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(54) Control system of air conditioner and method of producing control system thereof

(57) In a control system, single cycle-controlling PC board is mounted on a housing. The single cycle-controlling PC board is selected from cycle-controlling PC boards previously produced according to refrigerant flow paths in the refrigerant cycle, respectively. Each of the cycle-controlling PC boards has a sensor circuit for reading a detected signal of a sensor for detecting a temperature of a heat exchanger and a valve control circuit for operating a switch control of a switching valve according to corresponding one of the refrigerant flow paths. Single motor-controlling PC board is mounted on the housing. The motor-controlling PC board is selected from motor-controlling PC boards previously produced according to air conditioning abilities and inputted power supply voltages, respectively. Each of the motor-controlling PC boards has a motor control circuit for controlling a rotational frequency of a compressor motor and a speed of rotation of an outdoor fan according to corresponding one pair of the air conditioning abilities and the inputted power voltages.

Communication circuit electrically connects the one cycle-controlling PC board and the one motor-controlling PC board so as to communicate signals to each other.

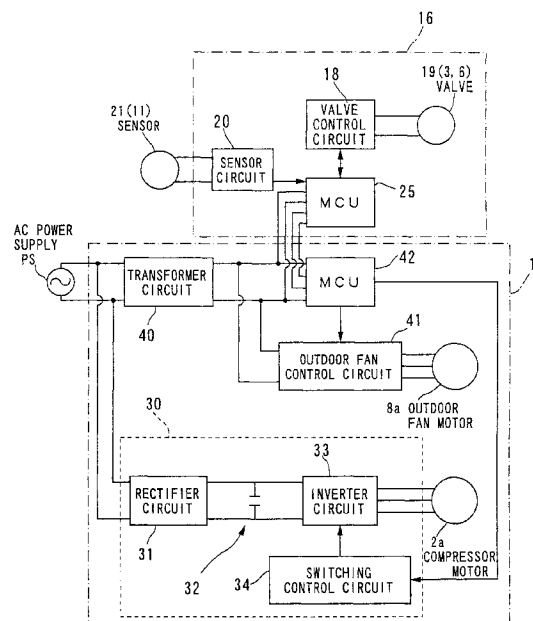


FIG. 2

Description

[0001] The present invention relates to a control system of air conditioners, such as a cooling-only air conditioner, multiple-indoor-unit type air conditioner, a heat pump type air conditioner and a refrigerant heating air conditioner using gas or petroleum.

[0002] The invention also relates to air conditioners having such a control system.

[0003] In general, there are many types of air conditioners, such as, cooling-only air conditioners, heat pump air conditioners and refrigerant heating air conditioners for heating the refrigerant by means of gas or petroleum.

[0004] These types of the air conditioners have at least different structures of refrigerant flow paths of the refrigerant cycles of them, respectively. Further, these air conditioners having different refrigerant flow paths are classified into single-indoor-unit type air conditioners having single indoor unit and multiple-indoor-unit type air conditioners depending on the number of indoor units which can be connected to an outdoor unit of the air conditioner. As the multiple-indoor-unit type air conditioners, there are two-room multiple-indoor-unit type air conditioners having two indoor units which can be connected to one outdoor unit of the air conditioners and three-room multiple-indoor-unit type air conditioners having three indoor units which can be connected to the one outdoor unit thereof.

[0005] Furthermore, these air conditioners having different refrigerant flow paths are classified variously depending on different air conditioning abilities and power supply voltages.

[0006] On the other hand, each of the air conditioners is provided with a control system having a plurality of electronic circuits for controlling, for example, a rotational frequency of a compressor motor and a switching timing of a four-way valve as a switching valve for switching a refrigerant flow path in a refrigerant cycle, thereby executing air conditioning operation of each of the air conditioners.

[0007] The specifications, such as operations, of the electronic circuits of the control systems are affected by the refrigerant flow paths, the air conditioning abilities and the power supply voltages of corresponding air conditioners, respectively. In addition, the first group of electronic circuits affected by the refrigerant flow paths and the second group of electronic circuits affected by the air conditioning abilities and the power supply voltages are so united, while being mixed, as to be formed on a printed circuit (PC) board.

[0008] Therefore, in known air conditioners, when developing and producing these various types of air conditioners each of which has one of the different refrigerant flow paths and one pair of the air conditioning abilities and power supply voltages, the electronic circuits in various types of control systems must be newly designed to be adaptable to the structures of the refriger-

ating flow paths of the refrigerant cycles and the air conditioning abilities and the power supply voltages, respectively.

[0009] That is, when developing and producing a new air conditioner having a pair of a predetermined air conditioning ability and a predetermined input power supply voltage, which are different from that of the existing air conditioners, although a new control system of the new air conditioner requires the same electric circuits related to the same refrigerant flow path of the existing air conditioner, all of the electric circuits of the new control system of the new air conditioner having the different air conditioning ability and the input power supply voltage must be designed from the beginning, and a new PC board, on which all of the electric circuits adapted to the different air conditioning ability and the input power supply voltage are formed, must be developed.

[0010] Similarly, when developing and producing a new air conditioner having a predetermined refrigerant flow path, which is different from that of the existing air conditioners, although a new control system of the new air conditioner requires the same electric circuits related to the same air conditioning ability and input power supply voltage of the existing air conditioner, all of the electric circuits of the control system of the new air conditioner having the different refrigerant flow path must be designed from the beginning, and a new PC board, on which all of the electric circuits adapted to the different refrigerant flow path are formed, must be developed.

[0011] As a result of that, for developing and producing the new control systems used for the new air conditioners having the predetermined refrigerant flow path, the predetermined air conditioning ability and the predetermined power supply voltage, at least one of which is different from that of the existing air conditioners, it takes much development and production time and a great many of production processes, thereby increasing the working amount of producing the new control systems of the new air conditioners.

[0012] The present invention seeks to provide a method of easily and quickly producing a variety of control systems of air conditioners having different specifications, such as, different refrigerating flow paths, different air conditioning abilities and different power supply voltages by combining one of a plurality of motor-controlling PC board each of which is previously produced according to a plurality of air conditioning abilities and inputted power supply voltages, with one of a plurality of cycle-controlling PC board each of which is previously produced according to a plurality of refrigerant flow paths.

[0013] Moreover, the present invention seeks to provide a control system of an air conditioner, which has single motor-controlling PC board selected from a plurality of motor-controlling PC boards previously produced according to a plurality of air conditioning abilities and input power supply voltages and single cycle-controlling PC board selected from a plurality of cycle-controlling PC boards previously produced according to a

plurality of refrigerant flow paths, making it possible to easily and quickly produce the control system of the air conditioner having the desired refrigerant flow path, the desired air conditioning ability and the desired power supply voltage.

[0014] According to one aspect of the present invention, there is provided a control system of an air conditioner having a compressor motor for driving a compressor constituting a refrigerating cycle of the air conditioner, a fan motor for rotating an outdoor fan of the air conditioner, a sensor for detecting at least a temperature of a heat exchanger constituting the refrigerant cycle, a switching valve constituting the refrigerant cycle for switching a refrigerant flow path therein and an expansion valve constituting the refrigerant cycle, the control system comprising a housing; one cycle-controlling PC board selected from a plurality of cycle-controlling PC boards previously produced according to a plurality of refrigerant flow paths in the refrigerant cycle, respectively, and mounted on the housing, each of said plurality of cycle-controlling PC boards having a sensor circuit for reading a detected signal of the sensor and a valve control circuit electrically connected to the sensor circuit for operating a switch control of the switching valve and an opening control of the expansion valve according to corresponding one of the refrigerant flow paths; one motor-controlling PC board selected from a plurality of motor-controlling PC boards previously produced according to a plurality of air conditioning abilities and inputted power supply voltages, respectively, and mounted on the housing, each of said plurality of motor-controlling PC boards having a motor control circuit for controlling a rotational frequency of the compressor motor and a speed of rotation of the outdoor fan according to corresponding one pair of the air conditioning abilities and the inputted power voltages; and a communication circuit electrically connecting the one cycle-controlling PC board and the one motor-controlling PC board so as to communicate signals to each other.

[0015] According to a second aspect of the present invention, there is provided a cycle-controlling PC board used to a control system of an air conditioner having a compressor motor for driving a compressor constituting a refrigerating cycle of the air conditioner, a fan motor for rotating an outdoor fan of the air conditioner, a sensor for detecting at least a temperature of a heat exchanger constituting the refrigerant cycle, and a switching valve for switching a refrigerant flow path and an expansion valve constituting the refrigerant cycle, in which the control system has a motor control circuit for controlling a rotational frequency of the compressor motor and a speed of rotation of the outdoor fan, the cycle-controlling PC board comprising a sensor circuit isolated from the motor control circuit for reading a detected signal of the sensor; a valve control circuit isolated from the motor control circuit and electrically connected to the sensor circuit for operating a switch control of the switching valve and an opening control of the expansion valve ac-

cording to one refrigerant flow path selected from a plurality of refrigerant flow paths; and a communication port electrically connected to the sensor circuit and the valve control circuit and adapted to be capable of communicating signals between the sensor and valve control circuits and the motor control circuit.

[0016] According to a third aspect of the invention, there is provided with a motor-controlling PC board used to a control system of an air conditioner having a compressor motor for driving a compressor constituting a refrigerating cycle of the air conditioner, a fan motor for rotating an outdoor fan of the air conditioner, a sensor for detecting at least a temperature of a heat exchanger constituting the refrigerant cycle, and a switching valve for switching a refrigerant flow path and an expansion valve constituting the refrigerant cycle, in which the control system has a sensor circuit for reading a detected signal of the sensor and a valve control circuit electrically connected to the sensor circuit for operating a switch control of the switching valve and an opening control of the expansion valve; the motor-controlling PC board comprising: a motor control circuit isolated from the sensor circuit and the valve control circuit for controlling a rotational frequency of the compressor motor and a speed of rotation of the outdoor fan according to one pair of air conditioning ability and inputted power voltage selected from a plurality of air conditioning abilities and inputted power voltages; and a communication port electrically connected to the motor control circuit and adapted to be capable of communicating signals between the motor control circuit and the sensor and valve control circuits.

[0017] According to a fourth aspect of the invention, there is provided with a control system having a compressor motor control circuit for controlling a compressor motor of a compressor constituting a refrigerating cycle of an air conditioner, an outdoor fan control circuit for controlling an outdoor fan motor rotating an outdoor fan of the air conditioner, a sensor circuit for reading out a signal detected by a temperature sensor and a valve control circuit for operating a switch control of a switching valve and an opening control of an expansion valve, in which each of the switching valve and the expansion valve constituting the refrigerant cycle, the control system comprising: motor-controlling PC board having one single PC board on which at least the compressor motor control circuit and the outdoor fan control circuit are formed; and cycle-controlling PC board having another single PC board on which at least the sensor circuit and the valve control circuit are formed.

[0018] In preferred embodiment of this aspect, motor-controlling PC board is selected from a plurality of motor-controlling PC boards previously produced corresponding to a plurality of air conditioning abilities and inputted power supply voltages, respectively.

[0019] This aspect of the invention has an arrangement that the cycle-controlling PC board is selected from a plurality of cycle-controlling PC boards previously

produced corresponding to a plurality of refrigerant flow paths in the refrigerant cycle, respectively.

[0020] According to a fifth aspect of the invention, there is provided a method of producing a control system of an air conditioner having a compressor motor for driving a compressor constituting a refrigerating cycle of the air conditioner, a fan motor for rotating an outdoor fan of the air conditioner, a sensor for detecting at least a temperature of a heat exchanger constituting the refrigerant cycle, a switching valve constituting the refrigerant cycle for switching a refrigerant flow path in the refrigerant cycle and an expansion valve constituting the refrigerant cycle, the method comprising the steps of: preparing a housing; preparing a plurality of cycle-controlling PC boards previously produced according to a plurality of refrigerant flow paths in the refrigerant cycle, respectively, each of said plurality of cycle-controlling PC boards having a sensor circuit for reading a detected signal of the sensor and a valve control circuit electrically connected to the sensor circuit for operating a switch control of the switching valve and an opening control of the expansion valve according to corresponding one of the refrigerant flow paths; selecting one cycle-controlling PC board from the prepared cycle-controlling PC boards so as to mount the selected one cycle-controlling PC board to the housing; preparing a plurality of motor-controlling PC boards previously produced according to a plurality of air conditioning abilities and inputted power supply voltages, respectively, each of said plurality of motor-controlling PC board having a motor control circuit for controlling a rotational frequency of the compressor motor and a speed of rotation of the outdoor fan according to corresponding one pair of the air conditioning abilities and the inputted power voltages; selecting one motor-controlling PC board from the prepared motor-controlling PC boards so as to mount the one selected motor-controlling PC board to the housing; and electrically connecting the one cycle-controlling PC board and the one motor-controlling PC board so as to communicate signals to each other.

[0021] As described above, the present invention has the structure that the various motor-controlling PC boards having different specifications, for example, the air conditioning abilities or the power supply voltages, and the various cycle-controlling PC boards having different refrigerant flow paths, such as the single type air conditioner, the multiple-indoor-unit type air conditioner and the refrigerant heating air conditioner, are formed into modules. Therefore, appropriate combination of the PC boards enables various control systems having different specifications to quickly and easily be developed and produced (manufactured).

[0022] For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made by way of example, to the accompanying drawings, in which:-

Fig. 1 is an electronic circuit diagram showing a DC

power supply system according to an embodiment of the present invention;

Fig. 2 is an electric circuit diagram showing the control system 15 shown in Fig. 1;

Fig. 3 is a view showing an appearance of electric circuits mounted on a motor-controlling PC board and a cycle-controlling PC board of the control system shown in Figs. 1 and 2;

Fig. 4 is a list showing a plurality of examples of types of the cycle-controlling PC boards according to the different refrigerant flow paths and the motor-controlling PC boards according to the different pairs of the air conditioning abilities and the input power supply voltages according to this embodiment;

Fig. 5 is a view showing a refrigerating cycle of a two-multiple-indoor-unit type air conditioner having a different refrigerant flow path as compared with the single-indoor-unit type air conditioner according to this embodiment;

Fig. 6 is a view showing a refrigerating cycle of a refrigerant heating air conditioner having a different refrigerant flow path as compared with the single-indoor-unit type air conditioner and the two-multiple-indoor-unit type air conditioner according to this embodiment;

Fig. 7 is a view, partly in cross section, showing an interior of a controller box while the motor-controlling PC board and the cycle-controlling PC board are vertically disposed in the controller box according to this embodiment;

Fig. 8 is a partly plan cross sectional view showing a plan cross section of the controller box when being viewed from a bottom surface of the control box according to this embodiment; and

Fig. 9 is a partly side cross sectional view of Fig. 8.

[0023] The embodiments of the present invention will now be described with reference to Fig. 1 ~ Fig. 9. Incidentally, the same reference characters are assigned to substantially identical elements in these figures.

[0024] Fig. 1 is a view showing a refrigerating cycle of a single-indoor-unit type air conditioner having a control system according to an embodiment of the present invention.

[0025] As shown in Fig. 1, this single-indoor-unit type air conditioner 1 has a refrigerating cycle 1a for reversibly circulating a refrigerant sequentially through a refrigerant pipe 9, a compressor 2, a four-way valve 3, such as a switching valve for switching a flow path of the refrigerant, an indoor heat exchanger 4 having an indoor fan 5, an electric expansion valve 6 and an outdoor heat exchanger 7 having an outdoor fan 8.

[0026] In addition, the compressor 2 has a compressor motor 2a electrically connected thereto for driving the compressor 2 and the outdoor fan 8 has an outdoor fan motor 8a electrically connected thereto for rotating the outdoor fan 8.

[0027] The compressor 2, the four-way valve 3, the electric expansion valve 6, the outdoor heat exchanger 7 and the outdoor fan 8 are provided in an outdoor unit 10 disposed out of a room. The outdoor unit 10 includes a temperature sensor 11 disposed to the outdoor heat exchanger 7 itself or in the vicinity thereof for detecting a temperature of the heat exchanger 7.

[0028] The indoor heat exchanger 4 and the indoor fan 5 are provided in an indoor unit 12 disposed in the room.

[0029] In the outdoor unit 10, a control system 15 is provided. The control system 15 is electrically connected to the compressor motor 2a, the four-way valve 3, the electric expansion valve 6 and the outdoor fan motor 8a.

[0030] The outdoor control system 15 receives a control command signal transmitted from a remote controller or the like (not shown) to switch the four-way valve 3 so as to circulate the refrigerant in a direction of the refrigerating cycle indicated by an arrow shaped as a dashed line shown in Fig. 1, thereby performing a cooling operation.

[0031] Moreover, the outdoor control system 15 receives a control command signal transmitted from the remote controller or the like to switch the four-way valve 3 so as to reversibly circulate the refrigerant in a direction of the refrigerating cycle indicated by an arrow shaped as a solid line shown in Fig. 1, thereby performing a heating operation.

[0032] Furthermore, the outdoor control system 15 controls a rotational frequency of the compressor motor 2a, controls a speed of rotation of the outdoor fan motor 8a and controls a degree of opening of the electric expansion valve 6. In addition, the outdoor control system 15 is adapted to perform two-way communication of data (signals) with respect to an indoor control unit (not shown) through a communication circuit (not shown).

[0033] Fig. 2 is an electric circuit diagram showing the control system 15 shown in Fig. 1 and Fig. 3 is a view showing an appearance of electric circuits mounted on a motor-controlling PC board and a cycle-controlling PC board of the control system shown in Figs. 1 and 2.

[0034] In Figs. 2 and 3, the control system 15 comprises the cycle-controlling PC board 16 and the motor-controlling PC board 17.

[0035] The cycle-controlling PC board 16 has single PC board 16a on which a valve control circuit 18 for controlling the switching operation of the four-way valve 3, the opening of the electric expansion valve 6 and a switching operation or an opening of valves 19 such as an opening/closing valve (not shown) is formed. Moreover, a sensor circuit 20 for operating a sensor 21, such as the outdoor side air temperature sensor 11, and for reading out a detected temperature signal of the sensor 11 and a connector 22 are formed on the PC board 16a.

[0036] On the PC board 16a, a cycle-controlling MCU (Micro Computer Unit) 25 is mounted. The MCU 25 has at least CPU, memory and input and output ports. The

input and output ports of the MCU 25 are electrically connected to the valve control circuit 18, the sensor circuit 20, the communication circuit with respect to the indoor control unit and the connector 22 by a circuit pattern (conductive pattern; not shown) on the PC board 16a.

[0037] The cycle-controlling MCU 25 is operative to read actual switch angles and degrees of opening of the valves 19, such as the four-way valve 3 and the electric expansion valve 6, through the valve control circuit 18 and control the switch angles and the degrees of opening of the valves 19 therethrough. Moreover, the MCU 25 is operative to read required data, such as the temperature signals detected by the sensor 21 through the sensor circuit 20, so as to store the data in a memory of the MCU 25.

[0038] On the other hand, the motor-controlling PC board 17 has single PC board 17a and a motor control circuit 30 mounted thereon for controlling the rotational frequency of the compressor motor 2a. The motor control circuit 30 has a rectifier circuit 31, such as a full wave rectifier circuit, a voltage double rectifier circuit and so on, for rectifying an AC voltage inputted from an external AC power supply PS so as to convert the AC voltage into a DC voltage, a smoothing circuit 32 comprising at least one electrolytic condenser 32a for smoothing the DC voltage outputted from the rectifier circuit 31 and an inverter circuit 33 having a plurality of switching elements 33a, such as Giant Transistors (G-Tr), Insulated Gate Bipolar Transistor (IGBT) or other similar elements and a switching control circuit 34 operatively connected to the switching elements 33a of the inverter circuit 33 for controlling switching timings of the switching elements 33a so that the switching elements 33a are alternatively gated on and off, thereby converting the DC voltage smoothed by the smoothing circuit 32 into an AC voltage. The compressor motor 2a is adapted to be rotatably driven by the AC voltage gained by the inverter circuit 33.

[0039] Moreover, the motor-controlling PC board 17 has a transformer circuit 40 mounted on the PC board 17a for transforming the AC voltage inputted from the external AC power supply PS into a predetermined voltage and an outdoor fan control circuit 41 mounted thereon and driven by the predetermined voltage for controlling a speed of rotation of the outdoor fan motor 8a.

[0040] The motor-controlling PC board 17 also has a motor-controlling MCU (micro-computer unit) 42 having at least CPU, memory and input and output ports mounted on the PC board 17a. The input and output ports of the MCU 42 are, through a circuit pattern (conductive pattern; not shown) on the PC board 17a, electrically connected to the motor control circuit 30 (the rectifier circuit 31, the smoothing circuit 32, the inverter circuit 33 and the switching control circuit 34), the transformer circuit 40, the fan control circuit 41 and a connector 43.

[0041] The MCU 42 is adapted to be driven by the predetermined voltage outputted from the transformer circuit

cuit 40 for reading the actual speed of rotation of the outdoor fan motor 8a and controlling the speed of rotation thereof. Moreover, the MCU 42 driven by the predetermined voltage is adapted to read the actual rotational frequency of the compressor motor 2a so as to properly control the switching timing of the switching control circuit 34.

[0042] Furthermore, the connector 43 of the motor-controlling PC board 17 and the connector 22 of the cycle-controlling PC board 16 are electrically and detachably connected to each other through a communication cable 48 having a pair of lead wires 49a and a pair of power supply lines 49b formed by a pair of wires. Thus, two-way data communication between the motor-controlling MCU 42 and the cycle-controlling MCU 25 can be performed through the communication cable 48.

[0043] In addition, the predetermined voltage outputted from the transformer circuit 40 can be supplied through the power supply lines 49b to the cycle-controlling MCU 25 of the cycle-controlling PC board 16 and the valve control circuit 18 thereof.

[0044] For example, the motor-controlling MCU 42 is adapted to read the actual speed of rotation of the outdoor fan motor 8a through the outdoor fan motor control circuit 41 and to read the actual rotational frequency of the compressor motor 2a through the inverter circuit 33 so as to communicate the read data to the MCU 25 of the cycle-controlling PC board 17 through the communication cable 48.

[0045] On the other hand, the MCU 25 is adapted to supply, to the motor-controlling MCU 42, required data which is stored in the memory thereof and which includes a target speed of rotation of the outdoor-fan motor 8a and a target rotational frequency of the compressor motor 2a.

[0046] That is, in this embodiment, the valve control circuit 18 and the sensor circuit 20, which are affected by changes of the refrigerating flow path and are not affected by changes of the air compressing ability and the input power supply voltage, are isolated from the motor control circuit 30 and the outdoor fan motor control circuit 41, which are affected by the changes of the air compressing ability and the input power supply voltage and not affected by the changes of the refrigerating flow path. Moreover, the isolated valve control circuit 18 and the sensor circuit 20 are mounted on the single PC board 16a and the isolated motor control circuits 30 and 34 are mounted on the single PC board 17a, which is separated from the PC board 16a.

[0047] Furthermore, the isolated cycle-controlling PC board 16 and the isolated motor-controlling PC board 17 are interfaced with the MCU 25 of the PC board 16 and the MCU 42 of the PC board 17, and the PC board 16 and the PC board 17 are detachably connected to each other through the communication cable 48.

[0048] Therefore, by previously preparing a plurality of cycle-controlling PC boards according to a plurality of refrigerant flow paths in the refrigerant cycle, respective-

ly, and preparing a plurality of motor-controlling PC boards according to a plurality of air conditioning abilities and input power supply voltages, it is possible to produce many types of control systems by combining one cycle-controlling PC board, which is selected from the plurality of cycle-controlling PC boards, with one motor-controlling PC board, which is selected from the plurality of motor-controlling PC boards.

[0049] Fig. 4 is a list showing a plurality of examples of types of the above-mentioned cycle-controlling PC boards 16A ~ 16E previously prepared according to the different refrigerant flow paths and the above-mentioned motor-controlling PC boards 17A ~ 17D previously prepared according to the different pairs of the air conditioning abilities and the input power supply voltages and a plurality of examples of the combination between the PC boards 16A ~ 16E and the PC boards 17A ~ 17D.

[0050] Depending on the input power supply voltage (V) and the air conditioning ability (the class), as the types of the motor-controlling PC boards 17, there is a motor-controlling PC board 17A using a single-phase (1 ϕ) input voltage of AC (alternative current) 100 V for 4kW (40) class and a motor-controlling PC board 17B using a single-phase (1 ϕ) input voltage of AC 200 V for 4kW/5kW (40/50) class. Moreover, there is a motor-controlling PC board 17C using a three-phase (3 ϕ) input voltage of AC (alternative current) 200 V for 4kW/5kW (40/50) class and a motor-controlling PC board 17D for worldwide inverters, which is adaptable to the input power supply voltage of, for example, AC 120V or AC 230V of the country to which the air conditioner will be exported, and is adaptable to a predetermined air conditioning ability.

[0051] For example, in the motor-controlling PC board 17A, a voltage double rectifier circuit 31A is used as the rectifier circuit 31 and, in the motor-controlling PC board 17B, a single-phase full wave rectifier circuit 31B is used as the rectifier circuit 31. Moreover, in the motor-controlling PC board 17C, a three-phase full wave rectifier circuit 31C is used as the rectifier circuit 31. In addition, the motor-controlling PC board 17D has one rectifier circuit 31D1 adaptable to an input voltage (power supply voltage) of AC 120V and another rectifier circuit 31D2 adaptable to an input voltage of AC 230V for switching the use of the rectifier circuits 31D1 and 31D2 according to the export country.

[0052] On the other hand, depending on the refrigerant flow paths, the types of the cycle-controlling PC boards 16 are classified into a cycle-controlling PC board 16A for a two multiple-indoor-unit type air conditioner having the outdoor unit to which two indoor units are connected and a three multiple-indoor-unit type air conditioner 16B for a three multiple-indoor-unit type having the outdoor unit to which three indoor units are connected. Furthermore, the types of the cycle-controlling PC boards 16 are classified into a cycle-controlling PC board 16C for the refrigerant heating air conditioner using gas, a cycle-controlling PC board 16D for the re-

frigerant heating air conditioner using petroleum and cycle-controlling PC boards for other air conditioners 16E, such as a cycle controlling PC board for a single-indoor unit type air conditioner having the outdoor unit to which single indoor unit is connected, as shown in Fig. 1.

[0053] For example, Fig. 5 shows a refrigerating cycle of a two-multiple-indoor-unit type air conditioner 1A having a different refrigerant flow path as compared with the single-indoor-unit type air conditioner 1.

[0054] As shown in Fig. 5, for example, in heating operation, the refrigerant discharged from the compressor 2 flows through the four-way valve 3 and diverges along two refrigerant flow paths. That is, one divergent refrigerant flows through one electric expansion valve 50a into one indoor unit 12a (indoor heat exchanger 4a).

[0055] On the other hand, other divergent refrigerant flows through other electric expansion valve 50b into other indoor unit 12b (indoor heat exchanger 4b).

[0056] The one divergent refrigerant flowing out of the one indoor unit 12a flows through the one expansion valve 6a. The other divergent refrigerant flowing out of the other indoor unit 12b flows through the other expansion valve 6b so that the one and other divergent refrigerants are mixed and the mixed refrigerant circulates along the arrow shaped as the solid line.

[0057] In addition, for example, Fig. 6 shows a refrigerating cycle of a refrigerant heating air conditioner 1B having a different refrigerant flow path as compared with the single-indoor-unit type air conditioner 1 and the two-multiple-indoor-unit type air conditioner 1A.

[0058] As shown in Fig. 6, for example, in heating operation, the refrigerant transmitted from the indoor heat exchanger 4 (indoor unit 12) diverges through a divergent pipe 55 and the divergent refrigerant flows through an opening/closing valve 56, which is opening, into a refrigerant heater 57 using gas or petroleum so as to be heated. The divergent refrigerant, which is heated and evaporated by the heater 57, is mixed with the refrigerant transmitted from the outdoor heat exchanger 7 and the mixed refrigerant flows into the compressor 2.

[0059] Therefore, the combinations shown in Fig. 4 permits the four types of motor-controlling PC boards 17A to 17D with the five types of cycle-controlling PC boards 16A to 16E to be combined variously. Thus, twenty combinations can be realized.

[0060] The above-mentioned twenty types outdoor control systems 15 adapted to different input power supply voltages and air conditioning abilities, and different refrigerant flow paths (refrigerating cycle structures) are not required to again design all of control circuits and develop a new PC boards whenever each of the outdoor control systems is developed. Thus, time and labor required for producing the outdoor control systems can considerably be saved. The types of the PC boards 16A to 16E and 17A to 17D are not limited to the above-mentioned types. The types may substantially be increased or decreased.

[0061] Fig. 7 is a view, partly in cross section, showing

an interior of a controller box (housing) 60 while the motor-controlling PC board 17 and the cycle-controlling PC board 16 are disposed in parallel in the controller box 60. Fig. 8 is a partly plan cross sectional view showing a plan cross section of the controller box 60 when being viewed from a bottom surface of the control box 60. Fig. 9 is a partly side cross sectional view of Fig. 8.

[0062] The controller box 60 is provided for the outdoor unit 10. A heat sink 61 is formed on an outer side surface of the controller box 60. Moreover, the cycle-controlling PC board 16 having, for example, substantially rectangular shape is secured to an internal anchoring mold 62.

[0063] As shown in Figs. 7 ~ 9, the motor-controlling PC board 17 having a substantially rectangular shape, which is larger than the cycle-controlling PC board 16 is secured close to the inner surface at the upper end of the controller box 60. The motor-controlling PC board 17 is disposed above the cycle-controlling PC board 16 in Fig. 7.

[0064] The connectors 43 are mounted lineally to one end portion of the motor-controlling PC board 17 and the connector 22 is mounted to one end portion of the cycle-controlling PC board 16. The one end portion of the cycle-controlling PC board 16 is close to the one end portion of the motor-controlling PC board 17 and the communication cable 48 electrically connects the connector 22 and one of the connectors 43.

[0065] Moreover, the motor-controlling PC board 17 and the cycle-controlling PC board 16 are so arranged as to be opposite to each other. The connectors 43 are mounted on an inner surface of the one end portion of the motor-controlling PC board 17. The connector 22 is mounted to a portion of an outer surface 16s of the cycle-controlling PC board 16 opposite to the inner surface 17s of the motor-controlling PC board 17. The mounted portions of the connectors 43 on the inner surface 17s of the motor-controlling PC board 17 are so located as to be offset toward a predetermined direction with respect to a projection position of the connector 22 on the inner surface 17s of the motor-controlling PC board 17. Incidentally, reference numeral 65 represents an SL connector joining portion.

[0066] This embodiment has the structure that the various motor-controlling PC boards 17 having different air conditioning abilities and adapted to different power supply voltages and the various cycle-controlling PC boards 16 for various air conditioners, such as the single-indoor-unit type air conditioner, the multiple-indoor-unit type air conditioner, the refrigerant heating air conditioner and so forth which are formed into modules. Therefore, when the two PC boards are appropriately combined with each other, a variety of control systems having different specifications can quickly and easily be developed and produced.

[0067] Since the motor-controlling PC boards 17 using input voltages of AC 100 V and AC 200/230 V are prepared, selection of the motor-controlling PC board

17 adapted to the air conditioners adapted to the input power supply voltages of AC 100 and AC 200/230 V enables the necessity of again designing all of circuits in the control system 15 and newly developing a PC board to be eliminated. Therefore, development and manufacturing can quickly and easily be performed.

[0068] Since the cycle-controlling PC boards 16 for controlling the multiple-indoor-unit type air conditioner, controlling the gas air conditioner and controlling petroleum air conditioner are prepared, selection of a cycle-controlling PC board adapted to control of each air conditioner enables the necessity of again designing all of circuits for the control system 15 and developing a new PC board to be eliminated.

[0069] Since electric power can be supplied from the transformer circuit 40 of the motor-controlling PC board 17 to the cycle-controlling PC board 16, electric power can be supplied to the cycle-controlling PC board 16 even if the combination of the two controlling PC boards 16 and 17 is varied. Therefore, a necessity of newly developing a transformer circuit 40 for an air conditioner having a different specification can be eliminated. Therefore, the control system 15 can quickly and easily be developed and manufactured.

[0070] The motor-controlling PC board 17 and the cycle-controlling PC board 16 are operative to perform data communication by dints of the MCU 25 and the MCU 42. Therefore, data of the rotational frequencies of the compressor motor 2a and the speed of rotation of the outdoor fan motor 8a or data of the electric current value can be transmitted from the MCU 42 mounted on the motor-controlling PC board 17 to the MCU 25 of the cycle-controlling PC board 16. Moreover, data of a target number of revolutions of the motor can be transmitted from the MCU 25 of the cycle-controlling PC board 16 to the MCU 42 of the motor-controlling PC board 17.

[0071] Since the motor-controlling PC board 17 and the cycle-controlling PC board 16 are so closely arranged as to be opposite to each other, the spaces for disposing the two PC boards 17 and 16 can be saved. Thus, the size of the controller box 60 can be reduced and the communication cable 48 for establishing the connection between the two PC boards 17 and 16 can be shortened.

[0072] Moreover, because the mounted portion of the connectors 43 on the inner surface 17s of the motor-controlling PC board 17 are so located as to be offset toward a predetermined direction with respect to a projection position of the connector 22 on the inner surface 17s of the motor-controlling PC board 17, it is possible to easily insert the communication cable 48 to the connector 22 of the cycle-controlling PC board 16 and one of the connectors 43 of the motor-controlling PC board 17. In addition, it is possible to pull out the communication cable 48 from the connectors 22 and 43.

[0073] While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled

in the art that the foregoing and other changes in form and details can be made therein without departing from the spirit and scope of the invention.

Claims

1. A control system of an air conditioner having a compressor motor for driving a compressor constituting a refrigerating cycle of the air conditioner, a fan motor for rotating an outdoor fan of the air conditioner, a sensor for detecting at least a temperature of a heat exchanger constituting the refrigerant cycle, a switching valve constituting the refrigerant cycle for switching a refrigerant flow path therein and an expansion valve constituting the refrigerant cycle, the control system comprising:

a housing;

one cycle-controlling PC board selected from a plurality of cycle-controlling PC boards previously produced according to a plurality of refrigerant flow paths in the refrigerant cycle, respectively, and mounted on the housing,

each of said plurality of cycle-controlling PC boards having a sensor circuit for reading a detected signal of the sensor and a valve control circuit electrically connected to the sensor circuit for operating a switch control of the switching valve and an opening control of the expansion valve according to corresponding one of the refrigerant flow paths;

one motor-controlling PC board selected from a plurality of motor-controlling PC boards previously produced according to a plurality of air conditioning abilities and inputted power supply voltages, respectively, and mounted on the housing,

each of said plurality of motor-controlling PC boards having a motor control circuit for controlling a rotational frequency of the compressor motor and a speed of rotation of the outdoor fan according to corresponding one pair of the air conditioning abilities and the inputted power voltages; and

a communication circuit electrically connecting the one cycle-controlling PC board and the one motor-controlling PC board so as to communicate signals to each other.

2. A cycle-controlling PC board used to a control system of an air conditioner having a compressor motor for driving a compressor constituting a refrigerating cycle of the air conditioner, a fan motor for rotating an outdoor fan of the air conditioner, a sensor for detecting at least a temperature of a heat exchanger constituting the refrigerant cycle, and a switching valve for switching a refrigerant flow path and an

expansion valve constituting the refrigerant cycle, in which the control system has a motor control circuit for controlling a rotational frequency of the compressor motor and a speed of rotation of the outdoor fan, the cycle-controlling PC board comprising:

a sensor circuit isolated from the motor control circuit for reading a detected signal of the sensor;

a valve control circuit isolated from the motor control circuit and electrically connected to the sensor circuit for operating a switch control of the switching valve and an opening control of the expansion valve according to one refrigerant flow path selected from a plurality of refrigerant flow paths; and

a communication port electrically connected to the sensor circuit and the valve control circuit and adapted to be capable of communicating signals between the sensor and valve control circuits and the motor control circuit.

3. A motor-controlling PC board used to a control system of an air conditioner having a compressor motor for driving a compressor constituting a refrigerating cycle of the air conditioner, a fan motor for rotating an outdoor fan of the air conditioner, a sensor for detecting at least a temperature of a heat exchanger constituting the refrigerant cycle, and a switching valve for switching a refrigerant flow path and an expansion valve constituting the refrigerant cycle, in which the control system has a sensor circuit for reading a detected signal of the sensor and a valve control circuit electrically connected to the sensor circuit for operating a switch control of the switching valve and an opening control of the expansion valve; the motor-controlling PC board comprising:

a motor control circuit isolated from the sensor circuit and the valve control circuit for controlling a rotational frequency of the compressor motor and a speed of rotation of the outdoor fan according to one pair of air conditioning ability and inputted power voltage selected from a plurality of air conditioning abilities and inputted power voltages; and

a communication port electrically connected to the motor control circuit and adapted to be capable of communicating signals between the motor control circuit and the sensor and valve control circuits.

4. A control system having a compressor motor control circuit for controlling a compressor motor of a compressor constituting a refrigerating cycle of an air conditioner, an outdoor fan control circuit for controlling an outdoor fan motor rotating an outdoor fan of the air conditioner, a sensor circuit for reading out

a signal detected by a temperature sensor and a valve control circuit for operating a switch control of a switching valve and an opening control of an expansion valve, in which each of the switching valve and the expansion valve constituting the refrigerant cycle, the control system comprising:

motor-controlling PC board having one single PC board on which at least the compressor motor control circuit and the outdoor fan control circuit are formed; and

cycle-controlling PC board having another single PC board on which at least the sensor circuit and the valve control circuit are formed.

5. A control system according to claim 4, wherein said motor-controlling PC board is adapted to be selected from a plurality of motor-controlling PC boards previously produced corresponding to a plurality of air conditioning abilities and inputted power supply voltages, respectively.
6. A control system according to claim 5, wherein said plurality of motor-controlling PC boards include at least a first motor-controlling PC board using an input voltage of AC 100V, a second motor-controlling PC board using an input voltage of AC 200V and a third motor-controlling PC board using changeably two input voltage of AC 120V and AC 230V.
7. A control system according to claim 4, wherein said cycle-controlling PC board is adapted to be selected from a plurality of cycle-controlling PC boards previously produced corresponding to a plurality of refrigerant flow paths in the refrigerant cycle, respectively.
8. A control system according to claim 7, wherein said plurality of cycle-controlling PC boards include at least a first cycle-controlling PC board used for a single-type air conditioner having single indoor unit, a second cycle-controlling PC board used for a multiple-indoor-unit type air conditioner having multiple indoor units and a third cycle-controlling PC board used for a refrigerant heating air conditioner.
9. A control system according to claim 4, wherein said compressor motor control circuit has a rectifier circuit for rectifying an AC voltage inputted from an external AC power supply so as to convert the AC voltage into a DC voltage, a smoothing circuit for smoothing the DC voltage outputted from the rectifier circuit and an inverter circuit having a plurality of switching elements for operating a switching control so that the switching elements are gated on and off, thereby converting the DC voltage smoothed by the smoothing circuit into an AC voltage, wherein said compressor motor is rotatably driven by the AC

voltage gained by the inverter circuit.

10. A control system according to claim 9, wherein said motor-controlling PC board has a first micro-computer unit mounted thereon and electrically connected to the compressor motor control circuit and the outdoor fan control circuit for controlling the compressor motor control circuit and the outdoor fan control circuit, and wherein said cycle-controlling PC board has a second micro-computer unit mounted thereon and electrically connected to the sensor circuit and the valve control circuit for controlling the sensor circuit and the valve control circuit, further comprising a communication circuit electrically connecting the first micro-computer unit and the second micro-computer unit so as to communicate signals to each other.
11. A control system according to claim 10, wherein said motor-controlling PC board has a power supply circuit mounted thereon for transforming the AC voltage inputted from the external AC power supply into a predetermined voltage, for supplying the transformed voltage to the first micro-computer unit of the motor-controlling PC board and the outdoor fan control circuit thereof and for supplying the transformed voltage through the communication circuit to the second micro-computer unit of the cycle-controlling PC board and the valve control circuit thereof.
12. A control system according to claim 11, further comprising a housing for storing the motor-controlling PC board and the cycle-controlling PC board, said motor-controlling PC board and the cycle-controlling PC board being mounted to the housing so that the motor-controlling PC board and the cycle-controlling PC board are close to each other, wherein said communication circuit has a first communication port mounted to one end portion of the motor-controlling PC board and electrically connected to at least the first micro-computer unit, a second communication port mounted to one end portion of the cycle-controlling PC board and electrically connected to at least the second micro-computer unit, said one end portion of the cycle-controlling PC board being close to the one end portion of the motor-controlling PC board, and a communication cable electrically connecting the first communication port and the second communication port.
13. A control system according to claim 12, wherein said motor-controlling PC board and said cycle-controlling PC board are so arranged as to be opposite to each other, said first communication port is mounted on a first surface of the one end portion of the motor-controlling PC board, and wherein said second communication port is mounted to a portion

of a second surface of the cycle-controlling PC board, said mounted portion of the first communication port on the first surface of the motor-controlling PC board being so located as to be offset toward a predetermined direction with respect to a projection position of the second communication port on the first surface thereof.

14. A method of producing a control system of an air conditioner having a compressor motor for driving a compressor constituting a refrigerating cycle of the air conditioner, a fan motor for rotating an outdoor fan of the air conditioner, a sensor for detecting at least a temperature of a heat exchanger constituting the refrigerant cycle, a switching valve constituting the refrigerant cycle for switching a refrigerant flow path in the refrigerant cycle and an expansion valve constituting the refrigerant cycle, the method comprising the steps of:

preparing a housing;
 preparing a plurality of cycle-controlling PC boards previously produced according to a plurality of refrigerant flow paths in the refrigerant cycle, respectively, each of said plurality of cycle-controlling PC boards having a sensor circuit for reading a detected signal of the sensor and a valve control circuit electrically connected to the sensor circuit for operating a switch control of the switching valve and an opening control of the expansion valve according to corresponding one of the refrigerant flow paths;
 selecting one cycle-controlling PC board from the prepared cycle-controlling PC boards so as to mount the selected one cycle-controlling PC board to the housing;
 preparing a plurality of motor-controlling PC boards previously produced according to a plurality of air conditioning abilities and inputted power supply voltages, respectively, each of said plurality of motor-controlling PC board having a motor control circuit for controlling a rotational frequency of the compressor motor and a speed of rotation of the outdoor fan according to corresponding one pair of the air conditioning abilities and the inputted power voltages;
 selecting one motor-controlling PC board from the prepared motor-controlling PC boards so as to mount the one selected motor-controlling PC board to the housing; and
 electrically connecting the one cycle-controlling PC board and the one motor-controlling PC board so as to communicate signals to each other.

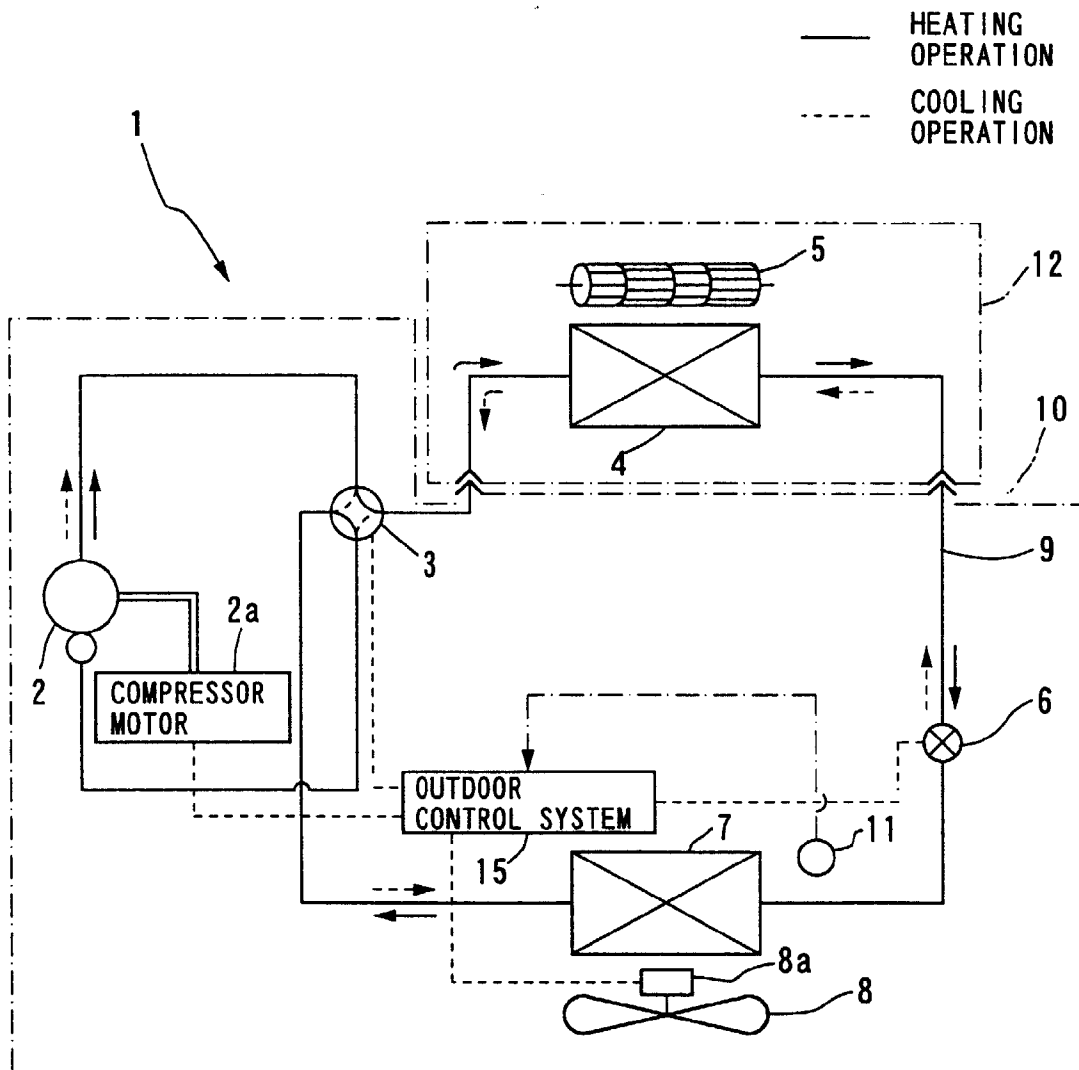


FIG. 1

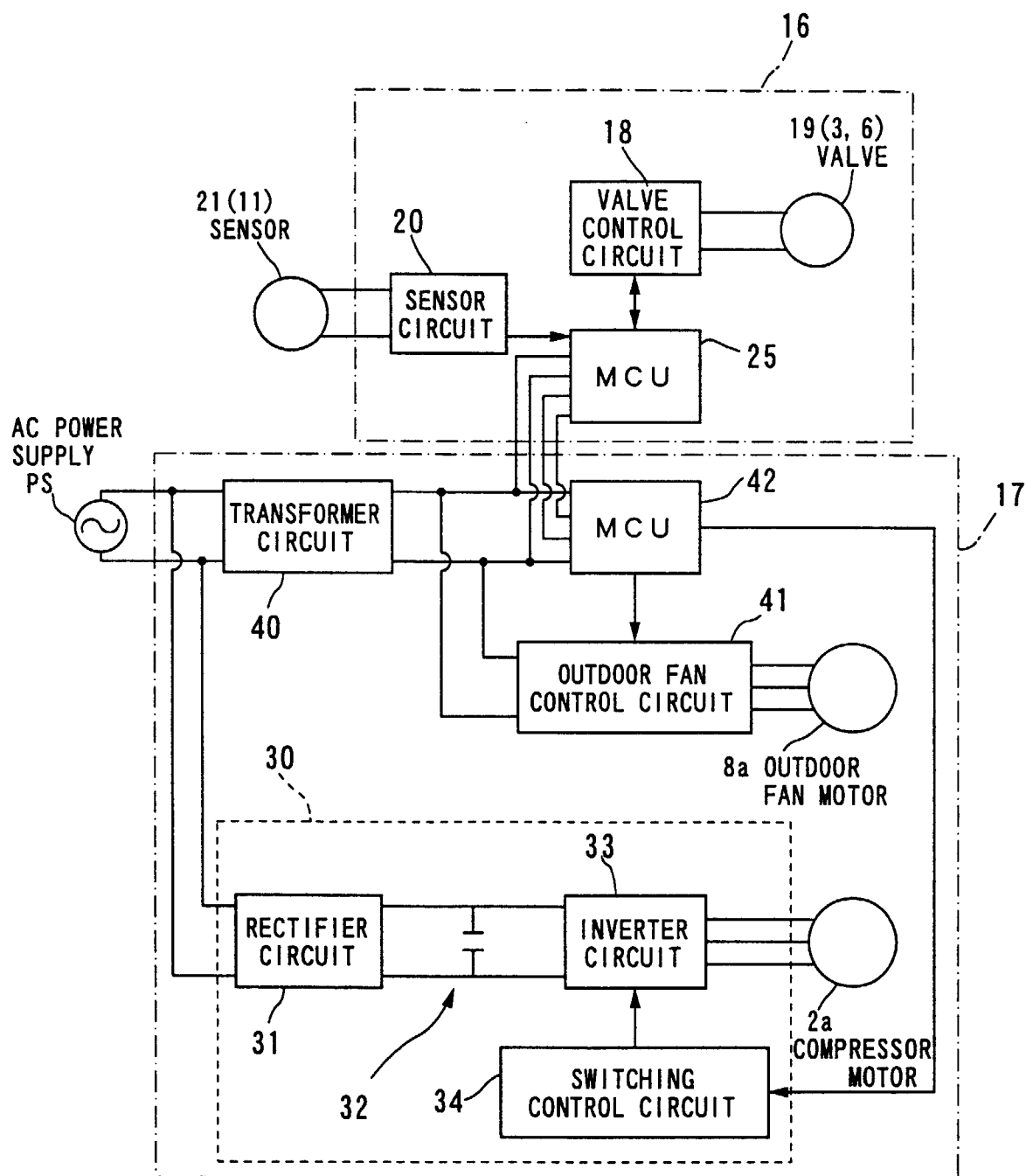


FIG. 2

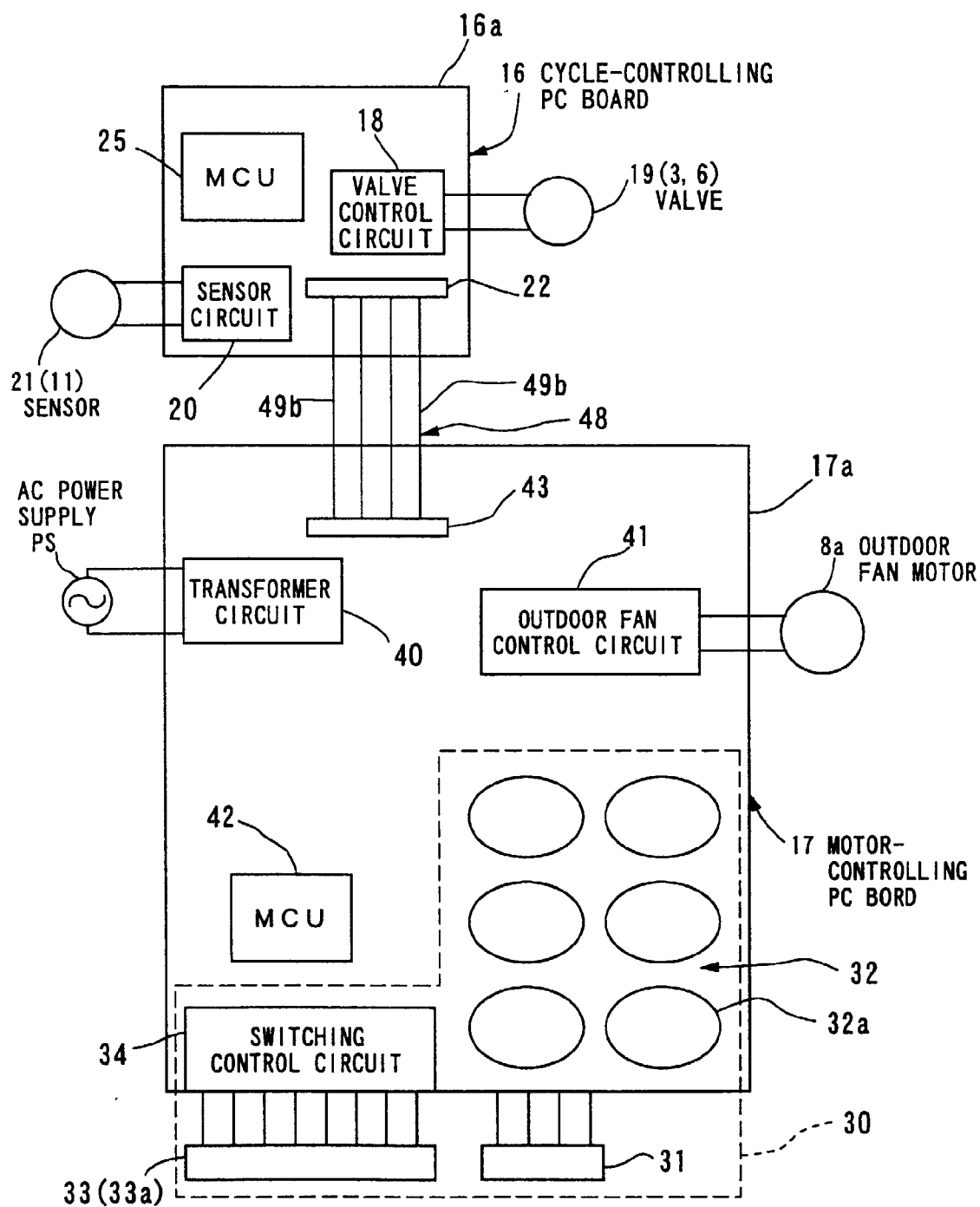


FIG. 3

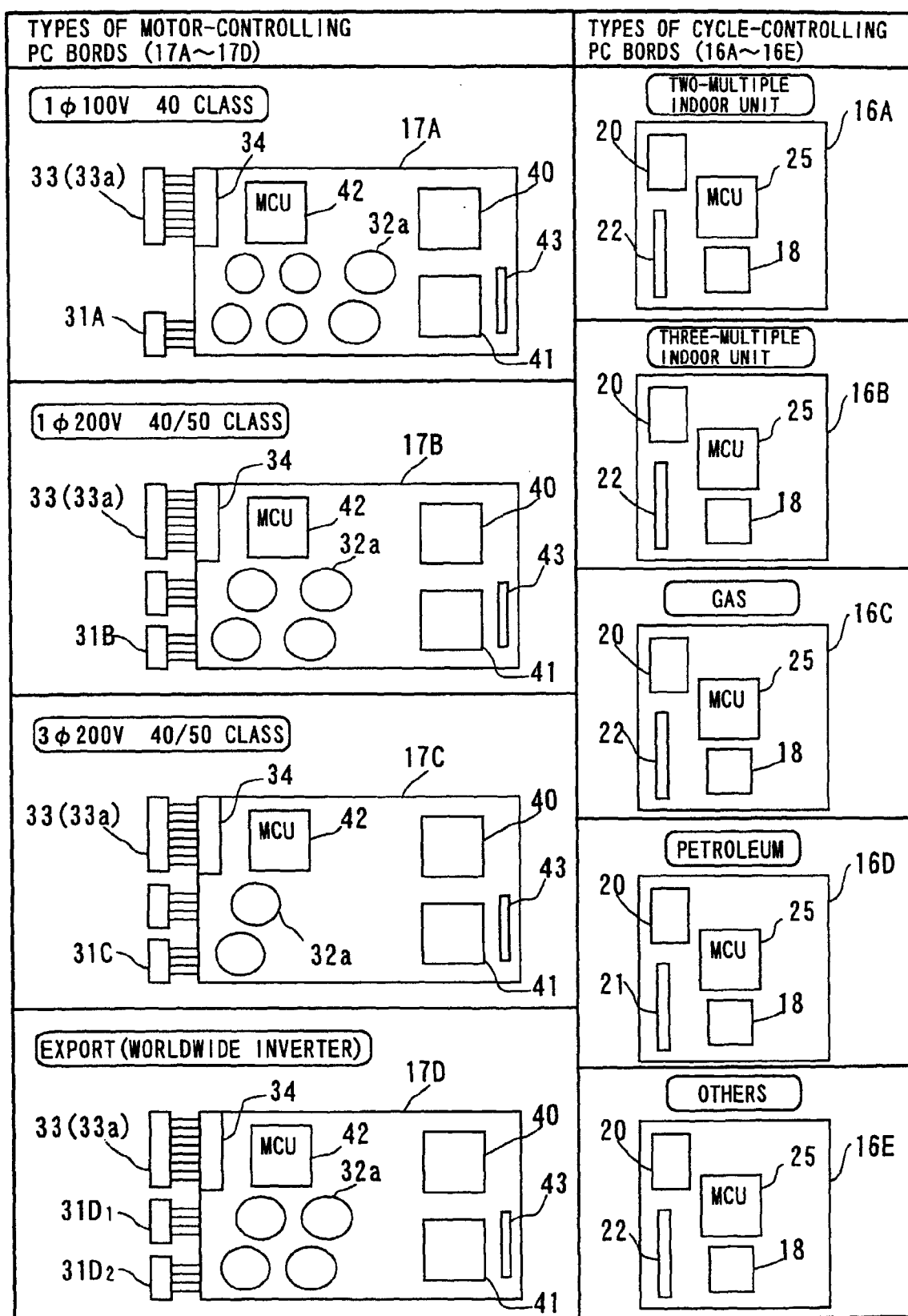


FIG. 4

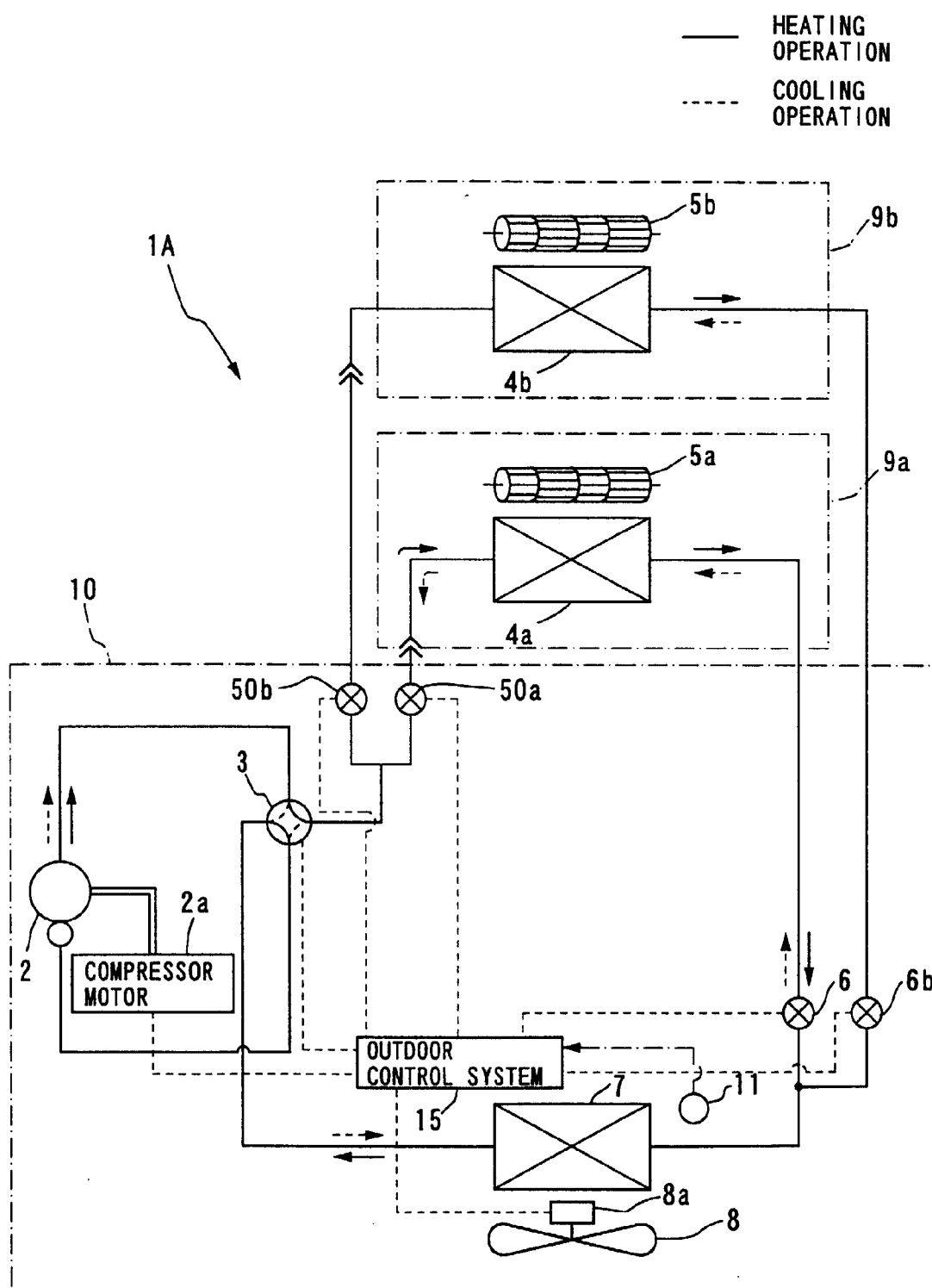


FIG. 5

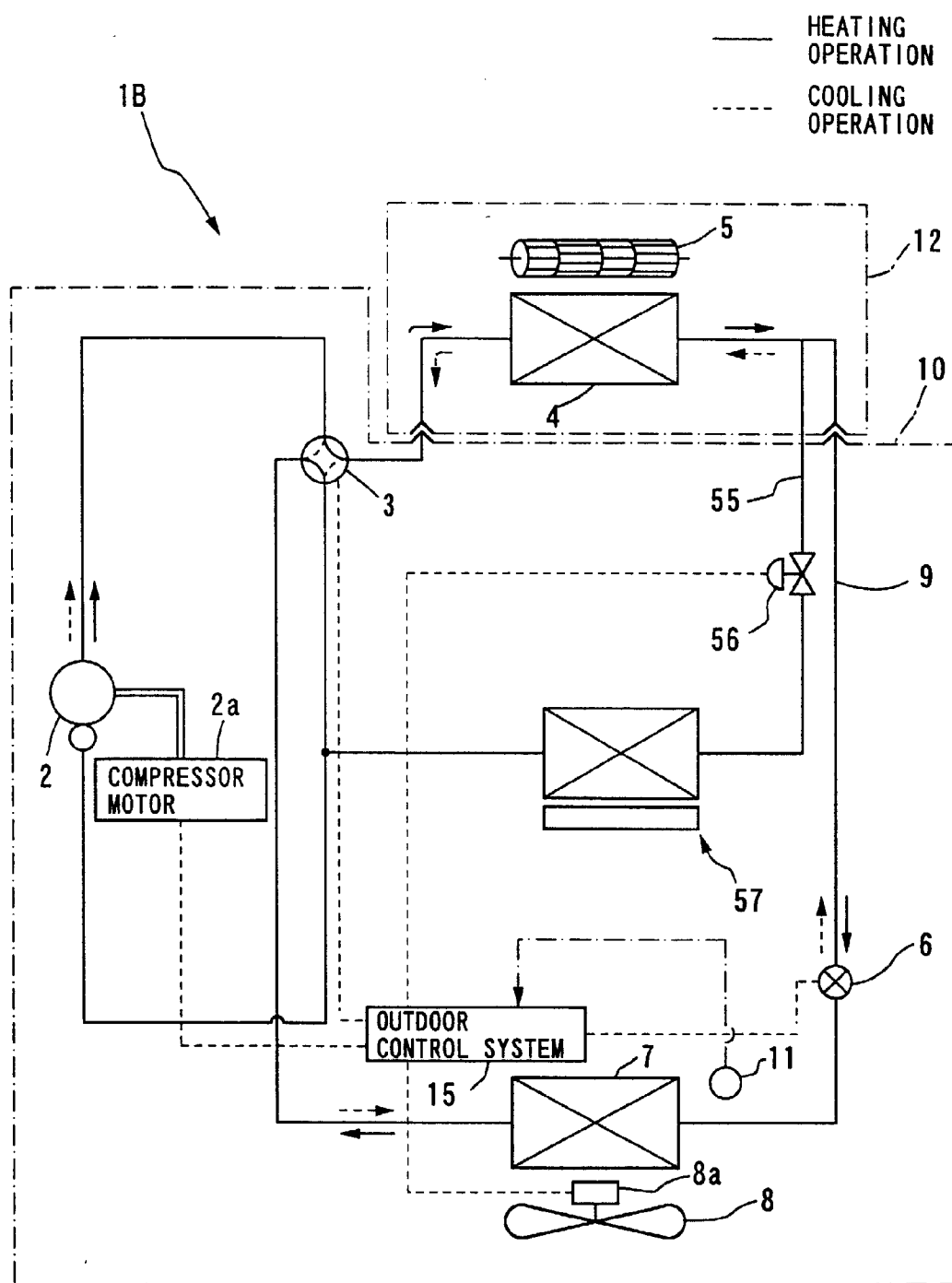


FIG. 6

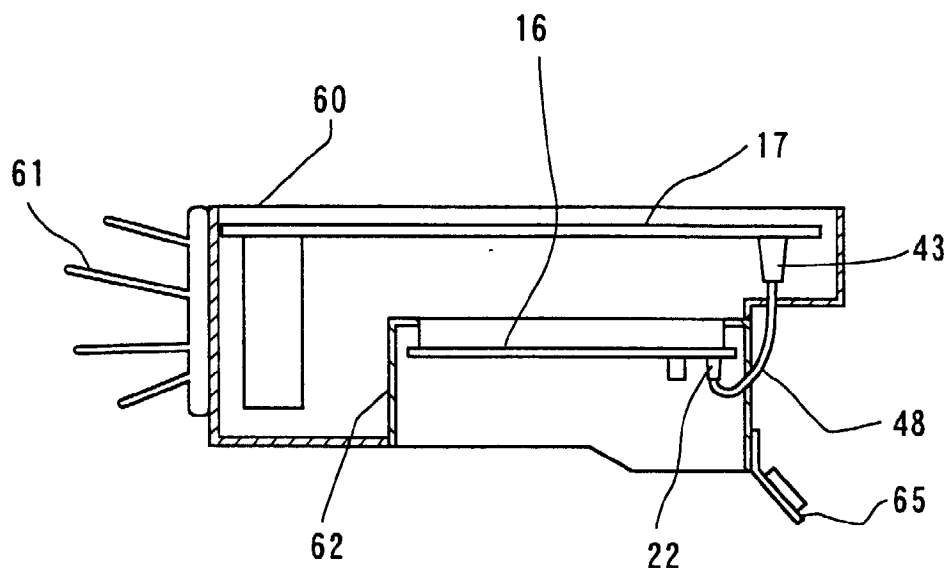


FIG. 7

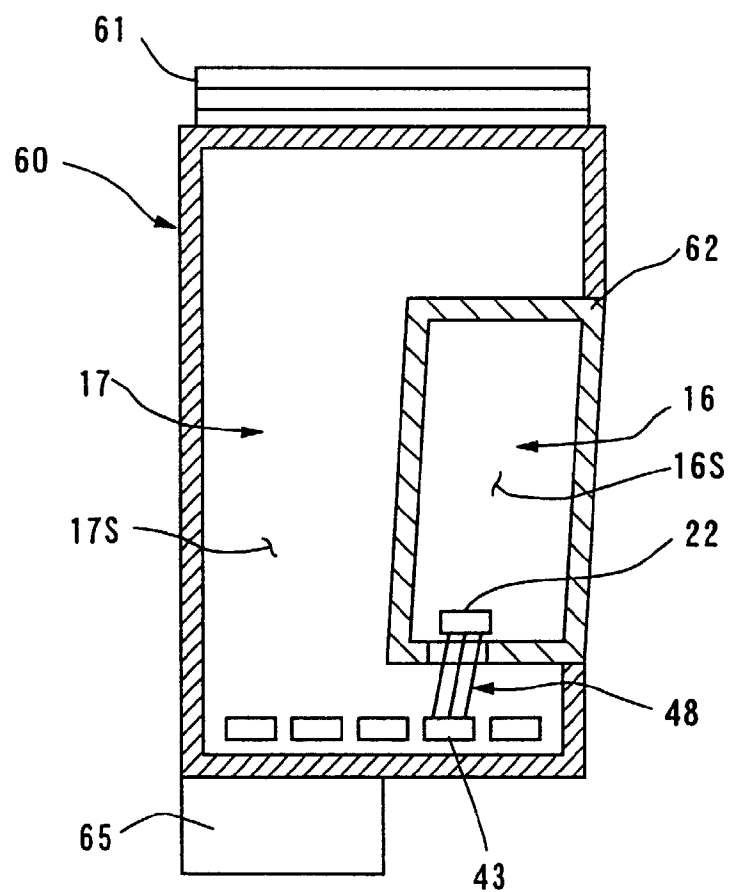


FIG. 8

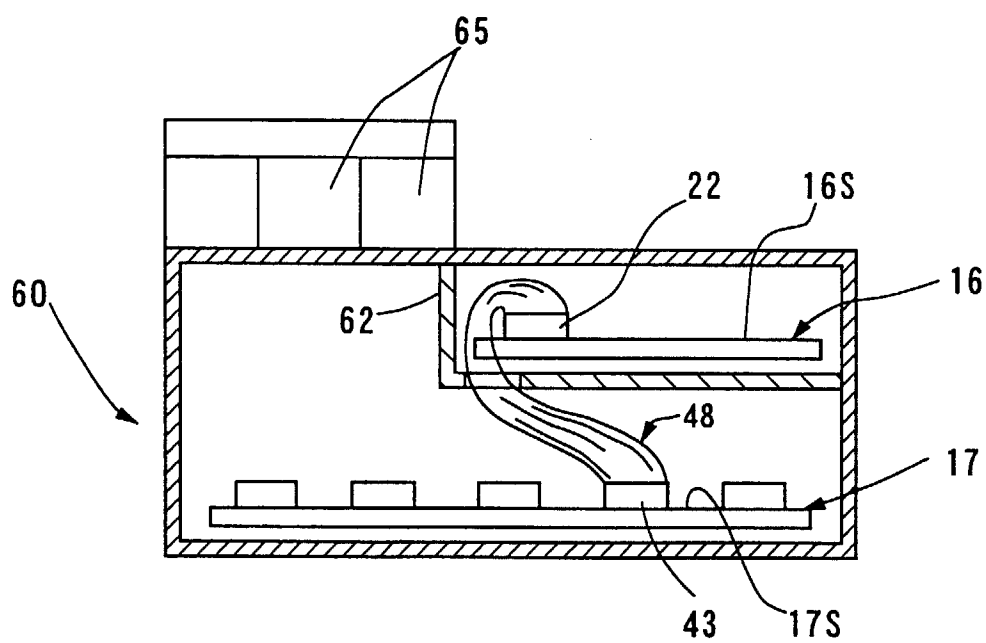


FIG. 9