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(71) Applicant: **Toshiba Carrier Corporation**
Kawasaki-shi, Kanagawa 212-8585 (JP)

(72) Inventors:
- **AOKI, Kazuhito**
  Shizuoka-ken, 416-8521 (JP)
- **SUGIYAMA, Akiyoshi**
  Shizuoka-ken, 416-8521 (JP)
- **UNNO, Hideharu**
  Shizuoka-ken, 416-8521 (JP)

(74) Representative: **Rehmann, Thorsten**
Gramm, Lins & Partner
Patent- und Rechtsanwälte PartGmbB
Theodor-Heuss-Strasse 1
38122 Braunschweig (DE)

(54) AIR-CONDITIONING APPARATUS

(57) When power supply from a main power supply (30) to a deactivated indoor unit (B1) is shut down by opening of a circuit breaker (31), the deactivated indoor unit (B1) operates by the output of the back-up power supply unit (41) and opens each louver (5) to prevent occurrence of condensation.

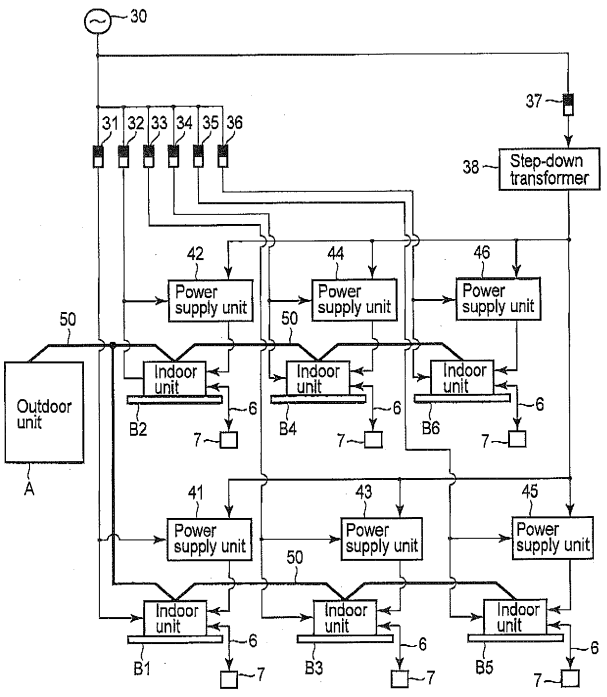

FIG. 5

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Description

FIELD

[0001] Embodiments described herein relate generally to a multi-split air-conditioning apparatus comprising at least one outdoor unit and indoor units.

BACKGROUND

[0002] A multi-split air-conditioning apparatus comprising a refrigerating cycle including a compressor, an outdoor heat exchanger, flow-control valves and indoor heat exchangers, and further comprising at least one outdoor unit including the compressor and the outdoor heat exchanger, and indoor units including the indoor heat exchangers and the flow-control valves, respectively, is known (JP 4160884 B and JP H04-263733 A).

[0003] The compressor includes a motor and a compression mechanism together with lubricating oil. When a refrigerant is discharged from the compressor, the lubricating oil in the compressor partially flows into the refrigerating cycle along with the refrigerant. The lubricating oil that flowed from the compressor passes through the indoor heat exchanger of each indoor unit together with the refrigerant and flows into the compressor again. However, if any of the indoor units is deactivated, the lubricating oil that flowed from the compressor is accumulated in an indoor heat exchanger of the deactivated indoor unit, which causes a shortage of the lubricating oil in the compressor.

[0004] In order to solve such a shortage of the lubricating oil, oil recovery control is performed at regular intervals in the air-conditioning apparatus by returning the refrigerant discharged from the compressor to the compressor through the outdoor heat exchanger, each flow-control valve and each indoor heat exchanger. In the oil recovery control, each indoor unit opens the flow-control valve and allows the refrigerant to flow regardless of whether the indoor unit is activated or deactivated. The entire lubricating oil in the refrigerating cycle including the lubricating oil accumulated in the indoor heat exchanger of the deactivated indoor unit can be recovered to the compressor by the oil recovery control.

[0005] However, the flow direction of the refrigerant at oil recovery control is the same as the case of cooling. Accordingly, each indoor heat exchanger functions as an evaporator, the housing of the deactivated indoor unit is cooled and condensation often occurs on the housing in the oil recovery control. The condensation causes growth of mold in the housing. Mold fungus from the indoor unit may be suspended in indoor space and cause degradation of the indoor condition.

[0006] Therefore, a measure against the occurrence of condensation caused by the oil recovery control is required in the deactivated indoor unit. However, user often shut down power supply to an indoor unit that is inactive for a long time by opening a circuit breaker. In this case, power is not supplied to the inactive indoor unit and a measure against the occurrence of condensation cannot be carried out.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a perspective view showing the appearance of an indoor unit of an embodiment.
FIG. 2 is an illustration showing an inner structure of the indoor unit of FIG. 1.
FIG. 3 is an illustration showing a state where each louver is opened in the indoor unit of FIG. 2.
FIG. 4 is an illustration showing a structure of a heat pump refrigerating cycle of the embodiment.
FIG. 5 is a block diagram showing an electrical circuit of the embodiment.
FIG. 6 is a block diagram showing a main section of the electrical circuit of FIG. 5.
FIG. 7 is a flowchart showing control of an outdoor controller of the embodiment.
FIG. 8 is a flowchart showing control of an indoor controller of the embodiment.
FIG. 9 is a time chart showing operation of the embodiment.

DETAILED DESCRIPTION

[0008] In general, according to one embodiment, an air-conditioning apparatus comprising a refrigerating cycle comprising a compressor (21), an outdoor heat exchanger (23), flow-control valves (18) and indoor heat exchangers (12); an outdoor unit (A) including the compressor (21) and the outdoor heat exchanger (23); indoor units (B1 to B6) including the indoor heat exchangers (12) and the flow-control valves (18), respectively, wherein each of the indoor units (B1 to B6) comprises an air inlet (3), at least one air outlet (4) and at least one louver (5) configured to open and close the air outlet (4), and is configured to allow air drawn from the air inlet (3) to flow through the indoor heat exchanger (12) and discharge the air from the indoor heat exchanger (12) to the air outlet (4); an outdoor controller (70) configured to control operation of the compressor (21) and to execute oil recovery control by returning a refrigerant (R) discharged from the compressor (21) to the compressor (21) through the outdoor heat exchanger (23), the flow-control valves (18) and the indoor heat exchangers (12); backup power supply units (41 to 46) configured to output backup power to the indoor units (B1 to B6), respectively, when power supply from a main power supply (30) to the indoor units (B1 to B6) is shut down; and indoor controllers (65) provided in the indoor units (B1 to B6), respectively, configured to operate by the power supply from the main power supply (30) or output from the respective backup power supply units (41 to 46), and configured to control operation of the respective indoor units (B1 to B6), wherein

when the power supply from the main power supply (30) to the indoor units (B1 to B6) is shut down, the indoor controllers (65) open the respective louvers (5) by the output of the respective backup power supply units (41 to 46).

[0009] An embodiment will be described hereinafter with reference to the accompanying drawings.

[0010] As an example of an indoor unit, a four-way ceiling cassette (embedded) type is described. As shown in FIG. 1 to FIG. 3, an indoor unit B1 comprises a main unit 1 embedded in a ceiling surface P of an air-conditioned room, a ceiling panel 2 attached to the lower surface of the main unit 1 and facing the inside of the air-conditioned room, an air inlet 3 formed in the center of the ceiling panel 2, air outlets 4 formed in the peripheral area in the ceiling panel 2, and louvers 5 attached to the air outlets 4. The louvers 5 can be opened, closed and swung. The louvers 5 block the air outlets 4 when they are closed (FIG. 2) and expose the air outlets 4 when they are opened (FIG. 3).

[0011] A signal cable 6 extends from the main unit 1. A remote-control operating unit 7 is connected to signal cable 6. Indoor unit B1 can be activated and deactivated and a target indoor air temperature Ts in the air-conditioned room can be set by operating the operating unit (remote controller) 7.

[0012] In the main unit 1, an indoor fan 11 is provided in a position facing the air inlet 3. The indoor fan 11 includes a drive motor 11M. A rectangular indoor heat exchanger 12 is provided to surround the indoor fan 11. An indoor air temperature sensor 13 configured to sense an inlet temperature (indoor air temperature) Ta is provided in an air course between the air inlet 3 and the indoor fan 11. A drain pan 14 is provided below the indoor heat exchanger 12. The drain pan 14 receives drain W from the surface of the indoor heat exchanger 12. A water level sensor 15 is attached to the drain pan 14. The water level sensor 15 senses a volume of the drain W in the drain pan 14. A drain hose 16 is attached to the lower part of the drain pan 14. The drain hose 16 penetrates the side wall of the main unit 1 and extends outside. A drain pump 17 is provided in the middle of the drain hose 16. The drain pump 17 draws the drain W in the drain pan 14 and discharges the drain W outside the main unit 1.

[0013] When the indoor fan 11 revolves, the air in the air-conditioned room is drawn into the main unit 1 from the air inlet 3 and flows through the indoor heat exchanger 12. The air flowing through the indoor heat exchanger 12 is cooled (in the case of cooling) or heated (in the case of heating) by heat exchange with a refrigerant in the indoor heat exchanger 12 and thereby becomes air-conditioned air. The air-conditioned air is blown from each air outlet 4 into the air-conditioned room.

[0014] As shown in FIG. 4, indoor unit B1 and indoor units B2 to B6 having a similar structure to indoor unit B1 are connected to an outdoor unit A by piping. The outdoor unit A includes a compressor 21, a four-way valve 22, an outdoor heat exchanger 23, an expansion valve 24, an outdoor fan 25, an inverter 26 and the like. Each of indoor units B1 to B6 includes the indoor fan 11, the indoor heat exchanger 12, a flow-control valve 18 and the like.

[0015] The compressor 21 is formed by including a compression mechanism 21a and a motor 21m configured to drive a shaft of the compression mechanism 21a in a sealed case 21c together with lubricating oil L. The compressor 21 draws, compresses and discharges a refrigerant R. A sliding portion of the compression mechanism 21a is lubricated with the lubricating oil L. If the lubricating oil L is insufficient, there is a possibility that the sliding portion of the compression mechanism 21a abnormally produces heat, which may results in a trouble such as seizure.

[0016] The outdoor heat exchanger 23 is connected to a discharge port of the compressor 21 through the four-way valve 22, and the indoor heat exchangers 12 are connected to the outdoor heat exchanger 23 through the expansion valve 24 and the flow-control valves 18 by piping. A suction port of the compressor 21 is connected to the indoor heat exchangers 12 through the four-way valve 22 by piping. Each flow-control valve 18 is a so-called pulse motor valve (PMV) which includes a pulse motor that operates on a low direct-current voltage and whose degree of opening varies according to the number of input driving pulses. For example, it takes about 20 seconds to drive each flow-control valve 18 to shift from a fully-closed state to a fully-open state or from the fully-open state to the fully-closed state. After driving the flow-control valve 18, the degree of opening is maintained without applying driving pulses.

[0017] The outdoor fan 25 draws outside air and supplies the air to the outdoor heat exchanger 23. The inverter 26 rectifies a voltage of an alternating-current source to a direct-current voltage, converts the direct-current voltage into an alternating-current voltage at a predetermined frequency F (Hz) by switching and outputs the alternating-current voltage. The motor 21m of the compressor 21 operates by the output of the inverter 26. The number of revolutions of the motor 21m (i.e., the ability of the compressor 21) varies according to the output frequency F of the inverter 26.

[0018] In the case of cooling, as shown by solid arrows, the refrigerant R discharged from the compressor 21 flows to the outdoor heat exchanger 23 through the four-way valve 22, and then the refrigerant R flows from the outdoor heat exchanger 23 to the indoor heat exchangers 12 through the expansion valve 24 and the flow-control valves 18. The refrigerant R flowing from the indoor heat exchangers 12 is drawn into the compressor 21 through the four-way valve 22. The outdoor heat exchanger 23 functions as a condenser (heat radiator) and each indoor heat exchanger 12 functions as an evaporator (heat absorber) by the flow of the refrigerant R. In the case of heating, as shown by dashed arrows, the flow passage of the four-way valve 22 is switched, the refrigerant R discharged from the compressor 21 flows to the indoor

heat exchangers 12 through the four-way valve 22, and the refrigerant R flows from the indoor heat exchangers 12 to the outdoor heat exchanger 23 through the expansion valve 24. The refrigerant R flowing from the outdoor heat exchanger 23 is drawn into the compressor 21 through the four-way valve 22. Each indoor heat exchanger 12 functions as a condenser and the outdoor heat exchanger 23 functions as an evaporator by the flow of the refrigerant R.

[0019] The air-conditioning apparatus is constituted by the outdoor unit A and indoor units B1 to B6. An electrical circuit of the air-conditioning apparatus is shown in FIG. 5.

[0020] Indoor unit B1 and a backup power supply unit 41 are connected to a main power supply (alternating-current source) 30 via a circuit breaker (CB) 31. In the same way, indoor units B2 to B6 and backup power supply units 42 to 46 are connected to the main power supply 30 via circuit breakers 32 to 36, respectively. Backup power supply units 41 to 46 are connected to the main power supply 30 via a circuit breaker 37 and a step-down transformer 38. Indoor unit B1 is connected to an output terminal of backup power supply unit 41. In the same way, indoor units B2 to B6 are connected to output terminals of backup power supply units 42 to 46, respectively. The outdoor unit A and indoor units B1 to B6 are connected to each other via a signal cable 50.

[0021] The main power supply 30 outputs a single-phase alternating-current voltage of, for example, 220V to 240V. Circuit breakers 31 to 37 are opened to shut down a current path in the case of overcurrent. Circuit breakers 31 to 37 can be opened and closed by occupants of rooms in which indoor units B1 to B6 are provided or users of indoor units B1 to B6, respectively. The step-down transformer 38 connected to the main power supply 30 via circuit breaker 37 converts the alternating-current voltage of the main power supply 30 into, for example, an alternating-current voltage of 24V. Since circuit breaker 37 is provided in a machine room of the building or outdoors, the occupant of each room or each user cannot operate circuit breaker 37. Circuit breaker 37 is always closed unless operated by a maintenance worker at the occurrence of abnormal condition or the maintenance.

[0022] When circuit breaker 31 is opened (i.e., when direct power supply from the main power supply 30 to indoor unit B1 is shut down), backup power supply unit 41 converts the voltage of the main power supply 30 into backup power for indoor unit B1 and outputs the power. In the same way, when circuit breakers 32 to 36 are opened (i.e., when direct power supply from the main power supply 30 to indoor units B2 to B6 is shut down), backup power supply units 42 to 46 convert the voltage of the main power supply 30 into backup power for indoor units B2 to B6 and output the power.

[0023] Since the outdoor unit A is provided outdoors and should drive the compressor 21 of large capacity, the outdoor unit A is connected to a three-phase alternating-current source in a completely different system from indoor units B1 to B6.

[0024] An electrical circuit of a main section of indoor unit B1 and an electrical circuit of a main section of backup power supply unit 41 are shown in FIG. 6.

[0025] Indoor unit B1 comprises a control circuit board 60. A rectifier circuit 61, a DC/DC converter 62, communication circuits 63 and 64, an indoor controller 65, drivers 66 to 69, power-supply lines (positive) P1 and P2, a power-supply line (negative) Pn, and diodes D1 and D2 are mounted on the control circuit board 60.

[0026] The rectifier circuit 61 rectifies the alternating-current voltage input from circuit breaker 31. The DC/DC converter 62 converts the output voltage of the rectifier circuit 61 into, for example, a direct-current voltage Vp1 of 5V and a direct-current voltage Vp2 of 12V. Direct-current voltage Vp1 is output between power-supply lines P1 and Pn. Direct-current voltage Vp2 is output between power-supply lines P2 and Pn. Communication circuits 63 and 64 and the indoor controller 65 are connected between power-supply lines P1 and Pn. Drivers 66 to 69 are connected between power-supply lines P2 and Pn. Communication circuits 63 and 64 and the indoor controller 65 operate on direct-current voltage Vp1 between power-supply lines P1 and Pn (or direct-current voltage Vq1 to be described later). Drivers 66 to 69 operate on direct-current voltage Vp2 between power-supply lines P2 and Pn (or direct-current voltage Vq2 to be described later).

[0027] Communication circuit 63 transmits and receives data between the indoor controller 65 and an outdoor controller 70 of the outdoor unit A via signal cable 50. Communication circuit 64 transmits and receives data between the indoor controller 65 and the operating unit 7 via signal cable 6. Communication circuit 64 also supplies power to the operating unit 7 simultaneously with communication. Each of the indoor controller 65, the outdoor controller 70 and the operating unit 7 is constituted by a micro-control unit (MCU) and a peripheral circuit thereof.

[0028] Signal lines 81 and 82 extend from a pair of control terminals of the indoor controller 65. Backup power supply unit 41 is connected between the signal lines 81 and 82.

[0029] The indoor controller 65 controls the operation of drivers 66 to 69 based on data transmission to and data reception from the outdoor controller 70, data transmission to and data reception from the operating unit 7, a sensing result of the indoor air temperature sensor 13, a sensing result of the water level sensor 15, a conduction state of the signal lines 81 and 82 and the like. Driver 66 operates on a direct-current voltage Vd2 (or direct-current voltage Vq2 to be described later) and drives the flow-control valve 18 under instructions from the indoor controller 65. Driver 67 operates on direct-current voltage Vd2 (or direct-current voltage Vq2 to be described later) and drives the motor 11M of the indoor fan 11 under instructions from the indoor controller 65. Driver 68 operates on direct-current voltage Vd2 (or direct-current

voltage Vq2 to be described later) and drives a motor 17M of the drain pump 17 under instructions from the indoor controller 65. Driver 69 operates on direct-current voltage Vd2 (or direct-current voltage Vq2 to be described later) and drives a motor (louver motor) 5M of each louver 5 under instructions from the indoor controller 65. The motor 17M of the drain pump 17 is a direct-current motor that operates on a low direct-current voltage, and operates on direct-current voltage Vd2 (or direct-current voltage Vq2 to be described later). Similarly, the motor of each louver 5 is a pulse motor that operates on a low direct-current voltage, and operates on direct-current voltage Vd2 (or direct-current voltage Vq2 to be described later).

[0030] Backup power supply unit 41 comprises a relay 51, a rectifier circuit 52, and a DC/DC converter 53. The relay 51 includes one coil 51c and two normally-closed contacts 51a and 51b (contacts that are closed if the coil 51c is not energized). The coil 51c is connected to the main power supply 30 via circuit breaker 31. Normally-closed contact 51a is connected and inserted into a current path between the secondary side of the step-down transformer 38 and the rectifier circuit 52. Normally-closed contact 51b is connected between the signal lines 81 and 82 extending from the indoor controller 65 of indoor unit B1. When circuit breaker 31 is closed, the relay 51 is energized and normally-closed contacts 51a and 51b are opened. When circuit breaker 31 is opened, the relay 51 is deenergized and normally-closed contacts 51a and 51b are closed again.

[0031] The rectifier circuit 52 rectifies the secondary voltage (alternating-current voltage 24V) of the step-down transformer 38. The DC/DC converter 53 converts the output voltage of the rectifier circuit 52 into backup direct-current voltages Vq1 and Vq2 for indoor unit B1 and outputs the voltages. The level of direct-current voltages Vq1 and Vq2 are the same as the level of direct-current voltages Vd1 and Vd2 output by the DC/DC converter 62 in indoor unit B1. That is, a setting is made such that direct-current voltage Vq1 = direct-current voltage Vd1, and direct-current voltage Vq2 = direct-current voltage Vd2.

[0032] Direct-current voltage Vq1 is supplied between power-supply lines P1 and Pn of indoor unit B1 via a power-supply line (positive) Q1 and a power-supply line (negative) Qn. Direct-current voltage Vq2 is supplied between power-supply lines P2 and Pn of indoor unit B1 via a power-supply line (positive) Q2 and power-supply line Qn.

[0033] Diodes D1 and D2 are inversely provided in power-supply lines P1 and P2 of indoor unit B1. Diode D1 allows direct-current voltage Vq1 supplied from backup power supply unit 41 to flow and prevents direct-current voltage Vp1 from flowing from indoor unit B1 to backup power supply unit 41. Diode D2 allows direct-current voltage Vq2 supplied from backup power supply unit 41 to flow and prevents direct-current voltage Vp2 from flowing from indoor unit B1 to backup power supply unit 41. A voltage is thus prevented from being externally applied to output terminals of the DC/DC converter 53 in backup power supply unit 41.

[0034] Communication circuits 63 and 64, the operating unit 7 and the indoor controller 65 of indoor unit B1 operate on direct-current voltage Vp1 when direct-current voltage Vp1 is output from the DC/DC converter 62, and operate on direct-current voltage Vq1 supplied from backup power supply unit 41 when direct-current voltage Vp1 is not output from the DC/DC converter 62. Drivers 66 to 69 of indoor unit B1 operate on direct-current voltage Vp2 when direct-current voltage Vp2 is output from the DC/DC converter 62, and operate on direct-current voltage Vq2 supplied from backup power supply unit 41 when direct-current voltage Vp2 is not output from the DC/DC converter 62.

[0035] When circuit breaker 31 is opened and the power supply from the main power supply 30 to indoor unit B1 is shut down, direct-current voltages Vp1 and Vp2 are not output from the DC/DC converter 62 of indoor unit B1. In this case, the relay 51 of backup power supply unit 41 is deenergized in response to the opening of circuit breaker 31, and normally-closed contacts 51a and 51b of the relay 51 are closed. When normally-closed contact 51a is closed, the current path between the secondary side of the step-down transformer 38 and the rectifier circuit 52 of backup power supply unit 41 is brought into conduction. Direct-current voltages Vq1 and Vq2 are thereby output from the DC/DC converter 53. Direct-current voltages Vq1 and Vq2 are supplied to indoor unit B1 via power-supply lines Q1, Q2 and Qn. Therefore, primary electrical components of indoor unit B1 can continue operating even if direct-current voltages Vp1 and Vp2 are not output from the DC/DC converter 62 of indoor unit B1.

[0036] As described later, the indoor controller 65 should change driving signals supplied to drivers 66 to 69 depending on whether circuit breaker 31 is opened or closed. Therefore, the indoor controller 65 continuously detects the conduction state of the signal lines 81 and 82. When the normally-closed contacts 51a and 51b of the relay 51 are closed, the signal lines 81 and 82 are brought into conduction. When the signal lines 81 and 82 are brought into conduction, the indoor controller 65 determines that circuit breaker 31 is opened.

[0037] The outdoor controller 70 of the outdoor unit A has control sections 70a to 70c as primary functions based on a control program stored in an internal memory.

[0038] The control section 70a controls the operation of the compressor 21, the operation of the outdoor fan 25, the output frequency F of the inverter 26 and the flow passage of the four-way valve 22 under instructions from the indoor controller 65.

[0039] The control section 70b performs oil recovery control at regular intervals to return lubricating oil L that flowed from the compressor 21 into the heat pump refrigerating cycle to the compressor 21, while the compressor 21 is operating. The oil recovery control is oper-

ation of returning the refrigerant R discharged from the compressor 21 to the compressor 21 through the four-way valve 22, the outdoor heat exchanger 23, each flow-control valve 18, each indoor heat exchanger 12 and the four-way valve 22. The flow direction of the refrigerant R at oil recovery control is the same as the case of cooling.

[0040] The control section 70c instructs indoor units B1 to B6 to start and end the oil recovery control.

[0041] The indoor controller 65 has a detection section 65a and control sections 65b and 65c as primary functions based on a control program stored in an internal memory.

[0042] The detection section 65a detects whether circuit breaker 31 has been closed or opened based on the conduction state between the signal lines 81 and 82.

[0043] When indoor unit B1 is deactivated, the control section 65b opens the flow-control valve 18 to a predetermined degree of opening (for example, full open) and activates the drain pump 17 if an instruction to start oil recovery control is received from the outdoor unit A, and closes the flow-control valve 18 and deactivates the drain pump 17 if an instruction to end oil recovery control is received from the outdoor unit A.

[0044] The control section 65c operates by the output of backup power supply unit 41 and opens each louver 5 if the detection section detects that circuit breaker 31 has been opened (i.e., power supply from the main power supply 30 to indoor unit B1 via circuit breaker 31 is shut down).

[0045] Electrical circuits of the other indoor units B2 to B6 and electrical circuits of backup power supply units 42 to 46 have the same structure and execute the same operation as the electrical circuit of indoor unit B1 and the electrical circuit of backup power supply unit 41, respectively.

[0046] Next, control executed by the outdoor controller 70 of the outdoor unit A is described with reference to a flowchart of FIG. 7.

[0047] If at least one of indoor units B1 to B6 is activated (YES in step S1), the outdoor controller 70 drives the inverter 26, activates the compressor 21 (step S2) and activates the outdoor fan 25 (step S3). At this time, in each of indoor units B1 to B6, an air-conditioning load in the corresponding room is calculated based on, for example, a difference between the indoor air temperature Ta sensed by the indoor air temperature sensor 13 and the target indoor air temperature Ts, and variations in the difference. The calculation results are transmitted from indoor units B1 to B6 to the outdoor controller 70 via communication circuit 63. The outdoor controller 70 determines and controls the output frequency F of the inverter 26 according to the total sum of air-conditioning loads of indoor units B1 to B6 (step S4). Then, a time count t1 is started (step S5), and time count t1 is compared with set time t1s (step S6). Time count t1 is time (cumulative time) during which the compressor 21 continues operating.

[0048] If time count t1 is less than set time t1s (NO in step S6), the outdoor controller 70 repeats the processing from step S1. If time count t1 has reached set time t1s (YES in step S6), the outdoor controller 70 starts oil recovery control and instructs indoor units B1 to B6 to start the oil recovery control(step S7). Along with the start of the oil recovery control, the outdoor controller 70 starts a time count t2 (step S8) and compares time count t2 with set time t2s (step S9). Time count t2 is the duration of the oil recovery control.

[0049] If time count t2 is less than set time t2s (NO in step S9), the outdoor controller 70 goes into standby. If time count t2 has reached set time t2s (YES in step S9), the outdoor controller 70 ends the oil recovery control and communicates with indoor units B1 to B6 to provide an instruction to end the oil recovery control (step S10). Along with the end of the oil recovery control, the outdoor controller 70 stops time counts t1 and t2 and zeros time counts t1 and t2 (step S11). Then, the outdoor controller 70 repeats the processing from step S1.

[0050] If all indoor units B1 to B6 are deactivated (NO in step S1), the outdoor controller 70 stops the inverter 26, deactivates the compressor 21 (step S12) and deactivates the outdoor fan 25 (step S13). Then, the outdoor controller 70 returns to step S1 and monitors activation of indoor units B1 to B6.

[0051] The indoor controller 65 of indoor unit B1 executes control shown in a flowchart of FIG. 8 and a time chart of FIG. 9.

[0052] First, the indoor controller 65 detects the conduction state between the signal lines 81 and 82 (step S21). The signal lines 81 and 82 are not brought into conduction when circuit breaker (CB) 31 is closed (i.e., the power is supplied from the main power supply 30 to indoor unit B1 via circuit breaker 31). The signal lines 81 and 82 are brought into conduction when circuit breaker (CB) 31 is opened. If the signal lines 81 and 82 are not brought into conduction, the indoor controller 65 determines that circuit breaker 31 is closed (YES in step S22) and thus monitors whether the operating unit 7 connected to indoor unit B1 is operated to activate indoor unit B1 (step S23). The determination on whether circuit breaker 31 is opened or closed in step S22 is certainly made regardless of whether indoor unit B1 is active or inactive.

[0053] If the operating unit 7 connected to indoor unit B1 is operated to activate indoor unit B1 (YES in step S23), the indoor controller 65 opens all the louvers 5 to a predetermined degree of opening (step S24), activates the indoor fan 11 (step S25) and controls the degree of opening of the flow-control valve (PMV) 18 according to the air-conditioning load of indoor unit B1 (step S26). The air-conditioning load of indoor unit B1 is determined based on a difference between a sensed temperature Ta of the indoor air temperature sensor 13 and a target indoor air temperature Ts set by the operating unit 7, variations in the difference, etc.

[0054] If the operating unit 7 connected to indoor unit B1 is operated to deactivate indoor unit B1 (NO in step S23), the indoor controller 65 deactivates the indoor fan

11 (step S27), fully closes the flow-control valve 18 (step S28) and closes all the louvers 5 (step S29). Then, the indoor controller 65 monitors an instruction from the outdoor unit A to start oil recovery control (step S30). If the instruction to start oil recovery is not received (NO in step S30), the indoor controller 65 repeats the processing from the first step S21.

[0055] Incidentally, in areas where the power supply to a indoor unit that is inactive for a long time is generally shut down by opening a circuit breaker, the occupant of the room in which indoor unit B1 is provided operates the operating unit 7 to deactivate indoor unit B1 and opens circuit breaker 31.

[0056] If circuit breaker 31 is opened, the signal lines 81 and 82 are brought into conduction. In this case, the indoor controller 65 determines that circuit breaker 31 is opened (NO in step S22), deactivates the indoor fan 11 (step S31), fully closes the flow-control valve 18 (step S32) and opens all the louvers 5 to the predetermined degree of opening (step S33). In this case, the indoor controller 65 operates on direct-current voltage Vq1 supplied from backup power supply unit 41. Each louver 5 operates on direct-current voltage Vq2 supplied from backup power supply unit 41.

[0057] After opening each louver 5, the indoor controller 65 monitors an instruction from the outdoor unit A to start oil recovery control (step S30). If the instruction to start oil recovery control is not received (NO in step S30), the indoor controller 65 repeats the processing from the first step S21.

[0058] If the instruction to start oil recovery control is received (YES in step S30), the indoor controller 65 determines whether the louvers 5 are closed (step S34). If the louvers 5 are closed (YES in step S34), i.e., if the power is supplied from the main power supply 30 to indoor unit B via circuit breaker 31 and indoor unit B is inactive, the indoor controller 65 opens the louvers 5 to the predetermined degree of opening (step S35). Then, the indoor controller 65 proceeds to step S36. If the louvers 5 are opened in step 34 (NO in step S34), i.e., if the power supply from the main power supply 30 to indoor unit B1 is shut down by the opening of circuit breaker 31, the indoor controller 65 proceeds to step S36 without executing step S35.

[0059] In step 36, the indoor controller 65 fully opens the flow-control valve 18. In this case, the flow-control valve 18 operates on direct-current voltage Vq2 supplied from backup power supply unit 41, and is changed from the fully-closed state to the fully-open state.

[0060] Since the flow-control valve 18 has been opened, the refrigerant R flows into the indoor heat exchanger 12 of deactivated indoor unit B1. Along with the flow of the refrigerant R, the lubricating oil L accumulated in the indoor heat exchanger 12 is recovered to the compressor 21. Since the refrigerant R flowing through the indoor heat exchanger 12 exchanges heat with the air around the indoor heat exchanger 12 and evaporates, frost forms on the surface of the indoor heat exchanger 12 and the main unit 1 of indoor unit B1 is cooled. In this case, however, since each louver 5 has been opened, the indoor air flows in the main unit 1 of indoor unit B1 through each air outlet 4. The cooling of the main unit 1 of indoor unit B1 can be lightened by the flow of the indoor air. As a result, condensation can be prevented in the main unit 1 of indoor unit B1.

[0061] The indoor controller 65 starts a time count t3 at the same time as the start of opening of the flow-control valve 18 in step S36 (step S37), and compares time count t3 with set time t3s (step S38). If time count t3 is less than set time t3s (NO in step S38), the indoor controller 65 goes into standby.

[0062] If time count t3 has reached set time t3s (YES in step S38), the indoor controller 65 determines that the flow-control valve 18 is fully open and activates the drain pump 17 (step S39). The drain W in the drain pan 14 is discharged outside indoor unit B1 by the activation of the drain pump 17. In this case, the drain pump 17 operates on direct-current voltage Vq2 supplied from backup power supply unit 41.

[0063] Next, the indoor controller 65 stops time count t3 and zeros time count t3 (step S40). Then, the outdoor controller 70 monitors an instruction from the outdoor unit A to end the oil recovery control (step S41). If the instruction to end the oil recovery control is not received (NO in step S41), the indoor controller 65 goes into standby.

[0064] If the instruction to end the oil recovery control is received (YES in step S41), the indoor controller 65 fully closes the flow-control valve 18 (step S42). In this case, the flow-control valve 18 is changed from the fully-open state to the fully-closed state by direct-current voltage Vq2 supplied from backup power supply unit 41.

[0065] Next, the indoor controller 65 monitors whether a sensing result of the water level sensor 15 is less than a predetermined volume (step S43). If the sensing result of the water level sensor 15 is greater than or equal to the predetermined volume (NO in step S43), the indoor controller 65 goes into standby. If the sensing result of the water level sensor 15 is less than the predetermined volume (YES in step S43), the indoor controller 65 deactivates the drain pump 17 (step S44). Then, the indoor controller 65 repeats the processing from the first step S21.

[0066] As described above, even if the power supply to deactivated indoor unit B1 is shut down by opening circuit breaker 31, backup power supply unit 41 is activated in response to the opening of circuit breaker 31 and the output of backup power supply unit 41 is supplied to indoor unit B1. Therefore, each louver 5 of indoor unit B1 can be opened as a measure against the occurrence of condensation in indoor unit B1.

[0067] Since each louver 5 is opened when the occupant opens circuit breaker 31, the occupant does not find the movement of each louver 5 unsettling. If each louver 5 is opened each time oil recovery control is started after circuit breaker 31 is opened, the occupant may find it unsettling because each louver 5 moves unexpectedly.

Since each louver moves in spite of the fact that circuit breaker 31 has been already opened, the occupant may doubt that the power source is actually shut down. The occupant may also judge erroneously that circuit breaker 31 or indoor unit B1 is defective. The present invention can prevent such a doubt and an erroneous judgment that circuit breaker 31 or indoor unit B1 is defective.

[0068] It takes about 20 seconds to switch the flow-control valve 18 from the fully-closed state to the fully-open state. Once the flow-control valve 18 has been fully open, the fully-open state is maintained without the need for a driving pulse voltage. Since the drain pump 17 is not activated until the flow-control valve 18 is completely switched to the fully-open state, the power capacity of backup power supply units 41 to 46 can be minimized. Therefore, an increase in cost for installing backup power supply units 41 to 46 can be minimized.

[0069] After the end of the oil recovery control, the drain pump 17 continues operating on the condition that the volume of the drain W in the drain pan 14 is less than the predetermined volume. Therefore, sufficient space for receiving the drain W from the indoor heat exchanger 12 can be provided in the drain pan 14.

[0070] The control of the indoor controller 65 of indoor unit B1 is described above, but indoor controllers 65 of the other indoor units B2 to B6 also executes the same control.

[0071] In the present embodiment, all four louvers 5 are opened when circuit breaker 31 is opened, but the number of louvers 5 to be opened is not limited to this.

[0072] Four air outlets 2 and four louvers 5 are provided in the present embodiment, but the minimum number of each of the air outlets 2 and the louver 5 is one.

[0073] The outdoor unit A comprises one compressor 21 in the present embodiment, but the outdoor unit A may comprise compressors 21 connected in parallel to each other.

[0074] The outdoor unit A comprises one outdoor heat exchanger 23 in the present embodiment, but the outdoor unit A may comprise outdoor heat exchangers 23 connected in parallel to each other.

[0075] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

Claims

1. An air-conditioning apparatus **characterized by** comprising:

   a refrigerating cycle comprising a compressor (21), an outdoor heat exchanger (23), flow-control valves (18) and indoor heat exchangers (12);
   an outdoor unit (A) including the compressor (21) and the outdoor heat exchanger (23);
   indoor units (B1 to B6) including the indoor heat exchangers (12) and the flow-control valves (18), respectively, wherein each of the indoor units (B1 to B6) comprises an air inlet (3), at least one air outlet (4) and at least one louver (5) configured to open and close the air outlet (4), and is configured to allow air drawn from the air inlet (3) to flow through the indoor heat exchanger (12) and discharge the air from the indoor heat exchanger (12) to the air outlet (4);
   an outdoor controller (70) configured to control operation of the compressor (21) and to execute oil recovery control by returning a refrigerant (R) discharged from the compressor (21) to the compressor (21) through the outdoor heat exchanger (23), the flow-control valves (18) and the indoor heat exchangers (12);
   backup power supply units (41 to 46) configured to output backup power to the indoor units (B1 to B6), respectively, when power supply from a main power supply (30) to the indoor units (B1 to B6) is shut down; and
   indoor controllers (65) provided in the indoor units (B1 to B6), respectively, configured to operate by the power supply from the main power supply (30) or output from the respective backup power supply units (41 to 46), and configured to control operation of the respective indoor units (B1 to B6), wherein when the power supply from the main power supply (30) to the indoor units (B1 to B6) is shut down, the indoor controllers (65) open the respective louvers (5) by the output of the respective backup power supply units (41 to 46).

2. The air-conditioning apparatus of Claim 1, **characterized in that**
   the outdoor controller (70) provides each of the indoor controllers (65) with an instruction to start the oil recovery control, and
   the indoor controllers (65) open the respective flow-control valves (18) by the output of the respective backup power supply units (41 to 46) when the oil recovery control is started while the power supply from the main power supply (30) to the indoor units (B1 to B6) is shut down.

3. The air-conditioning apparatus of Claim 2, **characterized by** further comprising:

   drain pumps (17) configured to discharge drain (W) from the indoor heat exchangers (12) out of the indoor units (B1 to B6), respectively,

wherein the indoor controllers (65) activates the respective drain pumps (17) by the output of the respective backup power supply units (41 to 46) when the oil recovery control is started while the power supply from the main power supply (30) to the indoor units (B1 to B6) is shut down.

4. The air-conditioning apparatus of Claim 3, **characterized in that**
when the indoor controllers (65) open the respective flow-control valves (18) and then activate the respective drain pumps (17) by the output of the respective backup power supply units (41 to 46) when the oil recovery control is started while the power supply from the main power supply (30) to the indoor units (B1 to B6) is shut down.

5. The air-conditioning apparatus of Claim 3, **characterized in that**
the outdoor controller (70) provides each of the indoor controllers (65) with the instruction to start the oil recovery control and an instruction to end the oil recovery control, and
the indoor controllers (65) close the respective flow-control valves (18) by the output of the respective backup power supply units (41 to 46) and deactivate the respective drain pumps (17) when the oil recovery control is ended while the power supply from the main power supply (30) to the indoor units (B1 to B6) is shut down.

6. The air-conditioning apparatus of Claim 5, **characterized by** further comprising:

drain pans (14) configured to receive the drain (W) from the indoor heat exchangers (12), respectively; and
a water level sensor (15) configured to sense a volume of the drain (W) in each of the drain pans (14),
wherein the drain pumps (17) discharge the drain (W) in the drain pans (14) out of the respective indoor units (B1 to B6), and
the indoor controllers (65) deactivate the respective drain pumps (17) on a condition that a sensing result of the water level sensor (15) is less than a predetermined volume.

7. The air-conditioning apparatus of Claim 1 **characterized in that**
the indoor units (B1 to B6) receive the power supply from the main power supply (30) through circuit breakers (31 to 36), respectively, and
the backup power supply units (41 to 46) convert a voltage of the main power supply (30) into backup direct-current voltages (Vql, Vq2) for the indoor units (B1 to B6) and output the direct-current voltages (vq1, Vq2), when the circuit breakers (31 to 36) have been opened.

8. The air-conditioning apparatus of any one of Claims 1 to 7, **characterized by** further comprising a motor (5M) configured to operate on a low direct-current voltage and drives each of the louvers (5).

9. The air-conditioning apparatus of any one of Claims 3 to 5, **characterized in that**
each of the drain pumps (17) includes a direct-current motor configured to operate on a low direct-current voltage.

10. The air-conditioning apparatus of any one of Claims 2 to 6, **characterized in that**
each of the flow-control valves (18) includes a pulse motor configured to operate on a low direct-current voltage.

11. The air-conditioning apparatus of any one of Claims 1 to 7, **characterized in that**
the outdoor controller (70) executes the oil recovery control at regular intervals.

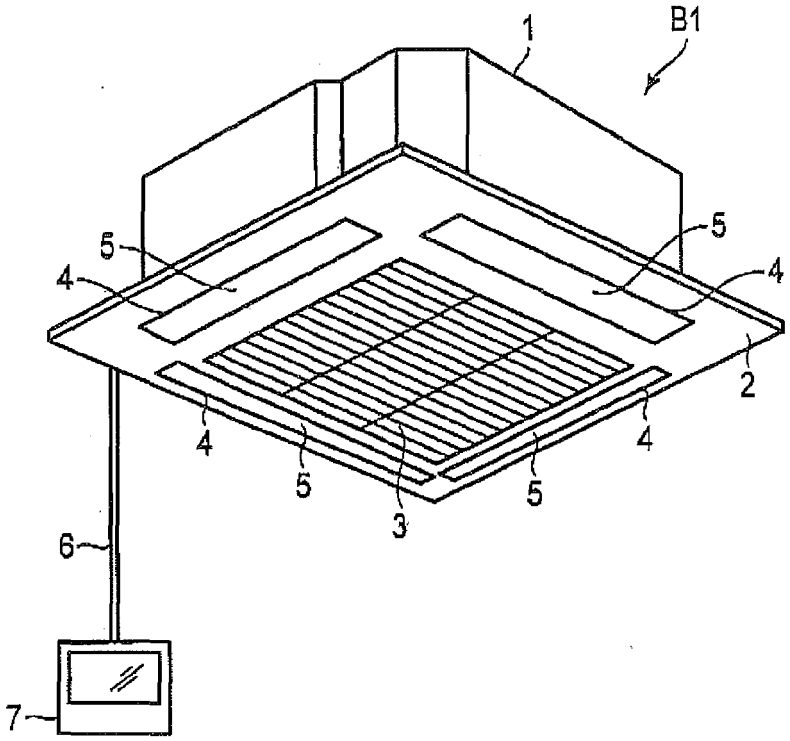
B1
1
5
4
5
4
2
4
5
3
5
4
6
7

FIG. 1

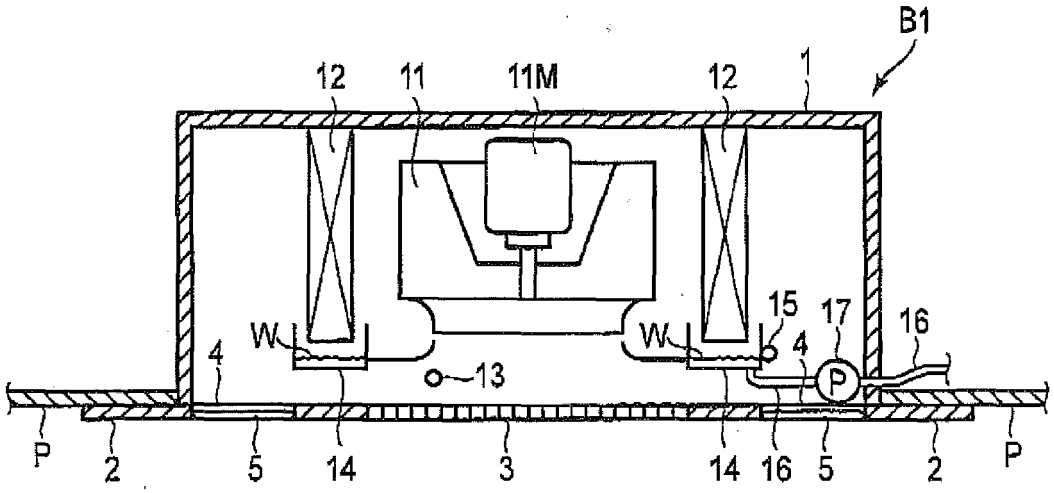
B1
12
11
11M
12
1
15
17
16
W
W
4
4
13
P
P
2
5
14
3
14
16
5
2

FIG. 2

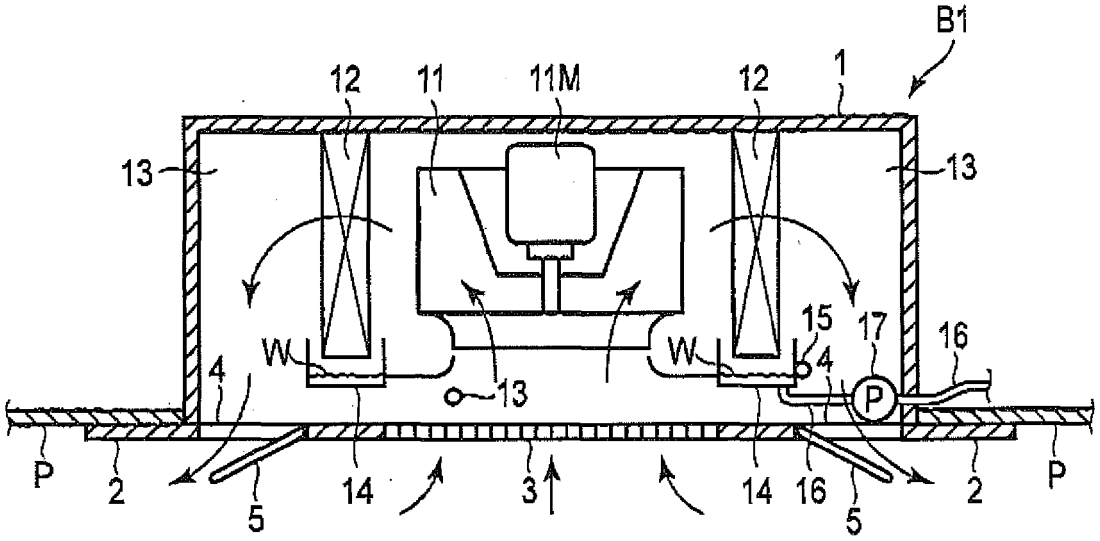

FIG. 3

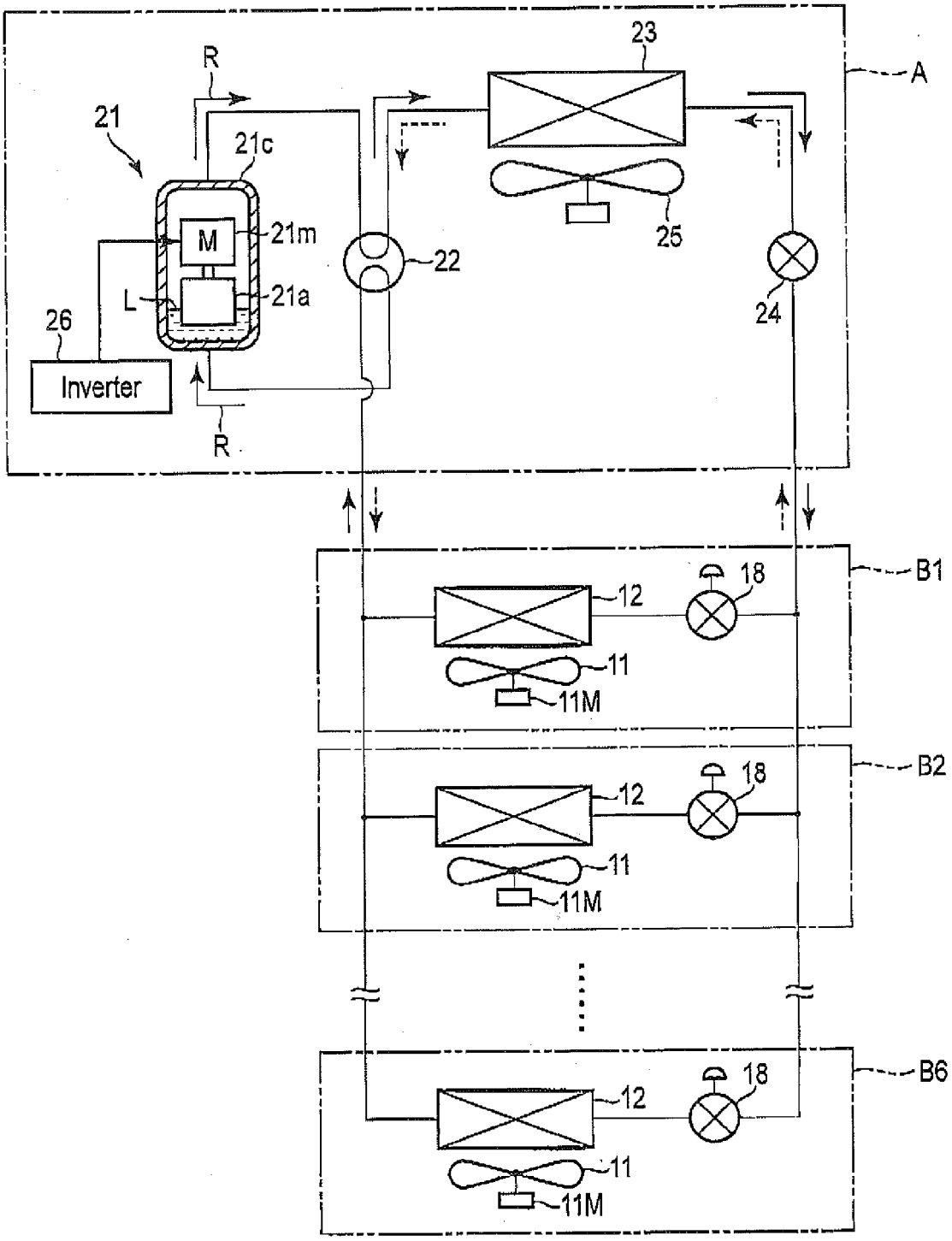
A
23
R
21
21c
M
21m
22
25
L
21a
24
26
Inverter
R
B1
18
12
11
11M
B2
18
12
11
11M
B6
18
12
11
11M

FIG. 4

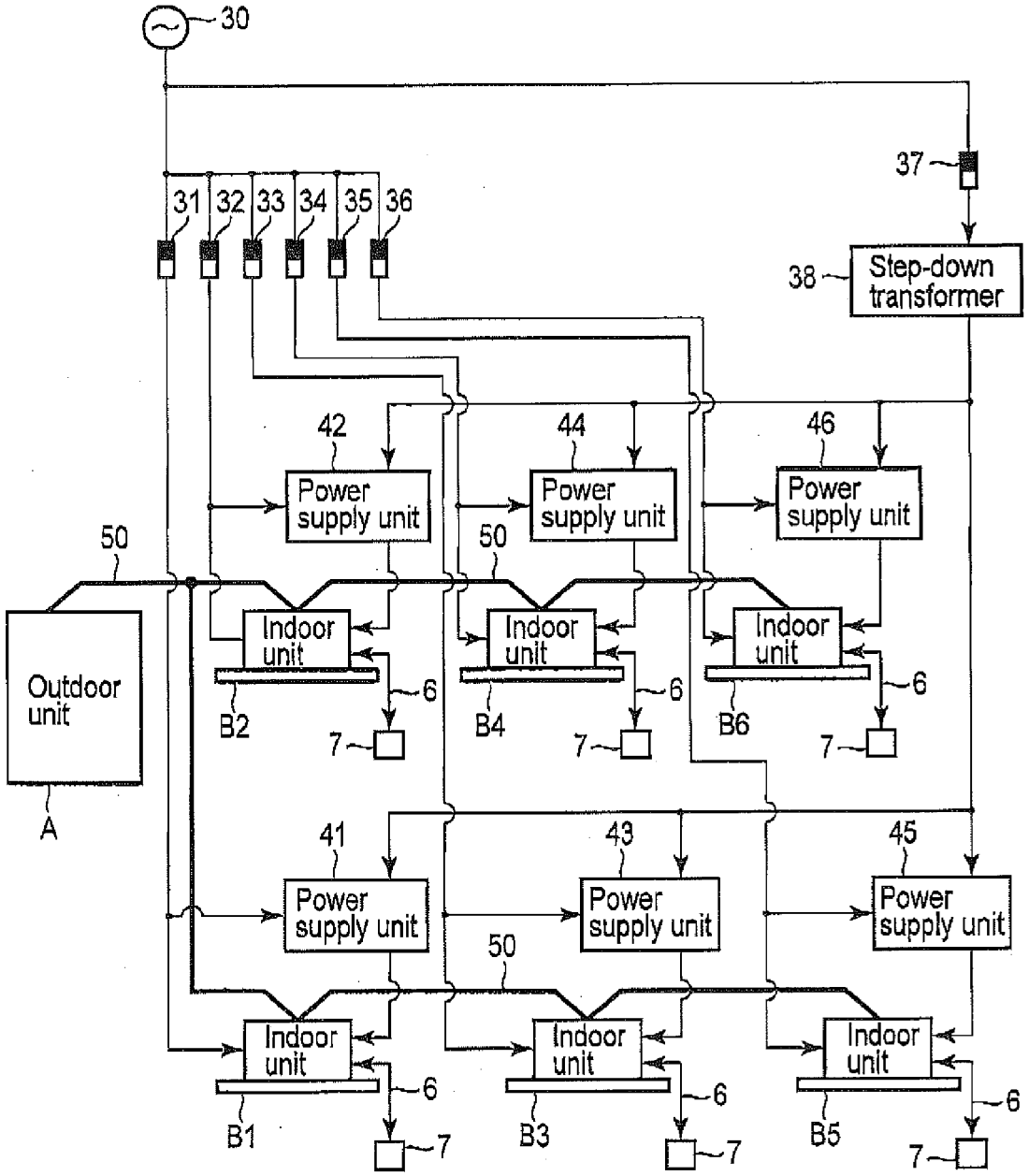
30
31
32
33
34
35
36
37
38
Step-down transformer
42
44
46
Power supply unit
Power supply unit
Power supply unit
50
50
Outdoor unit
A
Indoor unit
Indoor unit
Indoor unit
6
6
6
B2
B4
B6
7
7
7
41
43
45
Power supply unit
Power supply unit
Power supply unit
50
Indoor unit
Indoor unit
Indoor unit
6
6
6
B1
B3
B5
7
7
7

FIG. 5

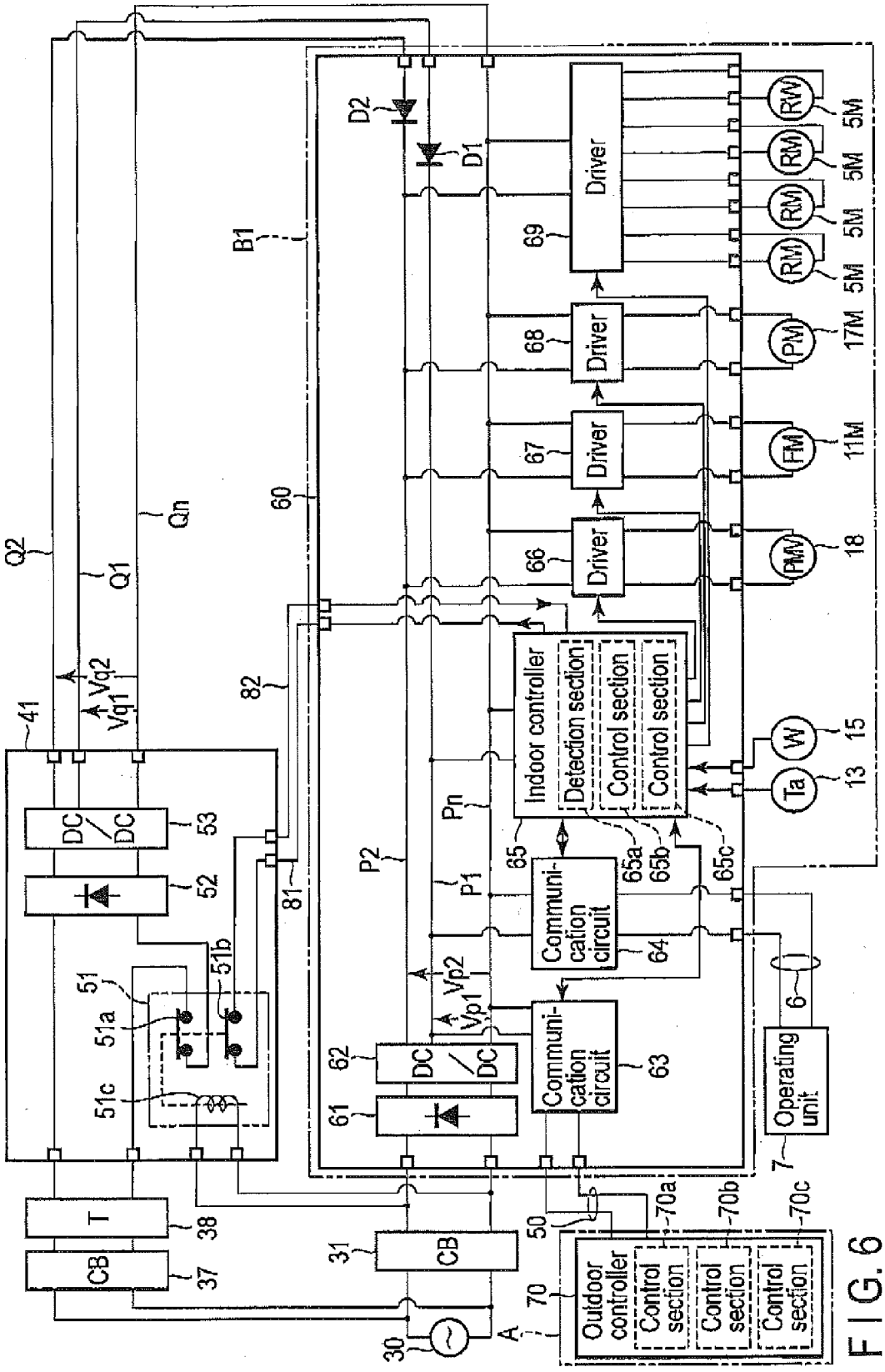
Q2
Q1
Qn
Vq2
Vq1
41
B1
60
82
81
D2
D1
69
Driver
68
Driver
67
Driver
66
Driver
RW
RM
RM
RM
PM
FM
PMV
5M
5M
5M
5M
17M
11M
18
Indoor controller
Detection section
Control section
Control section
85
65a
65b
65c
W
Ta
15
13
Pn
P2
P1
Vp2
Vp1
Communi-cation circuit
64
Communi-cation circuit
63
62
61
DC
DC
6
Operating unit
7
53
52
51
51a
51b
51c
T
38
CB
37
CB
31
30
A
50
70
Outdoor controller
Control section
Control section
Control section
70a
70b
70c

FIG. 6

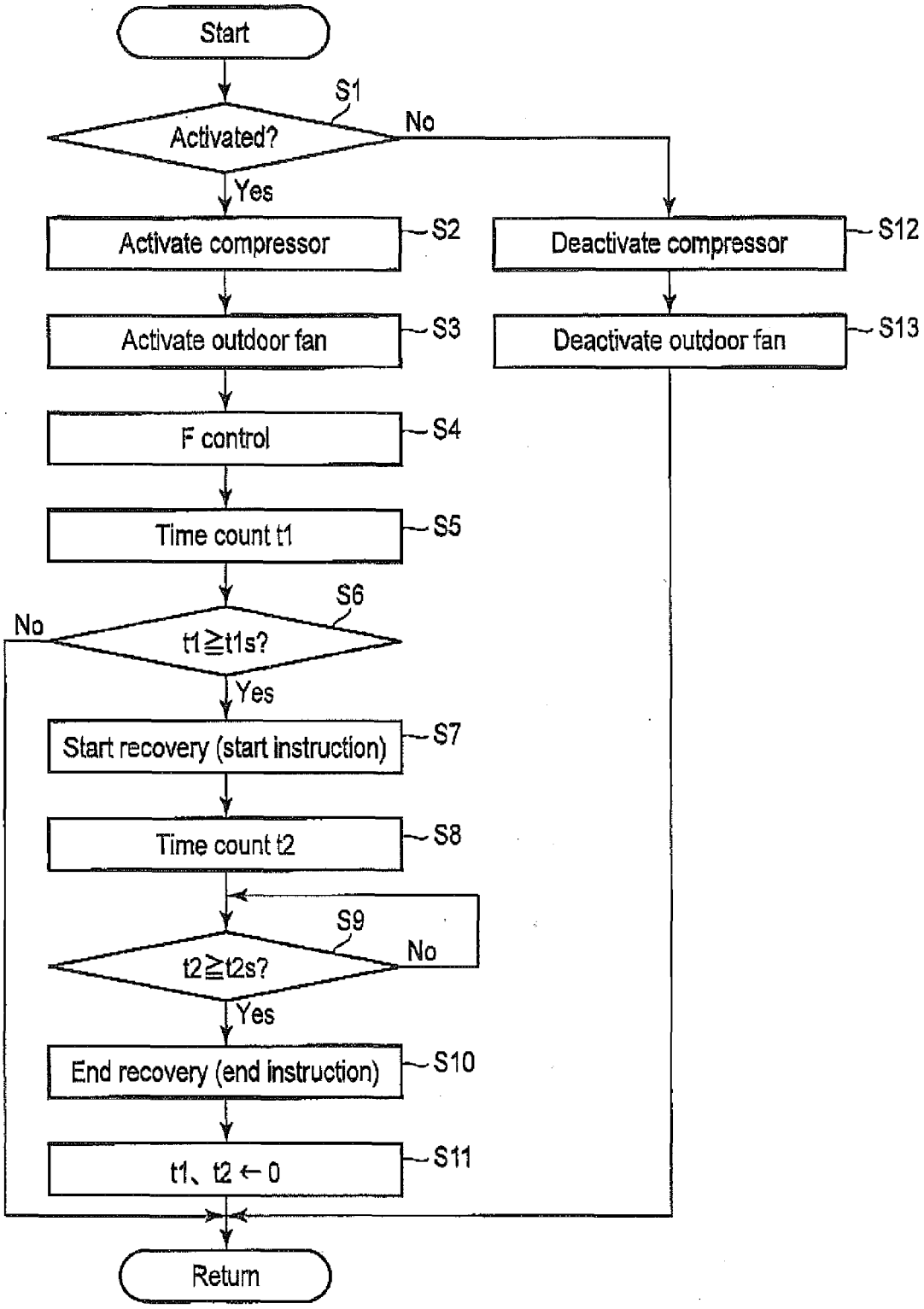
Start
S1
Activated?
No
Yes
Activate compressor
S2
Deactivate compressor
S12
Activate outdoor fan
S3
Deactivate outdoor fan
S13
F control
S4
Time count t1
S5
S6
No
t1≧t1s?
Yes
Start recovery (start instruction)
S7
Time count t2
S8
S9
t2≧t2s?
No
Yes
End recovery (end instruction)
S10
t1、t2←0
S11
Return

FIG. 7

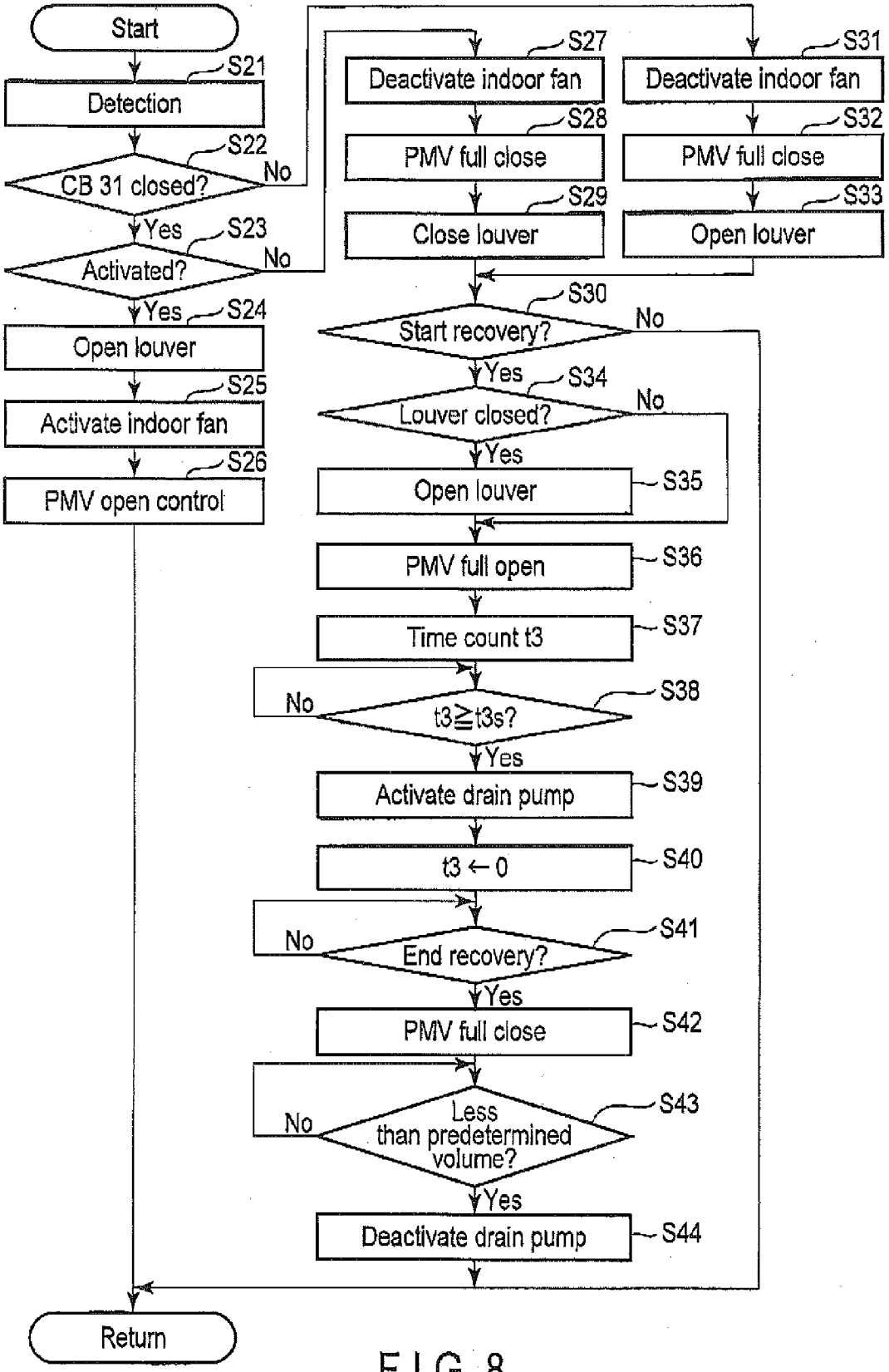
Start
S21
Detection
S22
CB 31 closed?
No
Yes
S23
Activated?
No
Yes
S24
Open louver
S25
Activate indoor fan
S26
PMV open control
S27
Deactivate indoor fan
S28
PMV full close
S29
Close louver
S31
Deactivate indoor fan
S32
PMV full close
S33
Open louver
S30
Start recovery?
No
Yes
S34
Louver closed?
No
Yes
S35
Open louver
S36
PMV full open
S37
Time count t3
S38
No
t3≧t3s?
Yes
S39
Activate drain pump
S40
t3 ← 0
S41
No
End recovery?
Yes
S42
PMV full close
S43
No
Less than predetermined volume?
Yes
S44
Deactivate drain pump
Return

FIG. 8

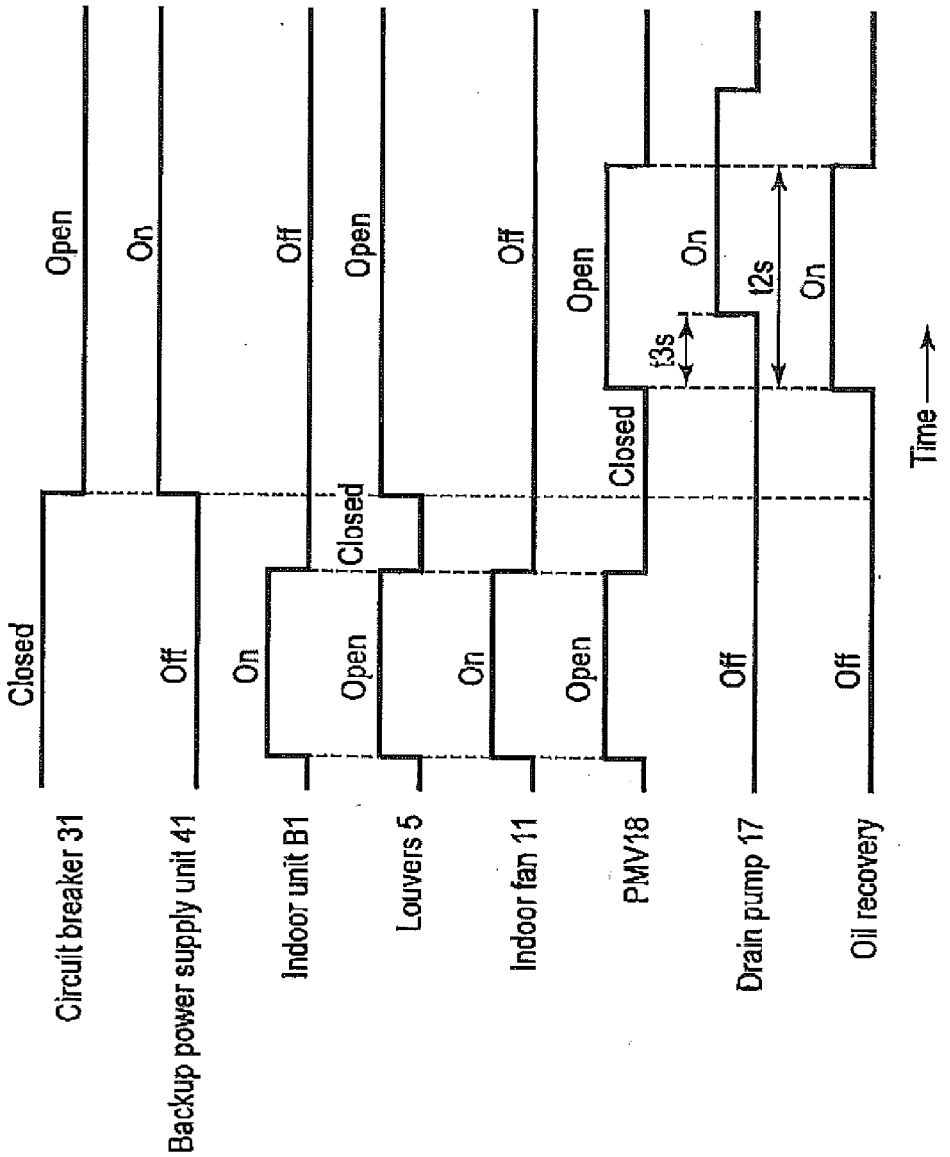
Circuit breaker 31
Closed
Open
Backup power supply unit 41
Off
On
Indoor unit B1
On
Off
Louvers 5
Open
Closed
Indoor fan 11
On
Off
PMV18
Open
Closed
Drain pump 17
Off
On
t3s
t2s
Oil recovery
Off
On
Time

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 15 19 7355

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 498 019 A1 (DAIKIN IND LTD [JP]) 12 September 2012 (2012-09-12) * claims 1-4; figure 2 * -----	1-11	INV. F24F13/22 F24F11/00
A	WO 2012/169110 A1 (MITSUBISHI ELECTRIC CORP [JP]; IKEDA TAKASHI [JP]; TAKAGI MASAHIKO [JP]) 13 December 2012 (2012-12-13) * abstract; figure 1 * -----	1-11	

TECHNICAL FIELDS SEARCHED (IPC)

F24F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 June 2016	Vuc, Arianda

CATEGORY OF CITED DOCUMENTS

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15-06-2016

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		WO 2012169110 A1	13-12-2012

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