit 200a is not larger than the total operational load LTc to be borne by the cooling-mode indoor units 200b, 200c and 200d, the outdoor control unit 120 sets the opening ratio V0 of the outdoor expansion valve 102 to the second level V2, in operation 24. In the air conditioner of the present invention, the first and second levels V1 and V2 of the opening ratio of the outdoor expansion valve 102 are stored, as data obtained from tests, in the memory of the outdoor control unit 120.

[0066] Thereafter, the outdoor control unit 120 drives the outdoor expansion valve 102 according to the preset first or second level V1 or V2, in operation 26, thus controlling the opening ratio V0 of outdoor expansion valve 102.

[0067] After the control for the opening ratio V0 of outdoor expansion valve 102, the outdoor control unit 120 recognizes a sensed outdoor air temperature, in operation 28, based on an outdoor temperature signal output from the outdoor temperature sensor 108.

[0068] In operation 30, the outdoor control unit 120 determines whether the sensed outdoor air temperature Mo is higher than the preset reference outdoor temperature Mr. In the embodiment of the present invention, the preset reference outdoor temperature Mr is 0°C.

[0069] When the sensed outdoor air temperature Mo has been determined to be higher than the preset reference outdoor temperature Mr in operation 30, the outdoor control unit 120 sets the desired compression capacity CP of the compressors 103a and 103b to the first compression capacity CP1, in operation 32.

[0070] Thereafter, the outdoor control unit 120 drives the compressors 103a and 103b to provide the first compression capacity CP1, in operation 34. The outdoor control unit 120 further recognizes a sensed output refrigerant pressure Pd in operation 36, based on an output refrigerant pressure signal output from the pressure sensor 105.

[0071] Thereafter, the outdoor control unit 120 determines, in operation 38, whether the sensed output refrigerant pressure Pd is included between the lower and upper limits P1 and P2 of a first reference pressure. When the sensed output refrigerant pressure Pd is lower than the lower limit P1 or higher than the higher limit P2 of the first reference pressure, the outdoor control unit 120 controls the rpm of the outdoor fan 113 in operation 40, thus controlling the output refrigerant pressure. In a detailed description, when the sensed output refrigerant pressure Pd is higher than the upper limit P2 of the first reference pressure, the outdoor control unit 120 increases the rpm of the outdoor fan 113, thus enhancing the heat exchanging efficiency of the outdoor heat exchangers 101a and 101b and thereby reducing the output refrigerant pressure. However, when the sensed output refrigerant pressure Pd is lower than the lower limit P1 of the first reference pressure, the outdoor control unit 120 reduces the rpm of the outdoor fan 113, thus reducing the heat exchanging efficiency of the outdoor heat exchangers 101a and 101b and thereby increasing the output refrigerant pressure. In the above state, the outdoor control unit 120 controls the rpm of the outdoor fan 113, based on an rpm signal output from the rpm sensor 114. After the control for the rpm of the outdoor fan 113 of operation 40, the process is returned to operation 36.

[0072] When the sensed outdoor air temperature Mo has been determined to be not higher than the preset reference outdoor temperature Mr in operation 30, the outdoor control unit 120 sets the desired compression capacity CP of the compressors 103a and 103b to the second compression capacity CP2 smaller than the first compression capacity CP1, in operation 42. The outdoor control unit 120 thus appropriately determines the desired compression capacity CP of the compressors 103a and 103b, according to a variation in the outdoor air temperatures, thereby enhancing the operational performance of the air conditioner.

[0073] After setting the desired compression capacity CP of the compressors 103a and 103b to the second compression capacity CP2, the outdoor control unit 120 drives the compressors 103a and 103b to provide the second compression capacity CP2, in operation 44. The outdoor control unit 120 further recognizes a sensed output refrigerant pressure Pd in operation 46, based on an output refrigerant pressure signal output from the pressure sensor 105. Thereafter, the outdoor control unit 120 determines, in operation 48, whether the sensed output refrigerant pressure Pd is included between the lower and upper limits P11 and P12 of a second reference pressure.

[0074] When the sensed output refrigerant pressure Pd is lower than the lower limit P11 or higher than the higher limit P12 of the second reference pressure, the outdoor control unit 120 controls the rpm of the outdoor fan 113 in operation 50, thus controlling the output refrigerant pressure. In other words, when the sensed output refrigerant pressure Pd is higher than the upper limit P12 of the second reference pressure, the outdoor control unit 120 increases the rpm of the outdoor fan 113, thus enhancing the heat exchanging efficiency of the outdoor heat exchangers 101a and 101b and thereby reducing the output refrigerant pressure. However, when the sensed output refrigerant pressure Pd is lower than the lower limit P11 of the second reference pressure, the outdoor control unit 120 reduces the rpm of the outdoor fan 113, thus reducing the heat exchanging efficiency of the outdoor heat exchangers 101a and 101b and thereby increasing the output refrigerant pressure. After the control for the rpm of the outdoor fan 113 of operation 50, the process is returned to operation 46.

[0075] When the outdoor control unit 120 determines, in operation 38 or 48, that the sensed output refrigerant pressure Pd is included between the lower and upper limits P1 and P2 of the first reference pressure, or between the lower and upper limits P11 and P12 of the second reference pressure, the outdoor control unit 120 determines, in operation 52, whether the cooling major

combined-mode operation of the air conditioner must be stopped or not. When the outdoor control unit 120 determined that the cooling major combined-mode operation of the air conditioner must be continued, the process is retuned to operation 12 so as to continue the cooling major combined-mode operation of the air conditioner.

[0076] However, when the outdoor control unit 120 determined that the cooling major combined-mode operation of the air conditioner must be stopped, the outdoor control unit 120 stops the operations of the compressors 103a and 103b, the outdoor fan 113, and other drive parts, thus stopping the cooling major combined-mode operation of the air conditioner.

[0077] As apparent from the above description, the present invention provides an air conditioner having an outdoor unit and a plurality of indoor units connected to the outdoor unit, and a method of controlling an operation of the air conditioner. In the air conditioner and the control method thereof, an outdoor control unit controls amounts of refrigerant fed from compressors to the indoor units, in response to operational loads to be borne by the indoor units, thus appropriately responding to variations in the operational loads to be borne by the indoor units. Particularly when the air conditioner operates in a combined mode in which some indoor units operate in a cooling mode and some other indoor units operate in a heating mode, at the same time, the cooling-mode performance and the heating-mode performance of the indoor units are optimized. The air conditioner thus optimally operates in the combined mode. Furthermore, the outdoor control unit of the air conditioner determines a desired compression capacity of the compressors according to outdoor air temperatures, and controls an rpm of an outdoor fan according to pressures of the output refrigerant discharged from the compressors, thus optimally operating the compressors in response to variations in the outdoor air temperatures.

[0078] Although a preferred embodiment of the present invention has been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

[0079] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0080] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0081] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0082] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An air conditioner, comprising:

an outdoor unit (100) having a compressor (103a/b), an outdoor heat exchanger (101a/b), an outdoor expansion valve (102) and an ON/OFF valve (109);
a plurality of indoor units (200a-d) respectively having a plurality of indoor heat exchangers (201a-d);
a first refrigerant line (HPP) through which a refrigerant discharged from the compressor (103a/b) flows from the compressor (103a/b) to the plurality of indoor units (200a-d) while passing through the ON/OFF valve (109);
a second refrigerant line (RP) through which the refrigerant discharged from the compressor (103a/b) flows from the compressor (103a/b) to the plurality of indoor units (200a-d) while passing through the outdoor heat exchanger (101a/b) and the outdoor expansion valve (102); and
a control unit (120, 210a-d) to control an amount of the refrigerant flowing through the first refrigerant line (HPP) and an amount of the refrigerant flowing through the second refrigerant line (RP), according to operational loads to be borne by the plurality of indoor units (200a-d).

2. The air conditioner according to claim 1, wherein the ON/OFF valve (109) is connected at an inlet thereof to a position between the compressor (103a/b) and the outdoor heat exchanger (101a/b), and is connected at an outlet thereof to the plurality of indoor units (200a-d).

3. The air conditioner according to claim 1 or claim 2, wherein the outdoor expansion valve (102) is connected to an outlet of the outdoor heat exchanger (101a/b).

4. The air conditioner according to any preceding claim, wherein the control unit (120, 210a-d) con-

trols the ON/OFF valve (109) and the outdoor expansion valve (102) so as to control the amount of the refrigerant flowing through the first refrigerant line (HPP) and the amount of the refrigerant flowing through the second refrigerant line (RP).

5. The air conditioner according to any preceding claim, wherein the control unit (120, 210a-d) comprises:

an indoor control unit (210a-d) to provide the operational loads to be borne by the plurality of indoor units (200a-d) operating in a cooling mode or a heating mode; and
an outdoor control unit (120) to control the ON/OFF valve (109) and an opening ratio of the outdoor expansion valve (102), in response to the operational loads provided by the indoor control unit (210a-d).

6. The air conditioner according to claim 5, wherein the outdoor control unit (120) determines the opening ratio of the outdoor expansion valve (102), so as to optimize operational performances of the indoor units (200a-d) operating in the cooling mode and operational performances of all the indoor units (200a-d) which include the indoor units (200a-d) operating in the cooling mode and the indoor units (200a-d) operating in the heating mode, during a cooling major combined-mode operation in which a major part of the indoor units (200a-d) operates in the cooling mode and a minor part of the indoor units (200a-d) operates in the heating mode.

7. The air conditioner according to claim 5 or claim 6, wherein the plurality of indoor units (200a-d) further comprise a plurality of indoor temperature sensors (203a-d), respectively, and the indoor control unit (210a-d) provides the operational loads, which are borne by the plurality of indoor units (200a-d), according to differences between indoor temperatures around the indoor units (200a-d) and preset reference temperatures.

8. The air conditioner according to any one of claims 5 to 7, wherein the outdoor control unit (120) compares a total operational load to be borne by the indoor units (200a-d) operating in the heating mode to a total operational load to be borne by the indoor units (200a-d) operating in the cooling mode, and determines the opening ratio of the outdoor expansion valve (102) according to a result of the total operational load comparison.

9. An air conditioner, comprising:

an outdoor unit (100) having a compressor (103a/b), an outdoor heat exchanger (101a/b), an outdoor expansion valve (102), an ON/OFF valve (109), an outdoor fan (113), an outdoor temperature sensor (108) and a pressure sensor (105);
a plurality of indoor units (200a-d) each having an indoor temperature sensor (203a-d) and an indoor heat exchanger (201a-d);
a first refrigerant line (HPP) through which a refrigerant discharged from the compressor (103a/b) flows from the compressor (103a/b) to the plurality of indoor units (200a-d) while passing through the ON/OFF valve (109);
a second refrigerant line (RP) through which the refrigerant discharged from the compressor (103a/b) flows from the compressor (103a/b) to the plurality of indoor units (200a-d) while passing through the outdoor heat exchanger (101a/b) and the outdoor expansion valve (102);
an indoor control unit (210a-d) to provide operational loads, which are borne by the plurality of indoor units (200a-d), according to differences between indoor temperatures sensed by the indoor temperature sensors (203a-d) of the indoor units (200a-d) and preset reference temperatures; and
an outdoor control unit (120) to control the ON/OFF valve (109) and an opening ratio of the outdoor expansion valve (102) in response to the operational loads provided by the indoor control unit (210a-d), and to determine a desired compression capacity of the compressor (103a/b) according to an outdoor temperature sensed by the outdoor temperature sensor (108), and to control a rotating speed of the outdoor fan (113) according to an output refrigerant pressure of the compressor (103a/b) which is sensed by the pressure sensor (105) when the compressor (103a/b) operates according to the desired compression capacity.

10. The air conditioner according to claim 9, wherein the outdoor control unit (120) determines the desired compression capacity of the compressor (103a/b) to be higher as the outdoor temperature, sensed by the outdoor temperature sensor (108), is higher.

11. The air conditioner according to claim 10, wherein the outdoor control unit (120) increases the rotating speed of the outdoor fan (113) to reduce the output refrigerant pressure of the compressor (103a/b), and reduces the rotating speed of the outdoor fan (113) to increase the output refrigerant pressure of the compressor (103a/b).

12. The air conditioner according to claim 11, wherein the outdoor unit (100) further comprises a speed sensor (114) to sense the rotating speed of the out-

door fan (113), and the outdoor control unit (12) controls the outdoor fan (113) according to the rotating speed of the outdoor fan (113) which is sensed by the speed sensor (114).

13. A method of controlling an air conditioner, the air conditioner having an outdoor unit (100) having a compressor (103a/b), an outdoor heat exchanger (101a/b), an outdoor expansion valve (102) and an ON/OFF valve (109); a plurality of indoor units (200a-d) respectively having a plurality of indoor heat exchangers (201a-d); a first refrigerant line (HPP) through which a refrigerant discharged from the compressor (103a/b) flows from the compressor (103a/b) to the plurality of indoor units (200a-d) while passing through the ON/OFF valve (109); and a second refrigerant line (RP) through which the refrigerant discharged from the compressor (103a/b) flows from the compressor to the plurality of indoor units (200a-d) while passing through the outdoor heat exchanger (101a/b) and the outdoor expansion valve (102), the method comprising:

calculating operational loads to be borne by the plurality of indoor units (200a-d); and
controlling an amount of the refrigerant flowing through the first refrigerant line (HPP) and an amount of the refrigerant flowing through the second refrigerant line (RP), according to the operational loads to be borne by the plurality of indoor units (200a-d).

14. The method according to claim 13, wherein the operational loads to be borne by the plurality of indoor units (200a-d) are calculated according to differences between indoor temperatures around the indoor units (200a-d) and preset reference temperatures.

15. The method according to claim 13 or claim 14, wherein the calculating of the operational loads and the controlling of the amounts of the refrigerant comprise:

calculating a total operational load to be borne by indoor units (200a-d) operating in a cooling mode and a total operational load to be borne by indoor units (200a-d) operating in a heating mode during a cooling major combined-mode operation in which a major part of the plurality of indoor units (200a-d) operates in the cooling mode and a minor part of the plurality of indoor units (200a-d) operates in the heating mode;
comparing the total operational load to be borne by the indoor units (200a-d) operating in the cooling mode to the total operational load to be borne by the indoor units (200a-d) operating in the heating mode; and
controlling the ON/OFF valve (109) and an opening ratio of the outdoor expansion valve (102) according to a result of the comparing of the total operational loads.

16. The method according to claim 15, wherein the controlling of the opening ratio of the outdoor expansion valve (102) is executed to optimize operational performances of the indoor units (200a-d) operating in the cooling mode and operational performances of all the indoor units (200a-d) which include the indoor units (200a-d) operating in the cooling mode and the indoor units operating in the heating mode, during the cooling major combined-mode operation.

17. The method according to any one of claims 13 to 16, further comprising:

sensing an outdoor temperature by an outdoor temperature sensor (108) provided in the outdoor unit (100), after the controlling of the amounts of the refrigerant; and
determining a desired compression capacity of the compressor (103a/b) according to the outdoor temperature sensed by the outdoor temperature sensor (108).

18. The method according to claim 17, further comprising:

sensing an output refrigerant pressure of the compressor (103a/b) when the compressor (103a/b) operates according to the desired compression capacity; and
controlling a rotating speed of an outdoor fan (113) provided in the outdoor unit (100), according to the output refrigerant pressure of the compressor (103a/b).

19. The method according to claim 18, wherein the controlling of the rotating speed of the outdoor fan (113) comprises:

comparing the output refrigerant pressure of the compressor (103a/b) to a preset reference pressure; and
increasing the rotating speed of the outdoor fan (113) when the output refrigerant pressure of the compressor (103a/b) is higher than the preset reference pressure, and reducing the rotating speed of the outdoor fan (113) when the output refrigerant pressure of the compressor (103a/b) is lower than the preset reference pressure.

FIG 1

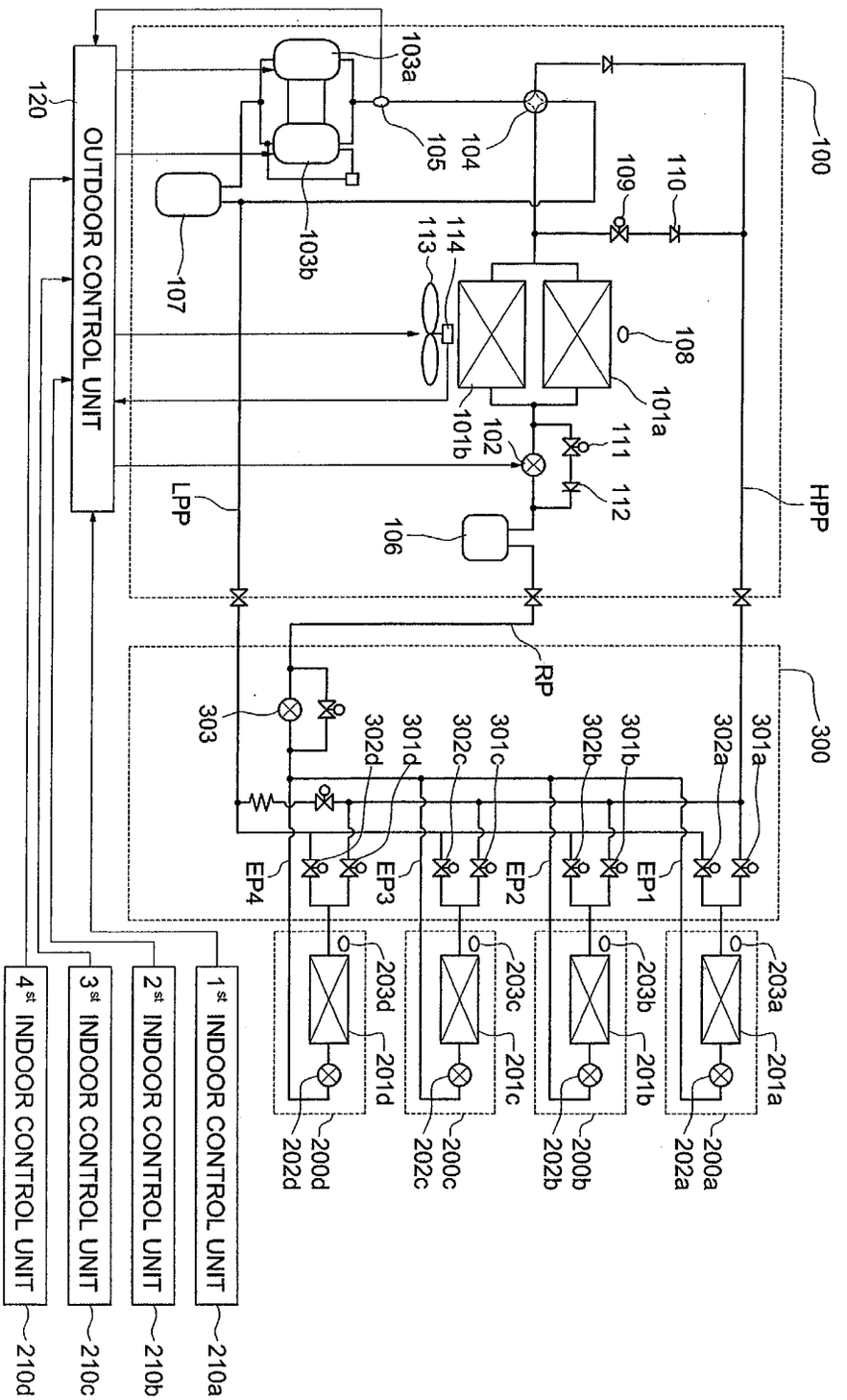

OUTDOOR CONTROL UNIT
120
103a
103b
104
105
107
100
109
110
113
114
108
101a
101b
102
111
112
LPP
HPP
106
RP
300
303
302d
301d
302c
301c
302b
301b
302a
301a
EP4
EP3
EP2
EP1
203d
203c
203b
203a
201d
201c
201b
201a
200d
202d
200c
202c
200b
202b
200a
202a
1st INDOOR CONTROL UNIT
2st INDOOR CONTROL UNIT
3st INDOOR CONTROL UNIT
4st INDOOR CONTROL UNIT
210a
210b
210c
210d

FIG 2

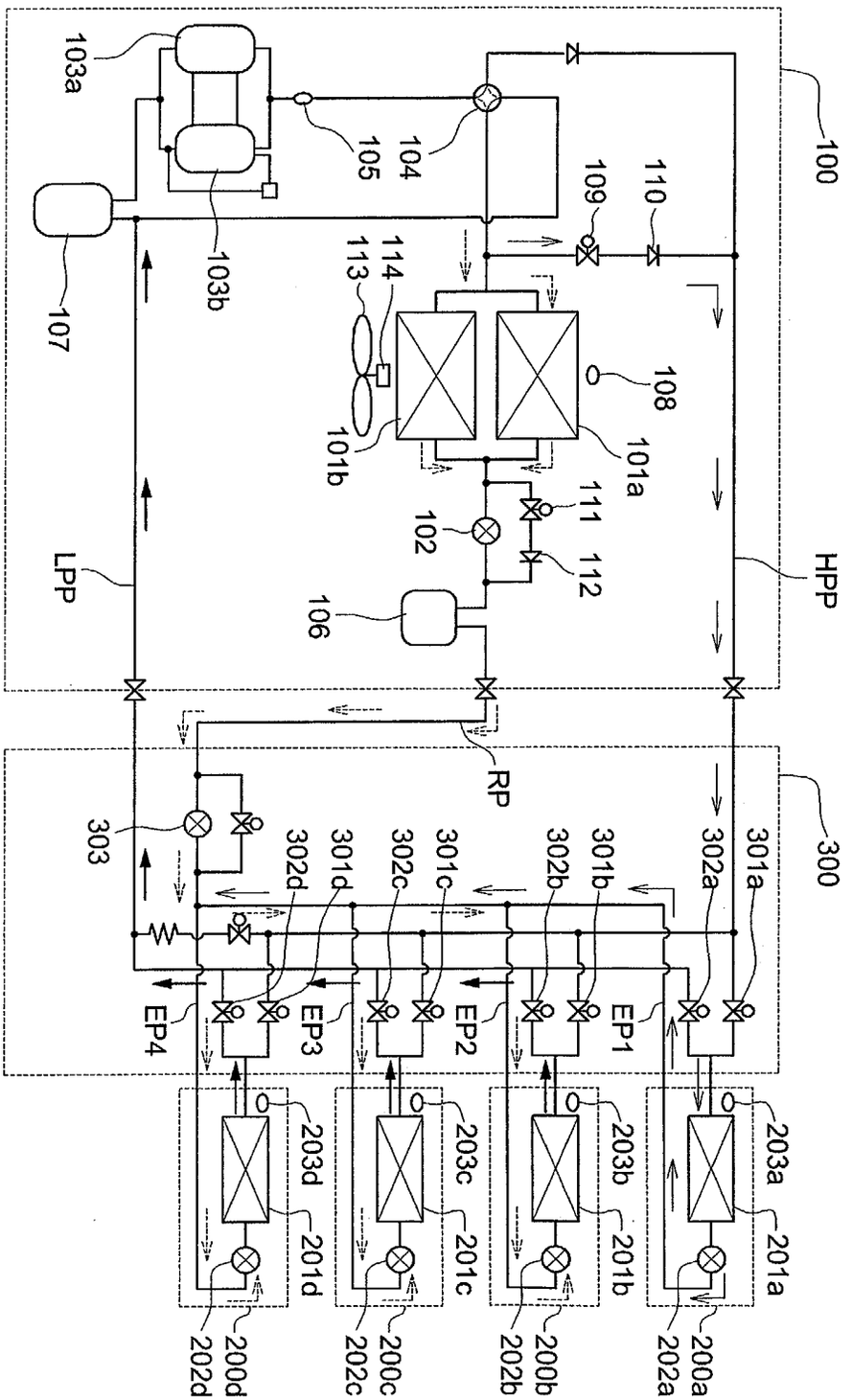

100
103a
103b
104
105
107
108
109
110
111
112
113
114
101a
101b
102
106
LPP
HPP
RP
300
303
301a
301b
301c
301d
302a
302b
302c
302d
EP1
EP2
EP3
EP4
200a
200b
200c
200d
201a
201b
201c
201d
202a
202b
202c
202d
203a
203b
203c
203d

FIG 3

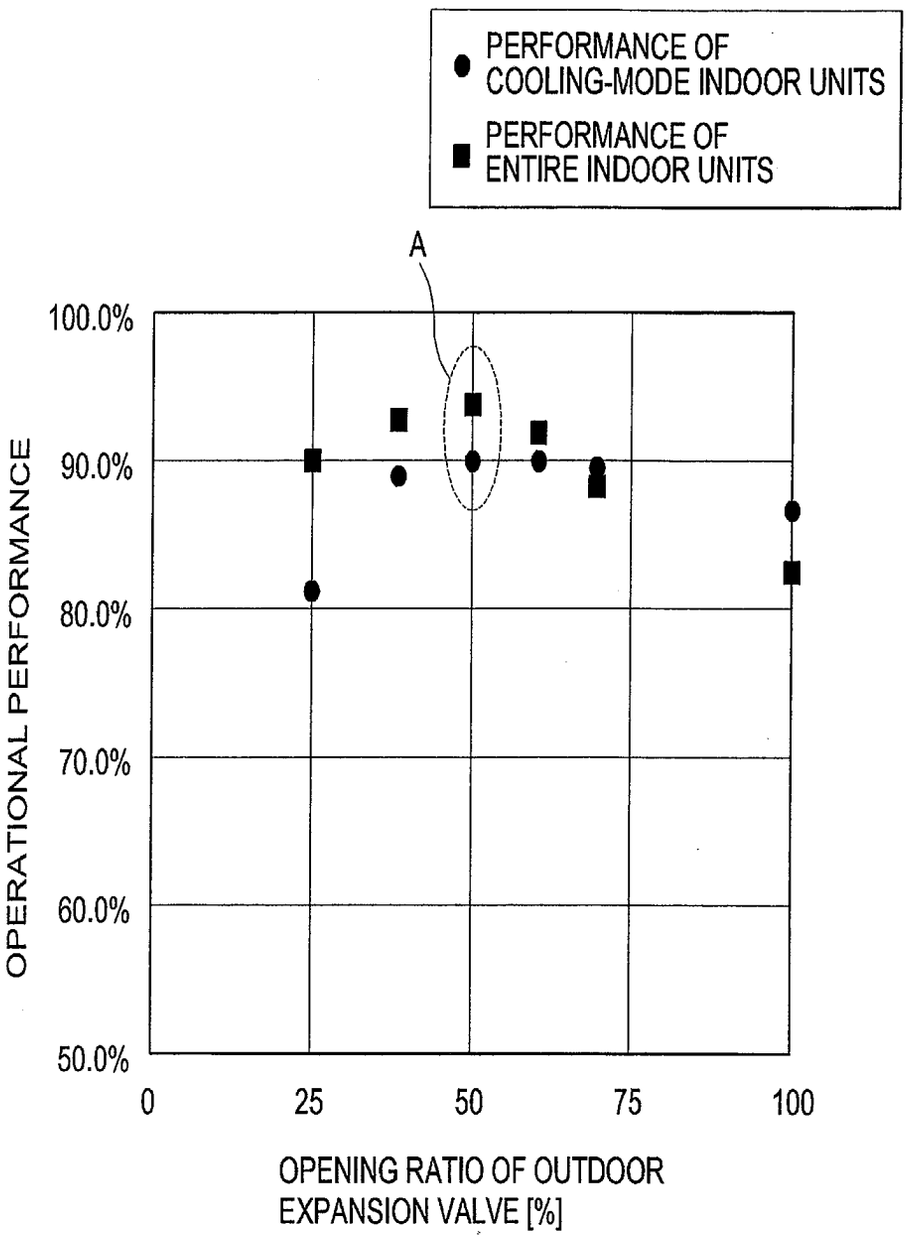

PERFORMANCE OF COOLING-MODE INDOOR UNITS
PERFORMANCE OF ENTIRE INDOOR UNITS
A
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
OPERATIONAL PERFORMANCE
0
25
50
75
100
OPENING RATIO OF OUTDOOR EXPANSION VALVE [%]

FIG 4

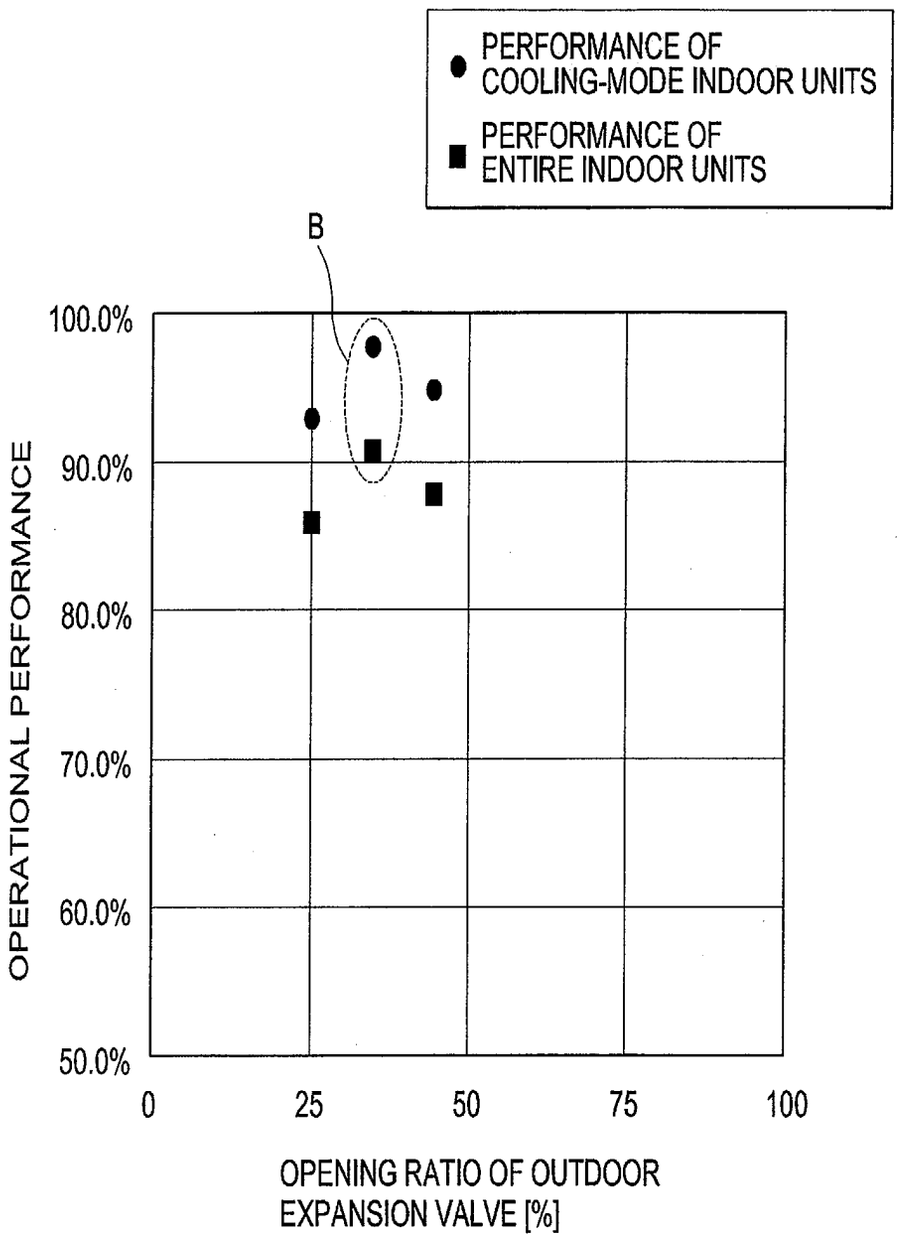

PERFORMANCE OF COOLING-MODE INDOOR UNITS
PERFORMANCE OF ENTIRE INDOOR UNITS
B
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
OPERATIONAL PERFORMANCE
0
25
50
75
100
OPENING RATIO OF OUTDOOR EXPANSION VALVE [%]

FIG 5a

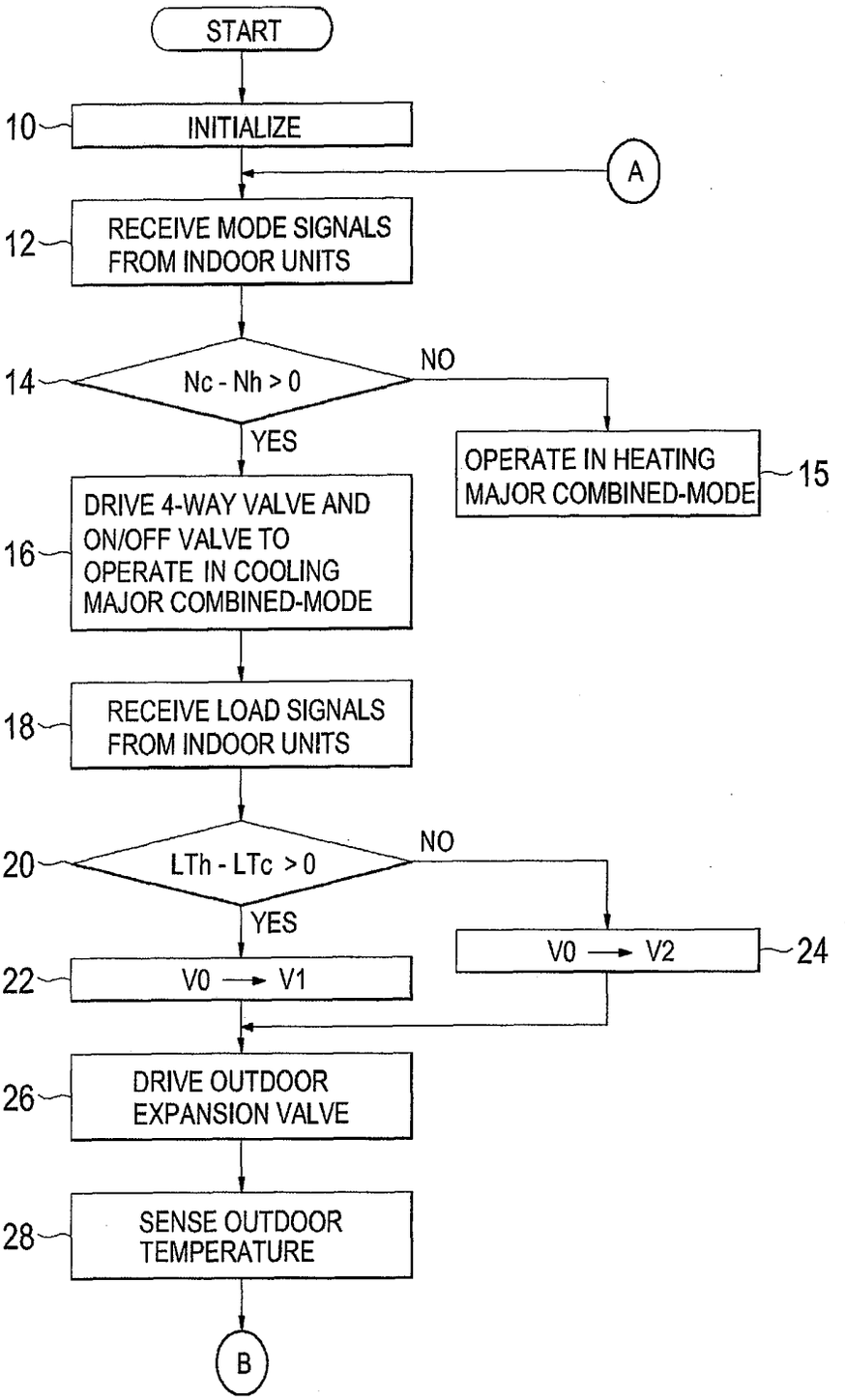
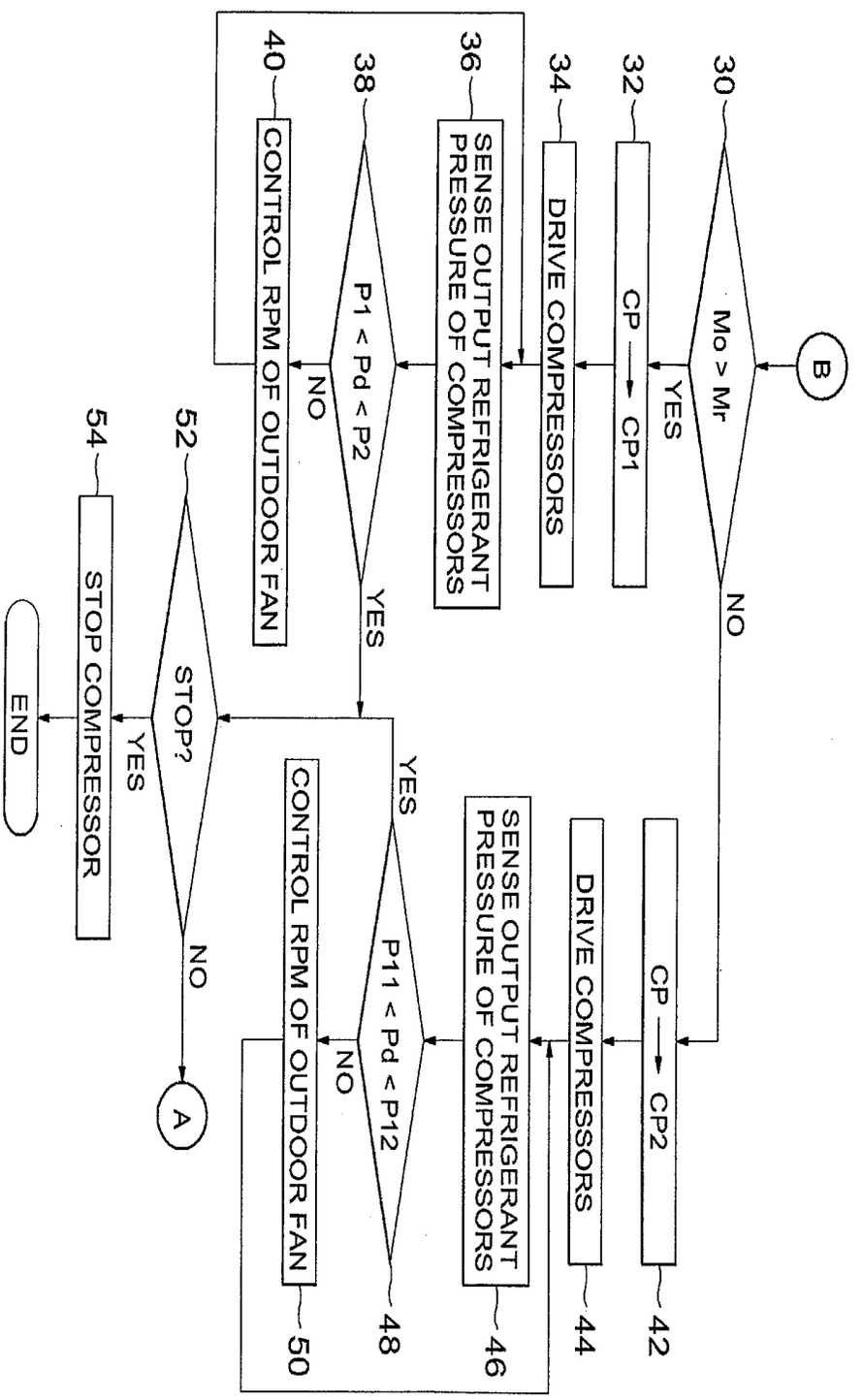

START
10
INITIALIZE
A
12
RECEIVE MODE SIGNALS FROM INDOOR UNITS
14
Nc - Nh > 0
NO
YES
OPERATE IN HEATING MAJOR COMBINED-MODE
15
16
DRIVE 4-WAY VALVE AND ON/OFF VALVE TO OPERATE IN COOLING MAJOR COMBINED-MODE
18
RECEIVE LOAD SIGNALS FROM INDOOR UNITS
20
LTh - LTc > 0
NO
YES
V0 → V2
24
22
V0 → V1
26
DRIVE OUTDOOR EXPANSION VALVE
28
SENSE OUTDOOR TEMPERATURE
B

FIG 5b


B
30
Mo > Mr
YES
NO
32
CP → CP1
34
DRIVE COMPRESSORS
36
SENSE OUTPUT REFRIGERANT PRESSURE OF COMPRESSORS
38
P1 < Pd < P2
NO
YES
40
CONTROL RPM OF OUTDOOR FAN
42
CP → CP2
44
DRIVE COMPRESSORS
46
SENSE OUTPUT REFRIGERANT PRESSURE OF COMPRESSORS
48
P11 < Pd < P12
NO
YES
50
CONTROL RPM OF OUTDOOR FAN
52
STOP?
YES
NO
54
STOP COMPRESSOR
END
A

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 25 0231

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 040 376 A (UENO ET AL) 20 August 1991 (1991-08-20) * abstract; figure 1 * -----	1,9,13	F24F11/00 F25B13/00 F24F3/06
A	US 5 009 078 A (OHKOSHI ET AL) 23 April 1991 (1991-04-23) * abstract; figure 1 * -----	1,9,13	
A	US 5 009 077 A (OKOSHI ET AL) 23 April 1991 (1991-04-23) * abstract * -----	1,9,13	
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 142 (M-1101), 10 April 1991 (1991-04-10) & JP 03 020574 A (SANYO ELECTRIC CO LTD), 29 January 1991 (1991-01-29) * abstract * -----	1,9,13	
P,A	EP 1 371 911 A (LG ELECTRONICS INC) 17 December 2003 (2003-12-17) * abstract * -----	1,9,13	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F24F
F25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	14 February 2005	Valenza, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 25 0231

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-02-2005

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5040376 A	20-08-1991	JP 2823297 B2	11-11-1998
		JP 3244978 A	31-10-1991
		GB 2241315 A ,B	28-08-1991
		KR 9308002 B1	25-08-1993
US 5009078 A	23-04-1991	JP 2223755 A	06-09-1990
		AU 600419 B1	09-08-1990
		GB 2229551 A ,B	26-09-1990
		KR 9207811 B1	17-09-1992
US 5009077 A	23-04-1991	JP 3059362 A	14-03-1991
		GB 2235993 A ,B	20-03-1991
		KR 9307963 B1	25-08-1993
JP 03020574 A	29-01-1991	JP 2760577 B2	04-06-1998
EP 1371911 A	17-12-2003	KR 2003095611 A	24-12-2003
		CN 1483971 A	24-03-2004
		EP 1371911 A1	17-12-2003
		JP 2004020188 A	22-01-2004
		US 2003230107 A1	18-12-2003

EPO FORM P0459

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