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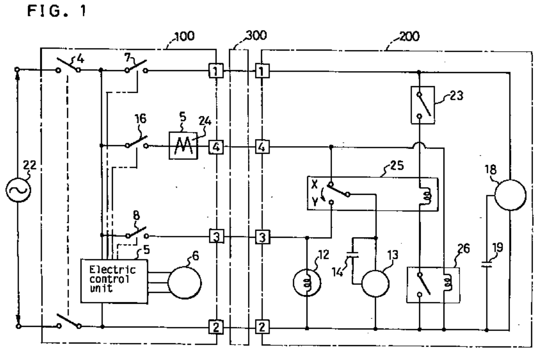
(54) **Split type air conditioner**

(57) The split type air conditioner of the present invention having an indoor unit (100) and an outdoor unit (200) is provided with a mechanical temperature detector (23) in the outdoor unit (200) to detect the frosted condition of an outdoor heat exchanger, and activates the CT (24) in the indoor drive circuit of an outdoor fan motor (13) as receiving means supplied with a frost detection signal delivered from the mechanical temperature detector (23) so as to deliver a de-ice operation start signal on the basis of the information from the CT (24).

FIG. 1



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Description

FIELD OF THE INVENTION AND RELATED ART STATEMENT

1. FIELD OF THE INVENTION

The present invention relates to a split type air conditioner which has an indoor unit and an outdoor unit.

2. DESCRIPTION OF THE RELATED ART

Recently, air conditioners have been used widely in many households. In Japan, such household air conditioners are mostly split type air conditioners used for both cooling and heating. When such a split type air conditioner is used for heating indoor space while outdoor-air temperature is low, de-ice operation control is essential to remove ice from the heat exchanger of the outdoor unit. Accordingly, in such circumstances, conventional split type air conditioners are required to perform de-ice operation control accurately and properly as a major demand or problem in this field.

A conventional split type air conditioner is described below referring to the accompanying drawings. FIG. 4 is a circuit diagram of an electrical configuration of a conventional split type air conditioner capable of performing cooling and heating operation. As shown in FIG. 4, the conventional split type air conditioner comprises an indoor unit 1, an outdoor unit 2 and an indoor-outdoor connection cable 3 for electrically connecting the indoor unit 1 and the outdoor unit 2 with each other.

In the indoor unit 1, one end of a main switch 4 thereof is connected to a power source 22, and the other end of the main switch 4 is connected to an indoor electronic control unit 50. An indoor fan motor 6, such as a transistor motor which is controlled by a transistor circuit, is connected to the indoor electronic control unit 50. A main relay 7 is ON/OFF-controlled by the indoor electronic control unit 50. A heating operation relay 8 shown in FIG. 4 is turned on at the time of heating. A de-ice operation detection circuit 9 is provided to detect de-ice operation.

On the other hand, the outdoor unit 2 is provided with an outdoor electronic control unit 11 to which electric power is supplied from a transformer 17 for the outdoor electronic control unit. A de-ice operation relay 10 and a four-way valve 12 are controlled by the outdoor electronic control unit 11. The four-way valve 12 has a function for selecting the refrigerant passage for a cooling cycle or a heating cycle depending on the cooling or heating operation. The four-way valve 12 is operated by the ON/OFF operation of a four-way valve relay 15 controlled by the outdoor electronic control unit 11. In addition, the outdoor unit 2 is provided with an outdoor fan motor 13, such as an induction motor, and a capacitor 14 for the outdoor fan motor. The outdoor fan motor 13 is driven and controlled by the ON/OFF operation of an outdoor fan motor relay 16 controlled by the outdoor electronic control unit 11. The outdoor unit 2 is also provided with a compressor 18 and a compressor capacitor 19 as shown in FIG. 4. Furthermore, the outdoor unit 2 is provided with a temperature sensor 20 for an outdoor heat exchanger and an outdoor-air temperature sensor 21.

The following is an explanation of the relationships among the components of the conventional split type air conditioner shown in FIG. 4 and the operations of the components.

The one end of the main switch 4 of the indoor unit 1 is connected to the power source 22, and the other end of the main switch 4 is connected to the indoor electronic control unit 50. When the main switch 4 is turned on, electric power is supplied to the indoor electronic control unit 50. The indoor electronic control unit 50 starts control operation and rotates the indoor fan motor 6. By the rotation of the indoor fan motor 6, indoor air passes through an indoor heat exchanger (not shown), thereby starting the circulation of the indoor air. When the user issues an operation start command at this time, the indoor electronic control unit 50 activates the main relay 7 to supply electric power from the power source 22 to the outdoor unit 2. At this time, electric power is supplied from the power source 22 to the compressor 18 to start the rotation of the compressor 18. At the same time, electric power is also supplied from the power source 22 to the outdoor fan motor 13 via the outdoor fan motor relay 16 to start the supply of outdoor air to an outdoor heat exchanger (not shown).

Furthermore, electric power is supplied from the power source 22 to the outdoor electronic control unit 11 via the transformer 17, and the outdoor electronic control unit 11 starts control operation. The four-way valve 12 for refrigerant passage selection is connected so that electric power is supplied to the four-way valve 12 via the heating operation relay 8 and the four-way valve relay 15. When electric power is not supplied from the power source 22 to the four-way valve 12, the refrigerant passes through the passage for the cooling cycle. Accordingly, unless the user designates heating operation and enter a heating operation command, the heating operation relay 8 is maintained in the OFF state by the indoor electronic control unit 50. In this state, the split type air conditioner starts cooling operation.

When the user issues a heating operation command, immediately after the start of the above-mentioned cooling operation, the indoor electronic control unit 50 activates the heating operation relay 8, and electric power is supplied from the power source 22 to the four-way valve 12 via the four-way valve relay 15. The refrigerant passage for the heating cycle is selected by this operation, and heating operation starts. At this time, outdoor air is supplied to the outdoor heat exchanger by the outdoor fan motor 13, and the heat of the outdoor air is transferred to the refrigerant via the outdoor heat exchanger. As a result, the refrigerant evaporates and is gasified. The refrigerant is then supplied to the indoor heat exchanger by the compressor 18.

The temperature sensor 20 detects the temperature of the outdoor heat exchanger at all times, and the outdoor-air temperature sensor 21 also detects outdoor-air temperature at all times. When outdoor-air temperature happens to become relatively high during heating operation, or when the temperature of the outdoor heat exchanger happens to become relatively high, the discharge pressure of the compressor 18 becomes high, thereby causing a overload condition of the compressor 18. To avoid such compressor overload, the outdoor electronic control unit 11 deactivates the outdoor fan motor relay 16, thereby to reduce the heat exchange of the outdoor heat exchanger.

On the other hand, in the heating operation, when outdoor-air temperature is low, ice accretion occurs at the outdoor heat exchanger. To remove ice, de-ice operation is carried out periodically. When the de-ice operation is carried out, the outdoor electronic control unit 11 deactivates the four-way valve relay 15 to set the four-way valve 12 to the cooling cycle side. At the same time, the outdoor electronic control unit 11 activates a de-ice operation detection relay 10 to supply electric power to the de-ice operation detection circuit 9. And the outdoor electronic control unit 11 informs the indoor electronic control unit 50 that the de-ice operation is carried out. The cooling operation is performed during the de-ice operation, and ice is removed by the heating of the outdoor heat exchanger. Furthermore, the indoor electronic control unit 50 performs control operations, such as the control of the entry of cool air to the indoor space, by stopping or decelerating the indoor fan motor 6 for example.

The above-mentioned conventional split type air conditioner requires an outdoor electronic control unit provided in the outdoor unit. Generally speaking, the semiconductor components in electronic control units are more susceptible to heat than other components.

Semiconductors in the outdoor electronic control unit may be heated beyond their allowable temperature limit and may cause thermal runaway when used in the outdoor electronic control unit which is heated by high-temperature outdoor air or direct sunlight during cooling operation. In order to solve this problem, it is essential to take actions such as the addition of heat sinks to the electronic components in the outdoor electronic control unit. As a result, the conventional outdoor electronic control unit has a factor which lowers the serviceability for maintenance because of the increase in component count. Furthermore, the conventional split type air conditioner is provided with electronic control units in both the indoor unit and outdoor unit, resulting in increase in production cost.

Moreover, some conventional split type air conditioners perform de-ice operation control during heating operation by using only the indoor electronic control unit. However, this kind of indoor electronic control unit is required to infer the temperature of the heat exchanger of the outdoor unit from the temperature of the heat exchanger of the indoor unit and the current flowing through the circuit. In addition, when various models are developed, various setting values must be selectively determined for each model, thereby impairing versatility in the de-ice operation control.

OBJECT AND SUMMARY OF THE INVENTION

An object of the present invention is to provide a split type air conditioner which can resist high-temperature and attains highly versatile de-ice operation control and can perform de-ice operation control accurately and properly even during heating operation in cold area where an outside-air temperature is low.

Another object of the present invention is to provide a split type air conditioner having enhanced maintainability by removing the outdoor electronic control unit.

In order to achieve the above-mentioned objects, the split type air conditioner of the present invention having an indoor unit and an outdoor unit comprises:

temperature detection means provided in the outdoor unit to detect a frosted condition of a heat exchanger in the outdoor unit;
receiving means provided in the indoor unit for receiving a frost detection signal delivered from the temperature detection means;
electronic control means which delivers a de-ice operation start signal when the frost detection signal delivered is received continuously for a certain time period by the receiving means;
de-ice control means which performs de-ice operation when the de-ice operation start signal is supplied; and
connecting means for electrically connecting the indoor unit to the outdoor unit.

Furthermore, the split type air conditioner of the present invention having an indoor unit and an outdoor unit comprises:

first temperature detection means provided in the outdoor unit to detect a frosted condition of a heat exchanger in the indoor unit;
second temperature detection means provided in the indoor unit to detect temperature of a heat exchanger in the indoor unit;
receiving means provided in the indoor unit for receiving a frost detection signal delivered from the first temperature detection means;
electronic control means which delivers a de-ice operation start signal when the temperature of the heat exchanger in the outdoor unit is recognized to be not more than a predetermined temperature by determination means and a table search when a frost detection signal delivered from the first temperature detection means is continuously supplied for a certain time period to the receiving means and when a temperature detection signal detected by

the second temperature detection means is supplied to the receiving means;

de-ice control means which performs de-ice operation when the de-ice operation start signal is supplied; and

connecting means for electrically connecting the indoor unit to the outdoor unit.

By the above-mentioned structure of the present invention, the temperature detection means provided in the outdoor heat exchanger of the outdoor unit detects the frosted condition of the outdoor heat exchanger and transmits the frosted condition of the outdoor heat exchanger to the electronic control unit provided in the indoor unit. The electronic control unit then issues a de-ice operation command. Therefore, the split type air conditioner of the present invention can properly perform de-ice operation control without providing an electronic control unit in the outdoor unit. Consequently, the de-ice operation control unit can be made at lower cost and can have enhanced maintainability. Additionally, the split type air conditioner of the present invention can attain de-ice operation control superior in accuracy and versatility, since the frosted/defrosted conditions of the outdoor heat exchanger are directly detected by the measurement of the temperature of the outdoor heat exchanger.

While the novel features of the invention are set forth particularly in the appended claims, the invention, both as to organization and content, will be better understood and appreciated, along with other objects and features thereof, from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of an electric configuration of an embodiment of a split type air conditioner capable of cooling and heating in accordance with the present invention;

FIG. 2 is a flowchart showing control performed at the start of de-ice operation in accordance with the present invention;

FIG. 3 is a flowchart showing control performed at the end of de-ice operation in accordance with the present invention; and

FIG. 4 is the circuit diagram of the electric configuration of the conventional split type air conditioner capable of cooling and heating.

It will be recognized that some or all of the Figures are schematic representations for purposes of illustration and do not necessarily depict the actual relative sizes or locations of the elements shown.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the split type air conditioner of the present invention is explained below referring to FIGs. 1 to 3.

FIG. 1 is a circuit diagram of an electric configuration of this embodiment of the split type air conditioner capable of cooling and heating. FIG. 2 is a flowchart showing control performed at the start of de-ice operation of this embodiment. FIG. 3 is a flowchart showing control performed at the end of de-ice operation of this embodiment.

As shown in FIG. 1, the split type air conditioner comprises an indoor unit 100, an outdoor unit 200 and an indoor-outdoor connection cable 300 for electrically connecting the indoor unit 100 and outdoor unit 200 with each other.

In the indoor unit 100, one end of a main switch 4 is connected to a power source 22, and the other end of the main switch 4 is connected to an electronic control unit 5. An indoor fan motor 6, such as a transistor motor which is controlled by a transistor circuit, is connected to the electronic control unit 5. A main relay 7, a heating operation relay 8 and an outdoor fan motor relay 16 are ON/OFF-controlled by the electronic control unit 5. The heating operation relay 8 is turned on in heating operation mode.

On the other hand, the outdoor unit 200 is not provided with an electronic control unit. As mentioned above, only the indoor unit 100 is provided with the electronic control unit 5. A four-way valve 12 is ON/OFF-controlled by the heating operation relay 8. The four-way valve 12 has a function for selecting the refrigerant passage for a cooling cycle or a heating cycle depending on the cooling or heating operation.

In addition, the outdoor unit 200 is provided with an outdoor fan motor 13, such as an induction motor, and a capacitor 14 for the outdoor fan motor. The outdoor fan motor 13 is connected to an outdoor fan motor selector 25 which drives and controls the outdoor fan motor 13. A connection terminal X of the outdoor fan motor selector 25 is connected to the outdoor fan motor relay 16, such as a solid-state relay (SSR), via a CT (current transformer) 24. The connection terminal Y of the outdoor fan motor selector 25 is connected to the heating operation relay 8 for ON/OFF-controlling the four-way valve 12.

As shown in FIG. 1, the outdoor unit 200 is provided with a compressor 18, and a known compressor capacitor 19 is connected to the compressor 18. Furthermore, the outdoor unit 200 is provided with a mechanical temperature detector 23 used as a temperature sensor for an outdoor heat exchanger (not shown). The mechanical temperature detector 23 provided to the outdoor heat exchanger comprises a bimetal or the like to detect change of temperature of the outdoor heat exchanger. As a result, the frosted/defrosted conditions of the outdoor heat exchanger is detected by the mechanical temperature detector 23. The ON and OFF operation temperatures, at which the mechanical temperature detector 23 is activated, are set in consideration of the growth rate of frost and the degree of defrosting at the outdoor heat exchanger, and the thermal response and variations in various factors of the mechanical temperature detector 23. In the mechanical temperature detector 23 of this embodiment, the ON operation temperature is set at -3°C, and the OFF operation temperature is set at 4°C.

The following is an explanation of the relationships among the components of the split type air conditioner of this embodiment and the operations of the components. Although the split type air conditioner of this embodiment is used for both cooling and heating, the operations of the components during cooling operation are not described, since the cooling operation are not directly related to the operations in accordance with the present invention.

The indoor unit 100 is connected to the power source 22. When the main switch 4 is turned on, electric power is supplied to the electronic control unit 5. The electronic control unit 5 then starts control operation and rotates the indoor fan motor 6. By the rotation of the indoor fan motor 6, indoor air passes through an indoor heat exchanger (not shown) and circulates in the indoor space.

When the user issues a heating operation start command in the above-mentioned condition, the electronic control unit 5 turns on the main relay 7, thereby supplying electric power from the power source 22 to the outdoor unit 200. At the same time, electric power is supplied to the compressor 18, and the compressor 18 starts to rotate. And, electric power is also supplied from the power source 22 to the outdoor fan motor 13 via the outdoor fan motor relay 16, such as a solid-state relay (SSR), so as to start the supply of outdoor air to the outdoor heat exchanger. Furthermore, the outdoor fan motor relay 16 is turned on, whereby an outdoor fan control relay 26 is turned on. Additionally, at the same time, the electronic control unit 5 turns on the heating operation relay 8, so as to turn on the four-way valve 12. As a result, the refrigerant passage for the heating cycle is selected and heating operation starts.

The CT 24 provided in the electronic control unit 5 functions as receiving means for detection signal of the mechanical temperature detector 23. During usual heating operation, the CT 24 recognizes a certain current value. In these circumstances, when the temperature of the outdoor heat exchanger becomes less than -3°C, the mechanical temperature detector 23 is turned on, and the connection of the outdoor fan motor selector 25 is switched from the connection terminal X to the connection terminal Y. As a result, electric power supplied to the outdoor fan motor 13 through the connection terminal X of the outdoor fan motor selector 25 is supplied from the connection terminal Y connected to the heating operation relay 8. Consequently, no current flows through the circuit of the connection terminal X of the outdoor fan motor selector 25, and the current value at the CT 24 changes from the certain value to almost 0. By detecting this change in the current flowing through the CT 24, the electronic control unit 5 recognizes that the mechanical temperature detector 23 is activated. A de-ice operation start command is then issued in accordance with a flowchart shown in FIG. 2. FIG. 2 is the flowchart showing control performed at the start of the de-ice operation in accordance with this embodiment.

Referring to FIG. 2, the mechanical temperature detector 23 is turned on first, and the value of the current flowing through the CT 24 provided in the electronic control unit 5 is reduced to almost 0 (step 101). A determination means of the electronic control unit 5 confirms that the relay 16 is in the ON state (step 102). A timer is used to confirm that the no-current time at the CT 24 has continued for a certain time period (such as 50 seconds) or more (step 103). In other words, the electronic control unit 5 delivers a de-ice operation start signal when a frost detection signal of the mechanical temperature detector 23 is received continuously for a certain time period by the CT 24. Furthermore, the determination means selects a de-ice operation prohibition period depending on the present count number N of de-ice operations stored in a counter of the electronic control unit 5 (step 104). When the count number N of de-ice operations is 0, the determination means determines whether the operation time after the end of the last de-ice operation is not less than a de-ice operation prohibition period (such as 30 minutes) or not. When the operation time is not less than 30 minutes, the count number N of de-ice operations is incremented by 1 (step 107), and the timer is turned on to compute the de-ice operation time period (step 108).

On the other hand, when the count number N of de-ice operations is judged to be 1 or more at step 104, the determination means determines whether the operation time period after the end of the last de-ice operation is not less than another de-ice operation prohibition period (such as 60 minutes) (step 105). When the operation time period is not less than 60 minutes, the present count number N of de-ice operations is incremented by 1 (step 107), and the timer is turned on to compute the de-ice operation time period (step 108).

When the no-current time at the CT 24 continues for a certain time period and the operation time period exceeds a predetermined de-ice operation prohibition period, the determination means increments the number of de-ice operations stored in the counter. The determination means then delivers the de-ice operation start signal to activate the timer so as to compute the de-ice operation time period as described above.

When the de-ice operation start signal is delivered, the electronic control unit 5 turns off the heating operation relay 8, whereby the four-way valve 12 and the outdoor fan motor 13 are turned off. When the four-way valve 12 and the outdoor fan motor 13 are turned off in this way, the de-ice operation starts. By this de-ice operation, the refrigerant passes through the passage for the cooling cycle, and the cooling operation is carried out.

Hereafter, the de-ice operation is performed continuously, and the ice in the outdoor heat exchanger melts. When the temperature of the mechanical temperature detector 23 rises to 4°C, the mechanical temperature detector 23 is turned off, and electric power is supplied again to the outdoor fan motor 13 from the connection terminal X of the outdoor fan motor selector 25. Therefore, the outdoor fan motor 13 is activated again, and current flows through the CT 24. As a result, the electronic control unit 5 recognizes that the mechanical temperature detector 23 has been turned off. A de-ice operation end command is then issued in accordance with a flowchart shown in FIG. 3. FIG. 3 is the flowchart showing control at the end of the de-ice operation in accordance with this embodiment.

Referring to FIG. 3, the mechanical temperature detector 23 is turned off first, and the value of the current flowing through the CT 24 is changed from almost 0 to a certain value. The determination means then turns off the outdoor fan motor relay 16 once (step 202). After this, the determination means stops the outdoor fan motor 13 again. Next, the determination means computes a de-ice time period t from the start of the de-ice operation to the change to the OFF state of the mechanical temperature detector 23 (that is, the OFF state means that the current value of the CT 24 becomes larger than 0 and reaches a predetermined value) by using a computing means and the timer, which are provided in the electronic control unit 5. In other words, the determination means computes the de-ice time period t from the time when the current value of the CT 24 is almost 0 to the time when the current value of the CT 24 becomes larger than 0. It is noted that in this embodiment the start of the de-ice operation corresponds to the time when the mechanical temperature detector 23 is turned on.

The electronic control unit 5 determines a de-ice operation time period corresponding to the computed de-ice time period t according to the table, and the de-ice operation is continued for the de-ice operation time period. When the de-ice time period t is less than 1 minute in this embodiment, the de-ice operation is forcibly carried out for 1 minute. When the de-ice time period t is in the range of 1 minute or more and less than 3 minutes, the de-ice operation is stopped. When the de-ice time period t is in the range of 3 minutes or more and less than 6 minutes, the de-ice operation is continued for 1 minute and then stopped. When the de-ice time period t is in the range of 6 minutes or more and less than 9 minutes, the de-ice operation is continued for 2 minute and then stopped. When the de-ice time period t is 9 minutes or more, the de-ice operation is continued for 3 minute and then stopped.

As described above, the electronic control unit 5 issues a de-ice operation stop command after a predetermined de-ice operation time period has passed, and the de-ice operation stops. Therefore, the total de-ice operation time period is defined as a period from the start of the de-ice operation to the time when the mechanical temperature detector 23 is turned off plus a de-ice operation continuation time determined according to the table depending on the period of the de-ice time. However, to prevent the generation of unusual noise at the selection time of the four-way valve 12, the de-ice operation is carried out forcibly at least 1 minute, regardless of the time from the start of the de-ice operation to the time when the mechanical temperature detector 23 is turned off. In this embodiment, the maximum total de-ice operation time period is set at 12 minutes.

As shown in FIG. 1, the outdoor fan control relay 26, which is controlled by the outdoor fan motor relay 16, performs outdoor fan control to prevent the pressure of the compressor 18 from rising high, regardless of the ON or OFF state of the mechanical temperature detector 23.

When the mechanical temperature detector 23 is in the OFF state, the outdoor fan motor 13 is ON/OFF-controlled by the ON/OFF operation of the outdoor fan motor relay 16.

On the other hand, when the mechanical temperature detector 23 is turned on the outdoor fan control relay 26 is activated by turning off of the outdoor fan motor relay 16. And the connection of the outdoor fan motor selector 25 is shifted from the connection terminal Y to the connection terminal X. Therefore, the outdoor fan motor 13 is in a condition that electric power can be supplied again from the connection terminal X of the outdoor fan motor selector 25. However, since the outdoor fan motor relay 16 is in the OFF state, the outdoor fan motor 13 is in the OFF state.

Furthermore, when the mechanical temperature detector 23 is in the ON state, the connection of the outdoor fan motor selector 25 is shifted from the connection terminal X to the connection terminal Y by turning on the outdoor fan motor relay 16. Therefore, electric power is supplied from the power source 22 to the outdoor fan motor 13 via the heating operation relay 8.

Consequently, the outdoor fan can be controlled by the outdoor fan motor relay 16 regardless of the ON or OFF state of the mechanical temperature detector 23.

The above-mentioned embodiment of the split type air conditioner is further provided with an indoor temperature detector (not shown) for detecting the temperature of the heat exchanger in the indoor unit 100. When the indoor temperature detector detects a temperature higher than a predetermined value at the indoor heat exchanger, the indoor temperature detector transmits the detection information to the electronic control unit 5. The temperature information of the indoor heat exchanger has been included as one of the de-ice operation start conditions stored in the electronic control unit 5. When the temperature of the indoor heat exchanger reaches a predetermined value or higher, the de-ice operation start command is issued. The de-ice operation start time can thus be selected more appropriately by providing such indoor temperature detection means and by including the temperature condition at the indoor heat exchanger in the de-ice operation start conditions as described above.

In case that frost is generated in the outdoor unit 200 of the split type air conditioner, the growth rate of the frost differs depending on whether the frost grows in a low outdoor-air temperature condition because the temperature of the outdoor heat exchanger is lowered by low outdoor-air temperature or the frost grows in a relatively high outdoor-air temperature condition because the pressure of the compressor is lowered when the outdoor fan is stopped to prevent the compressor pressure from rising high. In the latter case, the frost gradually grows because the pressure of the compressor is lowered when the outdoor fan is stopped in a relatively high outdoor-air temperature condition wherein the outdoor fan is ON/OFF-controlled to prevent the pressure of the compressor from rising high. Therefore, a so-called normal heating operation time period between a de-ice operation and the next of the de-ice operation can be made longer in the latter case than in the former case. For this reason, in the latter case, the de-ice operation start time can be delayed so that the deviation of the indoor air-conditioning temperature from a setting temperature is as less as possible.

As described above, in the split type air conditioner of this embodiment, the indoor temperature detector provided for the indoor heat exchanger detects the high-pressure condition of the indoor heat exchanger by measuring the temperature and sends the temperature information to the electronic control unit 5. The electronic control unit 5 has recognized in advance of the relationship between the high pressure at the indoor heat exchanger 5 and the low pressure at the outdoor heat exchanger. Therefore, the electronic control unit 5 recognizes the high-pressure condition of the indoor heat exchanger according to the temperature information and estimates the low-pressure condition of the outdoor heat exchanger. The electronic control unit 5 issues a de-ice operation start command when the electronic control unit 5 recognizes a low pressure value not more than a predetermined value wherein the de-ice operation is necessary for the outdoor heat exchanger. In this way, in the split type air conditioner of this embodiment, the grow rate of frost in the outdoor unit 200 is estimated by using the temperature information from the indoor heat exchanger, and the temperature information from the indoor heat exchanger has been included as a condition of the de-ice operation start command conditions. Accordingly, it is possible to accurately determine the de-ice operation start time. Consequently, in the split type air conditioner of this embodiment, the deviation of the indoor temperature from a setting temperature is minimized by extending the heating operation time as long as possible and by delaying the de-ice operation start time.

In addition, when the total de-ice operation time period is determined, the de-ice operation control is carried out in accordance with a memory table including informations on the amount of flow at the indoor fan, and the time period from the start of the de-ice operation to the start of the turning-off operation of the mechanical temperature detector 23. Accordingly, the de-ice operation of this embodiment can be performed at more appropriate times.

According to the present invention, no electronic control unit including the semiconductor devices is provided in the outdoor unit 200 of the split type air conditioner of the present invention. Therefore, the de-ice operation control unit can be made more high temperature resistive at lower cost and have enhanced serviceability or maintainability. In addition, the frosted/defrosted conditions of the outdoor heat exchanger are directly detected by measuring the temperature of the outdoor heat exchanger. Therefore, the determination of setting temperatures and other values are not required in designing various models. Consequently, the split type air conditioner of this embodiment can have high versatility.

In the split type air conditioner in accordance with the present invention, the mechanical temperature detection means, namely the mechanical temperature detector provided in the heat exchanger of the outdoor unit, detects the frost condition at the heat exchanger of the outdoor unit. The detection means transmits the information on the frost condition to the electronic control unit provided in the indoor unit by using the drive power source circuit for the outdoor fan motor. The electronic control means, namely the electronic control unit of the indoor unit, computes a de-ice operation time period depending on the transmitted information on the frost condition at the heat exchanger of the outdoor unit, and issues a de-ice operation start command. Since the split type air conditioner of the present invention is structured as described above, the split type air conditioner can perform de-ice control properly stably and reliably by means of the electronic control means including delicate semiconductor devices in the indoor unit.

In the split type air conditioner of the present invention, the mechanical temperature detection means provided in the indoor heat exchanger detects a high-pressure state of the compressor by measuring its temperature and recognizes a low-pressure condition of the outdoor heat exchanger depending on the temperature. When the outdoor heat exchanger of the split type air conditioner of the present invention detects a low pressure not more than a certain predetermined value wherein the de-ice operation is necessary for the outdoor heat exchanger, the split type air conditioner starts the de-ice operation. As a result, the de-ice operation start time can be determined accurately. Consequently, in the split type air conditioner of the present invention, the deviation of the indoor temperature from a setting temperature can be minimized by extending the heating operation time as long as possible and by delaying the start of the de-ice operation.

In the split type air conditioner of the present invention, the same four-conductor cables as that for the conventional split type air conditioner can be used as the indoor-outdoor connection cable for the de-ice operation control. Additionally, in the split type air conditioner of the present invention, the outdoor fan can be controlled so as to prevent the compressor pressure from rising high even when the mechanical temperature detection means provided in the outdoor heat exchanger has been activated. In other words, the cost reduction by eliminating delicate and expensive electronic control means in the outdoor unit, and the suitable control in conformity with the performances of the air conditioner can be attained without changing number of conventional four-conductor indoor-outdoor connection cables.

The electronic control unit of the split type air conditioner of the present invention is set previously in consideration of the thermal response and variations in various factors of the detection means. Therefore, the electronic control unit accurately detects such condition that the de-ice operation is necessary, and the electronic control unit also detects such condition that the stop of the de-ice operation is necessary. Accordingly, the split type air conditioner is structured to perform the de-ice operation properly.

The split type air conditioner of the present invention estimates the amount of frost generated at the heat exchanger of the outdoor unit on the basis of the time from the output of a frost detection signal to the output of a de-ice operation end signal from the mechanical temperature detection means provided in the outdoor unit. The split type air conditioner then adds such a correction time that which varies depending on the period, to the period from the start of the de-ice operation to the input of the de-ice operation end signal. As a result, the de-ice time period can have a proper value. Furthermore, the split type air conditioner also corrects the thermal response and variations in various factors of the mechanical temperature detection means. Consequently, the split type air conditioner of the present invention can perform highly accurate de-ice operation control even when the outdoor-air temperature is low.

There is a possibility that the amount of frost is small in the outdoor unit of the split type air conditioner of the present invention, and this eventually shortens the period between the output of the frost detection signal and the output of the de-ice operation end signal from the mechanical temperature detection means provided in the outdoor unit. In such case, if the four-way valve is configured to be switched immediately in the above-mentioned condition, large unusual noise may be generated at the time of the switching. To solve this problem, the de-ice time period in the split type air conditioner of the present invention is forcibly determined to have a predetermined value when the period from the output of the frost detection signal to the output of the de-ice operation end signal is not more than a predetermined value. In this way, the generation of such unusual noise is minimized at the time of the switching of the four-way valve.

Even in the conventional de-ice operation control, a de-ice operation prohibition period is provided to specify the time period from the end of a de-ice operation to the start of the next de-ice operation so that the de-ice operation is forcibly disabled for a predetermined time period. This de-ice operation prohibition period is constant regardless of the number of de-ice operations. However, The temperature of the outdoor heat exchanger at the end of the de-ice operation has a relatively high value wherein frost is relatively hard to grow. Therefore, the de-ice operation prohibition period after repetition of several de-ice operations should be made longer than the prohibition period at the start of air conditioner operation. Generally speaking, the time period from the end of a de-ice operation to the start of the next de-ice operation after repetition of several de-ice operations has been is longer than the time period from the start of air conditioner operation to the start of the first de-ice operation. Besides, the growth of frost is delayed after the de-ice operation has been conducted several times. For these reasons, in the split type air conditioner of the present invention, the number of de-ice operations from the start of air conditioner operation is counted so as to properly control the de-ice operation prohibition period.

In the split type air conditioner of the present invention, the counter provided in the outdoor unit computes the number of de-ice operations from the start of air conditioner operation. The number of de-ice operations is reset only when the electronic control unit used as receiving means to be supplied with operation start/stop signals is supplied with a stop signal. However, the number is not reset at the time of the selection of heating/cooling operation modes. Accordingly, the split type air conditioner in accordance with this invention resets the number of de-ice operations at appropriate timing. The number of de-ice operations is not reset at the time of the selection of heating/cooling operation modes because of the following reasons. The temperature of the outdoor heat exchanger has become a relatively high temperature as a matter of course at the time when the heating operation mode is switched to the cooling operation mode. If the number of de-ice operations is reset at the time of operation mode selection, the correction of the de-ice operation prohibition period becomes almost meaningless, and the heating operation time becomes short. This results in increase in the deviation of the indoor temperature from a setting temperature.

In the split type air conditioner of the present invention, the CT of the indoor fan drive circuit, the timer and the computing means provided in the indoor unit are used to compute the amount of flow at the indoor fan until up to the start of a de-ice operation. Furthermore, the determination means and the table are used to determine a de-ice operation time period. When the amount of flow at the indoor fan is changed, the amount of frost generated at the outdoor heat exchanger is also changed. Therefore, the split type air conditioner of the present invention corrects the de-ice operation time period depending on the amount of flow at the indoor fan, so as to appropriately set the de-ice operation time period. Thereby the heating operation time period is extended as long as possible. Moreover, the split type air conditioner of the present invention directly detects the temperature of the outdoor heat exchanger by using the mechanical temperature deteriorate means so as to carry out highly accurate de-ice operation control.

In the split type air conditioner of the present invention, the relay used as the operation detection means for the outdoor fan and provided in the indoor unit detects the operation condition of the outdoor fan. When the determination means confirms that the outdoor fan is in the OFF state, the frost detection signal from the mechanical temperature detection means provided in the outdoor unit is ignored so as to disable the de-ice operation control. This operation is adopted so as to extend the heating operation time period as long as possible in consideration of the case wherein outdoor fan control has been performed to prevent the compressor pressure from rising high. When the outdoor fan is controlled, the split type air conditioner of the present invention ignores the frost detection signal from the mechanical temperature detection means so as to appropriately set the start time of the de-ice operation.

Although the present invention has been described in terms of the presently preferred embodiments, it is to be understood that such disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the art to which the present invention pertains, after having read the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

Claims

1. A split type air conditioner having an indoor unit (100) and an outdoor unit (200), comprising:

temperature detection means (23) provided in said outdoor unit (200) to detect a frosted condition of a heat exchanger in said outdoor unit;
receiving means (24) provided in said indoor unit (100) for receiving a frost detection signal delivered from said temperature detection means (23);
electronic control means (5) which delivers a de-ice operation start signal when said frost detection signal is received continuously for a certain time period by said receiving means;
de-ice control means (8, 12) which performs de-ice operation when said de-ice operation start signal is supplied; and
connecting means (300) for electrically connecting said indoor unit to said outdoor unit.

2. A split type air conditioner having an indoor unit (100) and an outdoor unit (200), comprising:

first temperature detection means (23) provided in said outdoor unit (200) to detect a frosted condition of a heat exchanger in said outdoor unit;
second temperature detection means provided in said indoor unit to detect temperature of a heat exchanger in said indoor unit;
receiving means (24) provided in said indoor unit (100) for receiving a frost detection signal delivered from said first temperature detection means (23);
electronic control means (5) which delivers a de-ice operation start signal when the temperature of said heat exchanger in said outdoor unit is recognized to be not more than a predetermined temperature by determination means and a table search when a frost detection signal delivered from said first temperature detection means Is continuously supplied for a certain time period to said receiving means and when a temperature detection signal detected by said second temperature detection means is supplied to said receiving means;
de-ice control means (8, 12) which performs de-ice operation when said de-ice operation start signal is supplied; and
connecting means (300) for electrically connecting said indoor unit to said outdoor unit.

3. A split type air conditioner in accordance with claim 1, wherein said connecting means comprises

a first connection wire for connecting a circuit of said temperature detection means (23) provided in said outdoor unit (200) to the power source of said indoor unit (100);
a second connection wire for connecting circuits of said temperature detection means (23), an outdoor fan motor (13) and a four-way valve (12) of said outdoor unit (200) to said power source of said indoor unit (100);
a third connection wire for connecting said four-way valve circuit (12) and one of the connection terminals of an outdoor fan motor selection means (25) to said power source of said indoor unit (100); and
a fourth connection wire for connecting said outdoor fan motor circuit to said power source of said indoor unit (100) via the other connection terminal of said outdoor fan motor selection means (25).

4. A split type air conditioner in accordance with claim 1, wherein said temperature detection means (23) comprises a temperature-activated switch which is set to operate in a 0°C or below temperature range at one switch position and to operate in an above

0°C temperature range at the other switch position so as to detect the frosted/defrosted conditions of said heat exchanger in said outdoor unit.

5. A split type air conditioner in accordance with claim 1, wherein said temperature detection means (23) provided in said outdoor unit (200) detects the de-ice operation end condition of said heat exchanger in said outdoor unit, said receiving means receives a de-ice operation end detection signal delivered from said temperature detection means (23) as an input signal, said electronic control means computes the period from the delivery of said de-ice operation start signal to the reception of said input signal by using computing means on the basis of said input signal of said receiving means, and said electronic control means determines a de-ice operation time period after the reception of said input signal by using determination means and a table search.

6. A split type air conditioner in accordance with claim 1, wherein a de-ice operation time period is forcibly determined when the period from the start of de-ice operation to the reception of said de-ice operation end signal is recognized to be not more than a predetermined value by said receiving means (24) and a timer provided in said indoor unit (100).

7. A split type air conditioner in accordance with claim 1, wherein said electronic control means computes the number of de-ice operations from the start of air conditioner operation by using a counter (not shown) provided in said indoor unit (100), supplies the number of de-ice operations to a memory circuit, and determines a de-ice operation prohibition time depending on the number of de-ice operations by using determination means and a table search.

8. A split type air conditioner in accordance with claim 1, wherein said electronic control means (5) computes the number of de-ice operations from the start of air conditioner operation by using a counter provided in said indoor unit (100), the number of de-ice operations supplied to a memory circuit is reset only when said receiving means to be supplied with start/stop signals is supplied with said stop signal, but not reset at the time of the selection of operation modes.

9. A split type air conditioner in accordance with claim 1, wherein said electronic control means computes the amount of flow at an indoor fan until up to the start of a de-ice operation by using indoor fan operation voltage detection means, a timer and computing means provided in the indoor unit (100), and determine a de-ice operation time period by using determination means and a table search.

10. A split type air conditioner in accordance with claim 1, wherein said electronic control means detects the operation condition of an outdoor fan by using outdoor fan operation detection means provided in said indoor unit (100), and when determination means confirms that said outdoor fan is in the OFF state, said electronic control means does not respond to said frost detection signal so as to disable de-ice operation control.

FIG. 1

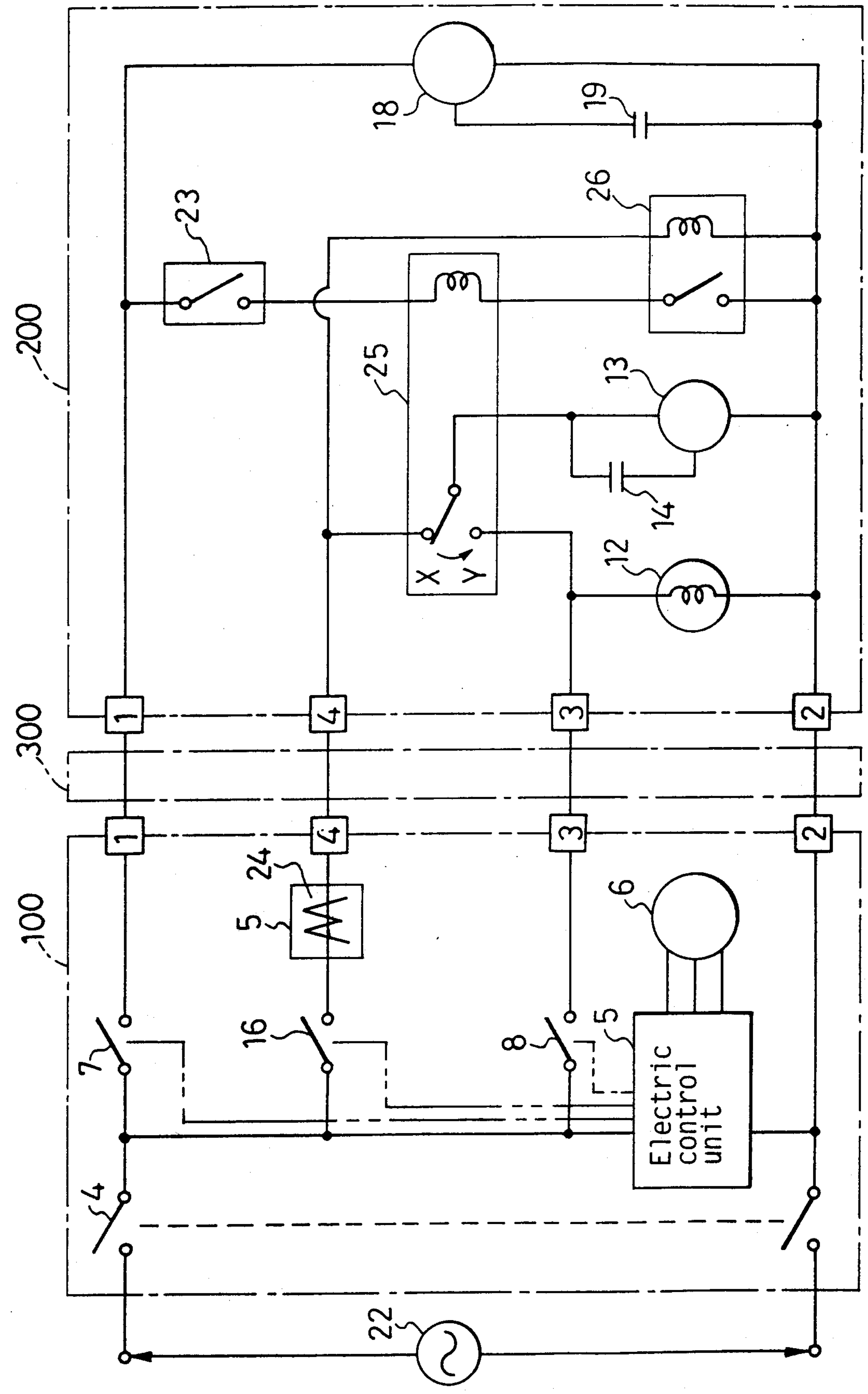
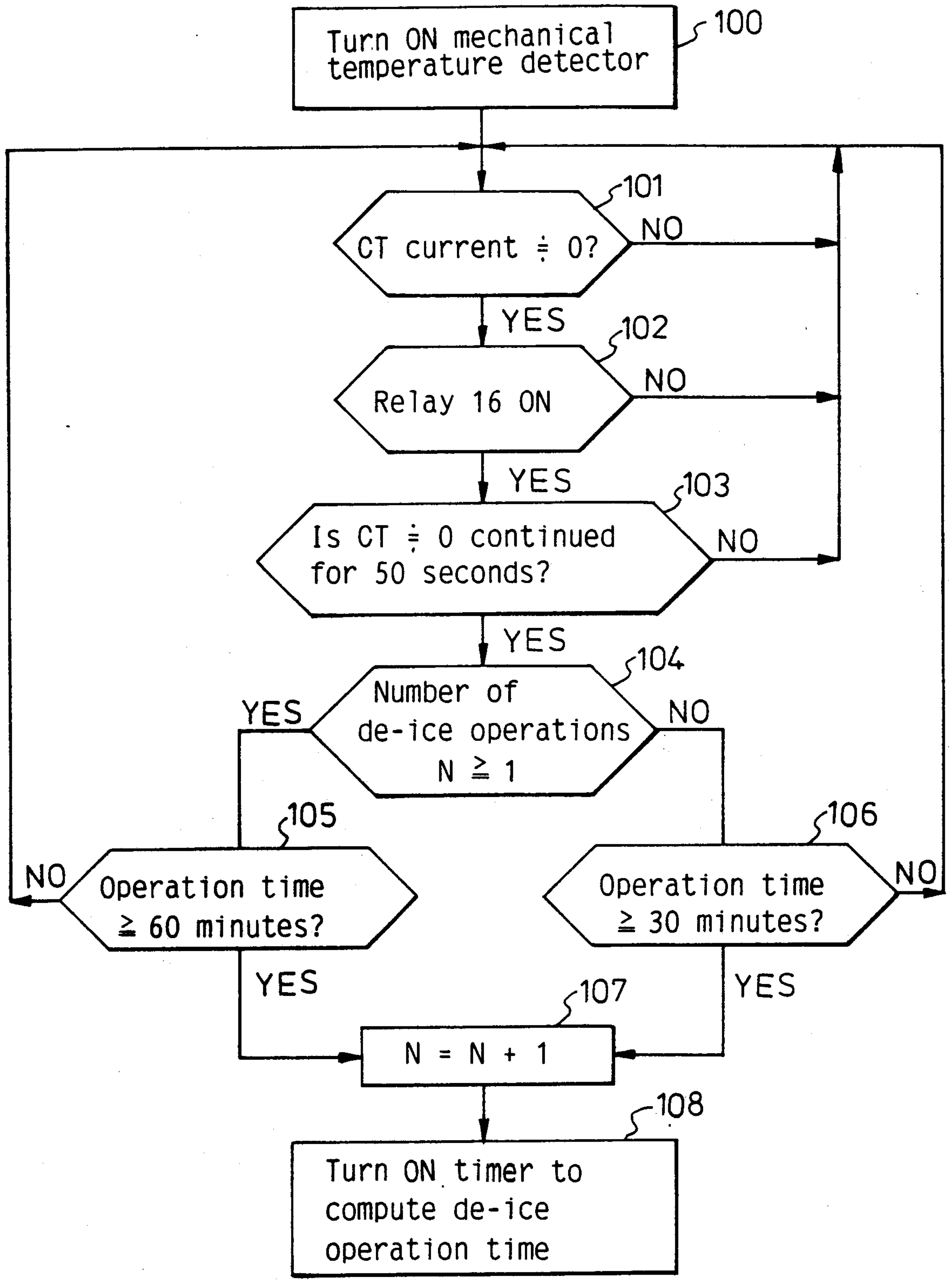

200
300
100
Electric control unit
X
Y
1
2
3
4
4
5
5
6
7
8
12
13
14
16
18
19
22
23
24
25
26

FIG. 2



Turn ON mechanical temperature detector
100
CT current ≑ 0?
101
NO
YES
Relay 16 ON
102
NO
YES
Is CT ≑ 0 continued for 50 seconds?
103
NO
YES
Number of de-ice operations N ≧ 1
104
YES
NO
Operation time ≧ 60 minutes?
105
NO
Operation time ≧ 30 minutes?
106
NO
YES
YES
N = N + 1
107
Turn ON timer to compute de-ice operation time
108

FIG. 3

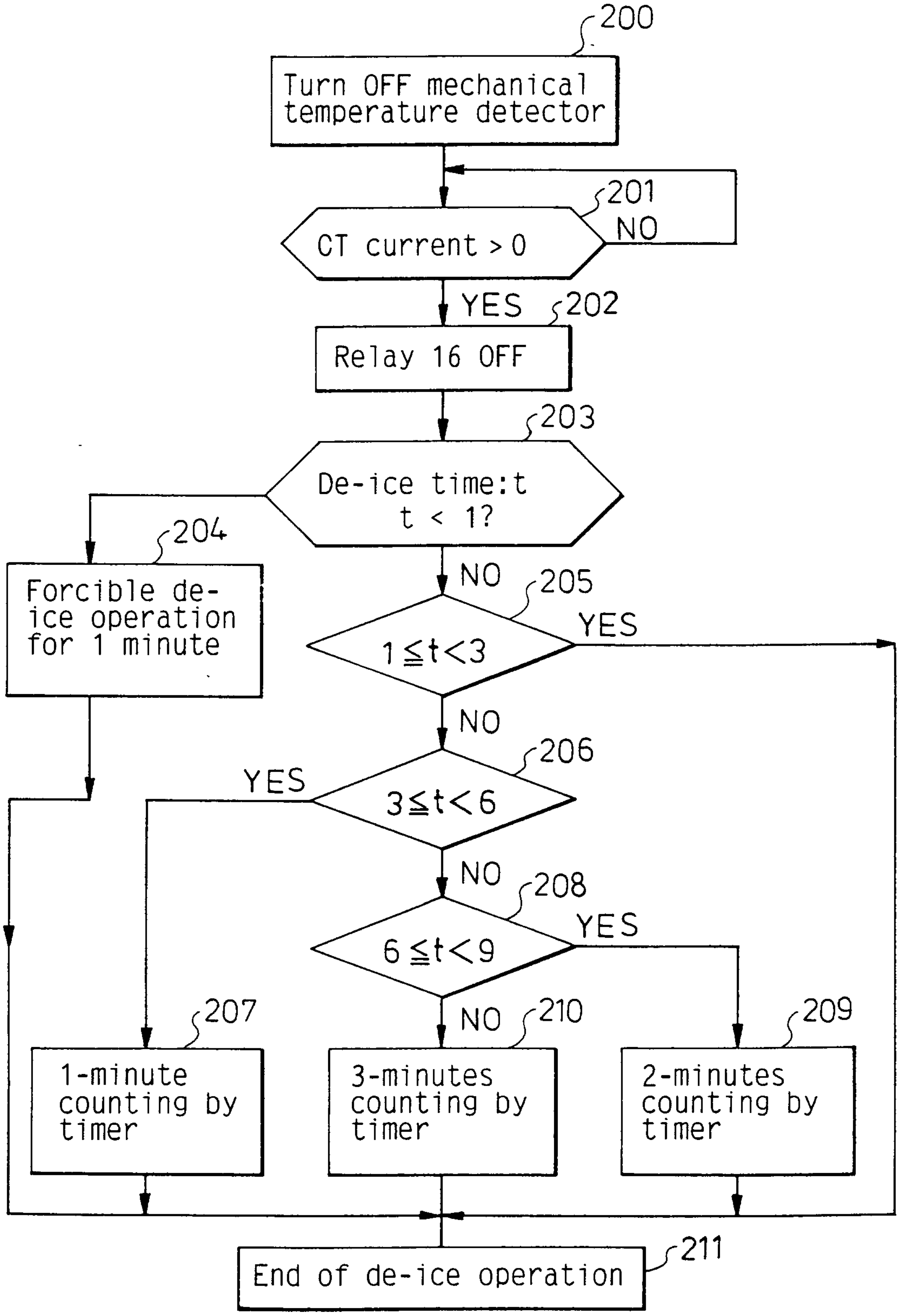

200
Turn OFF mechanical temperature detector
201
CT current > 0
NO
YES
202
Relay 16 OFF
203
De-ice time:t
t < 1?
204
Forcible de-ice operation for 1 minute
NO
205
1≦t<3
YES
NO
206
3≦t<6
YES
NO
208
6≦t<9
YES
207
1-minute counting by timer
NO
210
3-minutes counting by timer
209
2-minutes counting by timer
211
End of de-ice operation

FIG. 4 (Prior Art)