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DEFROSTING CONTROLLING CIRCUIT MEANS FOR ELECTRIC REFRIGERATOR

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FIG. 1

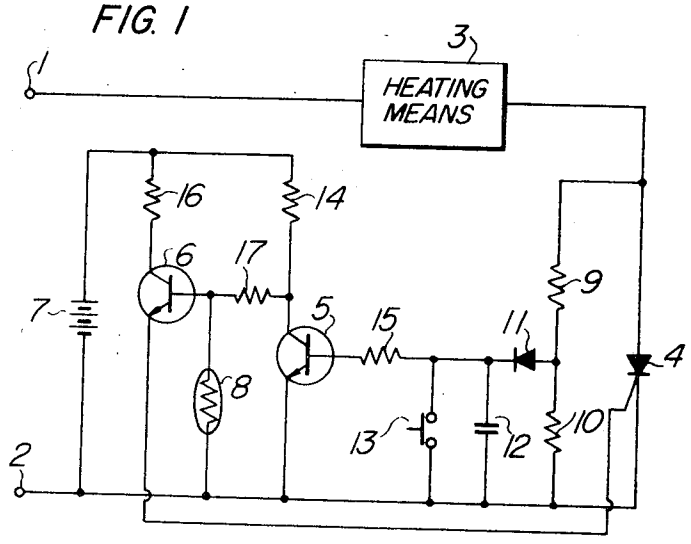
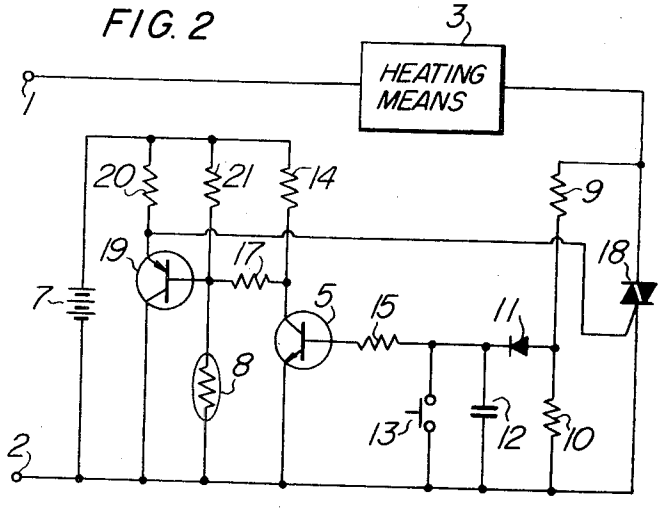


FIG. 2



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DEFROSTING CONTROLLING CIRCUIT MEANS FOR ELECTRIC REFRIGERATOR

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ABSTRACT OF THE DISCLOSURE

A defrosting control circuit means for an electric refrigerator comprising a transistor for triggering a solid-state semiconductor switching element connected in series with a heating means and another transistor for driving the first mentioned transistor to one state of conduction during a defrosting operation, said first mentioned transistor adapted to be switched in response to the output of a temperature detecting element representative of the temperature within the freezer. According to the present defrosting control circuit means, a defrosting operation is automatically ceased when the temperature within the freezer reaches a predetermined level where accumulated frost in the freezer is completely removed, so that excessive temperature rise or incomplete defrosting can be prevented.

The present invention relates to a defrositng control circuit means for electric refrigerators wherein the defrosting operation is performed automatically under electronic control by detecting the temperature within the freezer which is in defrosting operation.

It is generally known that when frost is accumulated in the freezer, i.e., on the surface of the evaporator of an electric refrigerator, the cooling power of the electric refrigerator is decreased. To remove such accumulated frost, various methods have been employed conventionally such as, for example, circulating hot gas in the evaporator with a defrosting valve opened for a fixed period of time, generating heat by a heater for a fixed period of time, etc. In the conventional defrosting systems, however, the defrosting period of time is fixed beforehand as set forth above, and therefore, inconveniences have been encountered such that since the defrosting condition is variable depending upon the amount of accumulated frost, if the amount is relatively small, the temperature within the compartments of the refrigerator rises excessively due to excessive length of the heating operation even after removal of all the accumulated frost, while if the amount of accumulated frost is relatively large, the defrosting operation is incomplete due to an insufficient length of the heating operation nothwithstanding the presence of frost still remaining.

The major object of the present invention is, therefore, to provide a defrosting control circuit means for an electric refrigerator which makes it possible to finish the defrosting operation with the operation of a heating means such as a heater or hot gas being stopped at the time when accumulated frost is completely removed, without suffering from the above-mentioned inconveniences.

Other objects, features and advantages of the present invention will be known from the following description of preferred embodiments made in conjunciton with the accompanying drawings in which:

FIG. 1 is an electric circuit diagram of a defrosting control circuit means for an electric refrigerator in accordance with an embodiment of the present invention; and

FIG. 2 is an electric circuit diagram similar to FIG. 1 in accordance with another embodiment of the present invention.

In the drawings, similar parts are denoted by like reference numerals.

FIG. 1 shows an embodiment of the present invention where a silicon controlled rectifier (hereafter referred to as SCR) is provided in the main circuit in series with a heating means so that the heating means may be controlled by turning the SCR ON or OFF. In the figure, reference numerals **1** and **2** represent AC power source terminals and **3** is a heating means which may be a heater or a relay adapted to actuate a valve through which hot gas is to be circulated. Reference numeral **4** is an SCR connected in series with the heating means **3**; **5** and **6**, NPN transistors having a state of conduction inverse to each other; **7**, a DC bias supply means; **8**, a thermistor thermally coupled with the inside of the freezer of an electric refrigerator to detect the temperature within the freezer; **9** and **10**, AC voltage dividing resistors the series connection of which is connected across the SCR **4** so that they serve to divide the AC voltage from the AC terminals **1** and **2** when the SCR is in non-conductive state; **11**, a diode for rectifying the AC voltage across the voltage dividing resistor **10**; **12**, a smoothing capacitor; **13**, a switch to be closed for an instant when a defrosting operation should be started; **14**, a collector resistor of the transistor **5**; **15**, a base resistor of the transistor **5**; **16**, a collector resistor of the transistor **6**; **17**, a base resistor of the transistor **6**.

While the refrigerator is in cooling operation, i.e., defrosting is not needed, the SCR **4** is non-conductive with the switch **13** opened. Therefore, the main circuit in which the heating means **3** is provided is opened, and no defrosting operation is performed due to inoperativeness of the heating means **3**. Under this condition in which no defrosting operation needs to be performed, an AC voltage is generated across the voltage dividing resistors **9** and **10**, so that the transistor **5** is maintained conductive with a deep base bias applied from the smoothing capacitor **12** which has been charged through the resistor **9** and the diode **11**. The resistance of each of the voltage dividing resistors is so selected as to make the current flowing through the heating means **3** too low to generate heat.

As for the transistor **6**, it is, on the contrary, maintained non-conductive since the collector voltage of the transistor **5** is at a low voltage due to conduction of the transistor **5**. Thus, no trigger current is supplied from the emitter of the transistor **6**, to the SCR **4**, which therefore is maintained non-conductive.

In order to initiate a defrosting operation of the circuit means of FIG. 1 which is in the state as set forth above, i.e., in a state where the transistor **6** and the SCR**4** are non-conductive and the transistor **5** is conductive with a sufficient base bias provided from the smoothing capacitor **12**, the switch **13** only has to be closed periodically for an instant by means of, for example, a timer. Suppose now that the switch **13** is closed for an instant. The electric charge stored in the smoothing capacitor **12** is allowed to flow therefrom through the switch **13**, wihch makes the base potential to the transistor **5** too low for the transistor **5** to be conductive. Then, the collector potential of the transistor **5** is made high enough for the transistor **6** to become conductive, so that the SCR **4** is supplied with a gate trigger current and also becomes conductive. Of course, the variable resistance characteristics of the thermistor **8** an the resistances of the resistors **14** and **17** are selected such that upon the switching of the transistor

5 from conductive to non-conductive state the transistor 6 is switched from non-conductive to conductive state. Thus, the main circuit consisting of a loop: AC power source terminal 1—heating means 3—SCR 4—AC power source terminal 2 is completed, and therefore a defrosting operation is initiated with the heting means 3 energized to generate heat.

It is known that the successive actions from the actuation of the switch 13 to firing of the SCR 4 are effected in a moment and that even after the switch 13 is restored to be opened the transistor 5 can still be maintained nonconductive as if the switch were continuously closed. This is because the fired and conducting SCR 4 has a forward voltage drop across itself which is a few volts at the highest and the smoothing capicitor 12 is not charged to such a high voltage that it renders the transistor 5 conductive with the switch 13 opened. Consequently, heating operation of the heating means 3 is continued even after the switch is restored to its opened state.

When accumulated frost in the freezer is completely removed by the defrosting operation, the temperature within the freezer begins to be raised higher than the temperature at the beginning of the defrosting operation. This temperature rise in the freezer is detected by the thermistor 8 thermally coupled with the inside of the freezer and the base bias to the transistor 6 is correspondlowered with an increase of the temperature within the freezer and the base bias to the transistor 6 is correspondingly decreased. When the temperature within the freezer reaches a predetermined level, the transistor 6 will be almost cut off with the gate trigger current to the SCR 4 being reduced. As a result, the conduction angle of the SCR 4 is smaller than 180°, which results in non-conductive part of phase within every positive half cycle of the alternating current from the AC power source.

Consequently, a certain voltage defined by the voltage dividing resistors 9 and 10 is generated across the smoothing capacitor 12, which makes the collector potential of the transistor 5 to be lowered so that the operation of the transistor 5 is transferred to the active region. In other words, positive feerback takes place to promote a cut-off of the transistor 6. Thus, switching is abruptly performed to bring the transistor 6 and the SCR 4 into the nonconductive state and the transistor 5 into the conductive state with a result that the main circuit is opened and heat generation by the heating means 3, hence a defrosting operation is ceased.

Once the transistor is cut off, the temperature within the freezer is lowered due to the cooling operation of the refrigerator, so that even the resistance of the thermistor 8 is increased as a result of a decrease in temperature within the freezer the transistor would not become conductive again and therefore the defrosting operation is no longer performed.

In the above-mentioned embodiment of the defrosting control circuit means of the present invention, use is made of an SCR by which the main circuit for energizing a heating means is alternatively opened and closed, but the defrosting control circuit means may include a bidirectional semiconductors element with control electrode in place of an SCR, still performing similar control action.

FIG. 2 shows another embodiment of the present invention in which a bidirectional semiconductor element with control electrode is substituted for an SCR. In the circuit of FIG. 2, during a cooling operation of the refrigerator, i.e., while a bidirectional semi-conductor element 18 in series with a heating means 3 is not conductive an NPN transistor 5 is conductive and a PNP transistor 19 subsequent to the transistor 5 is also conductive. In more detail, when the transistor 5 is conductive, the collector voltage thereof is decreased, which, however, results in a deep base bias to the transistor 19 the emitter of which is connected to the control electrode of the bidirectional semiconductor element 18 as can be seen from the circuit connection in the figure. Thus, the transistor 19 is also rendered conductive with its emitter potential almost equal to the potential of a grounded common terminal 2. Therefore, no trigger current is fed to the control electrode of the bidirectional semiconductor element 18, so that the latter is maintained non-conductive.

Now, assume that the switch 13 is closed for an instant. Then, the transistor 5 is first cut off and subsequently the transistor 19, and a trigger current is supplied to the control electrode of the bidirectional semiconductor element 18 to make it conductive. As a result, the main circuit consisting of AC power terminal 1, heating means 3, bidirectional semiconductor element 18 and grounded terminal 2 is completed, and a defrosting operation is initiated with the heating means 3 being energized to generate heat.

As the defrosting operation is continued, the resistance of the thermistor 8 thermally coupled with the inside of the freezer decreases in response to an increase in the temperature within the freezer, which results in making the base bias to the transistor 19 deeper, which in turn reduces the trigger current being fed to the control electrode of the bidirectional semiconductor element. Such reduction in trigger current acts to decrease the electric current flowing through the heating means 3, which promotes a decrease in the resistance of the thermistor 8 due to smaller heat generation by the heating means 3. By this positive feedback action, when the temperature within the freezer reaches a predetermined level, the transistors 5 and 19 are switched from non-conductive to conductive state while the bidirectional semiconductor element 18, from conductive to non-conductive state. Reference numeral 20 is an emitter resistor of the transistor 19 and 21 is a resistor constituting a voltage dividing circuit along with the thermistor 8 connected in series with the resistor 21, the junction of the thermistor and the resistor 21 being connected to the base of the transistor 19 to thereby apply a base bias to the transistor 19. It is apparent that the variable resistance characteristics of the thermistor 8 and the resistance of the resistor 21 are selected such that when the transistor 5 is conductive the transistor 19 is also rendered conductive.

Although particular examples of the defrosting control circuit means of the present invention have been described above, it can be readily understood that:

(1) The thermistor may be connected to the base of either one of the two transistors in FIGS. 1 and 2; and

(2) The application of a base bias to the preceding transistor may be carried out by first rectifying a portion of the terminal voltage of an AC power source and thereafter dividing the so rectified voltage by a series connection of two resistors, i.e., the order of the voltage divider and the rectifying section of FIGS. 1 and 2 may be inversed.

As can be appreciated from the foregoing description, since in the defrosting control circuit means in accordance with the present invention a defrosting operation is automatically ceased at the time when accumulated frost in the freezer is completely removed irrespective of its amount and since the structure is specific, there are provided such various advantages that not only inconveniences such as excess temperature rise within the compartments of the refrigerator and incompete removal of accumulated frost in the freezer can be prevented but also any transistors having rather a small current gain suffice to control a solid-state switching element or a solid-state switching element which requires rather a large gate trigger current can be used to constittue a defrosting control circuit means due to the fact that the switching element is controlled with two transistors, and that the circuit arrangement is easy because various kinds of active elements can be freely selected for the type of the circuit.

What is claimed is:

1. A defrosting control circuit means for an electric refrigerator comprising defrosting heater means, a solid-

state semi-conductor switching element with control electrode and a control section for controlling said switching element, characterized in that said control section includes means for converting a portion of the terminal voltage of an AC power source into a DC voltage when said switching element is non-conductive, said voltage converting means connected in series with said heater means and in parallel with said switching element, a first transistor so arranged as to be supplied with a DC base bias voltage from said voltage converting means so that said first transistor is switched to one of its conductive and non-conductive states, a second transistor so arranged as to be controlled by the output of said first transistor so that said second transistor is switched to one of its conductive and non-conductive states, said second transistor serving to trigger said switching element, and means for applying DC biases to said transistors, that a switch is provided to be closed for an instant to drive said first transistor for initiation of a defrosting operation, and that a temperature detecting element thermally coupled with the inside of the freezer of the refrigerator is associated with one of said transistors as a constituent of voltage divider for supplying said one of the transisto with a base bias.

2. A defrosting control circuit means as claimed i claim 1, characterized in that said voltage convertir means includes a diode.

3. A defrosting control circuit means as claimed i claim 1, characterized in that said temperature detectin element is a thermistor.

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