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METHOD FOR CONTROLLING DEFROSTING OPERATION IN A
REFRIGERATING CYCLE

The present invention relates to a method for
controlling a defrosting operation in a refrigerating cycle
5 of a refrigerator.

Figure 6 is a cross sectional view showing the
defrosting device of a refrigerator as disclosed in
Japanese Unexamined Utility Model Publication No.
65582/1985, wherein a conventional defrosting operation
10 control is carried out in the refrigerating cycle.
Figure 7 is a circuit diagram showing a basic
refrigerating cycle.

Reference numeral 1 designates a refrigerator
housing. Reference numeral 2 designates a fan.
15 Reference numeral 3 designates an evaporator. Reference
numeral 4 designates a receiver which is provided at the
outlet of the evaporator 3. Reference numeral 5
designates an end plate for supporting the evaporator 3.
Reference numeral 6 designates an electric heater in a
20 glass tube which is provided below the evaporator 3.

Reference numeral 7 designates a shade which is provided just above the heater 6. Reference numeral 8 designates a trough which is provided at the lowest portion in the evaporator chamber. Reference numeral 11 designates a guide for thermal convection which is attached to the lower end of the end plate 5. Reference numerals 12, 13, 14 and 15 designate a compressor, a condenser, an expansion device and refrigerating piping respectively.

10 The operation of the refrigerating cycle will be explained. When the refrigerating cycle, wherein the compressor 12, the condenser 13, the expansion device 14 and the evaporator 3 are connected together by use of refrigerating piping 15, is operated, the evaporator 3 is
15 cooled to a cryogenic temperature. The air in the refrigerating compartment is guided to the evaporator 3 having the cryogenic temperature to be cooled by heat exchange. The fan 2 gives forced convection to the cooled air, and feeds the cooled air into the
20 refrigerating compartment to cool the inside of it. The moisture contained in the air solidifies at the time of heat exchange and sticks on the surfaces of the evaporator 3 and the receiver 4 as frost. The frost
25 forms a layer between the evaporator 3 and the air to interfere with heat exchange therebetween. In order to eliminate such interference, refrigerators carry out defrosting operations periodically.

The defrosting operation heats the evaporator 3 and the receiver 4 to melt frost iced on their surfaces for removal. It means that the defrosting operation is opposite to the refrigerating operation wherein the evaporator 3 produces cooled air or absorbs heat. In the defrosting operation, it is common that the defrosting operation is carried out after the compressor 12 is stopped to suspend the refrigerating operation, and that the compressor 12 is restarted to perform the refrigerating operation after the defrosting operation has been completed.

In the defrosting operation, the heating element 6 is energized after the stoppage of the compressor 12 to develop heat, thereby heating air around it. The heated air is pushed up by free convection, and it carries out heat exchange with the frost on the evaporator to remove the frost. A portion of the heated air is guided by the thermal convection guide 11, which is inwardly bent, and goes up toward the receiver 4, thereby defrosting the surface of the receiver.

When a defrosting sensor which is provided on the receiver detects a temperature between 10°C and 15°C which is not less than the melting point of the frost, it is judged that the defrosting operation has been completed.

Since the conventional method uses the heat radiated from the heating element to defrost the evaporator and

the receiver, only the frost near to the heating element can be removed in a relatively short time. Furthermore, it takes a significantly long time to defrost the upper portions of the evaporator and the receiver which are furthest from the heater. This is because as the distance from the heating element increases, the more rapidly the quantity of heat in the heated air decreases. It is impossible to concentrate the whole heat radiated from the heating element to melt the frost. Although prolonging the heating time of the heating element helps the frost at a location apart from the heating element to melt, the longer the heating time becomes, the greater is the amount of the heat which is carried from the heating element into the refrigerating compartment to be cooled by the cooled air from the evaporator, disadvantageously causing the temperature in the refrigerating compartment to rise.

It is an aim of the present invention to provide a method for controlling a defrosting operation in a refrigerating cycle wherein a quantity of heat from a heating element is rapidly carried to a portion of an evaporator, and a receiver, apart from the heating element, thereby allowing the defrosting operation to be completed in a relatively short time such that thermally adverse effects to a refrigerating compartment to be cooled are minimized.

According to a first aspect of the present invention,

there is provided a method for controlling a defrosting operation in a refrigerating cycle wherein a compressor, a condenser, an expansion device, an evaporator and a receiver are connected together by use of refrigerating piping, the evaporator or the receiver is provided with a defrosting sensor and a heating element is provided in the vicinity of the evaporator, comprising:

energizing the heating element for a period from the initiation of the defrosting operation to the time when the defrosting sensor detects a temperature of not less than the melting point of frost, and

driving the compressor for a momentary period of time at predetermined intervals in such period to assist refrigerant movement around the piping.

According to a second aspect of the present invention, there is provided a method for controlling a defrosting operation in a refrigerating cycle wherein a compressor, a condenser, an expansion device, an evaporator and a receiver are connected together by use of refrigerating piping, the evaporator or the receiver is provided with a defrosting sensor, a heating element is provided in the vicinity of the evaporator, a refrigerant control valve is provided in the pipe connecting the condenser and the expansion device and a check valve is provided in the pipe connecting the evaporator and the compressor to prevent the refrigerant from flowing from the compressor back to the evaporator, comprising:

energizing the heating element for a period from the initiation of the defrosting operation to the time when the defrosting sensor detects a temperature of not less than the melting point of frost, and

driving the compressor for a momentary period of time at predetermined intervals in such period to assist refrigerant movement around the piping, and

keeping the refrigerant control valve open regardless of the ON and OFF operations of the compressor in such period.

The present invention utilizes the suspended refrigerating cycle during the defrosting operation while performing heating by the heating element, thereby improving defrosting capability.

5 Specific embodiments of the invention are now described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a front view of a refrigerator wherein a first embodiment of the present invention is carried out;

10 Figure 2 is a time chart showing the defrosting control in the first embodiment as shown in Figure 1;

Figure 3 is a refrigerant circuit diagram wherein a

second embodiment of the present invention is carried out;

Figure 4 is a time chart showing the defrosting control of the second embodiment as shown in Figure 3;

Figure 5 is a time chart showing the control in a normal refrigerating operation as shown in Figure 3;

Figure 6 is a front view of a refrigerator with the conventional defrosting device; and

Figure 7 is showing a basic refrigerant circuit diagram.

Firstly, a first embodiment of the method for controlling a defrosting operation in a refrigerating cycle according to the present invention will be explained with reference to Figures 1 and 2 which show the defrosting control applied to a refrigerator.

In Figure 1, reference numeral 1 designates a refrigerator housing. Reference numeral 2 designates a fan which is arranged in the top portion of an evaporator chamber in the housing. Reference numeral 3 designates an evaporator which is housed in the chamber. Reference numeral 4 designates a receiver which is provided at the outlet side of the evaporator 3 from which a refrigerant flows during a refrigerating operation. Reference numeral 6 designates a heating element in a glass tube which is

provided below the evaporator 3. Reference numeral 7 designates a shade which is just above the heating element 6 to prevent droplets from falling on the heating element during a defrosting operation. Reference numeral 8 designates a trough which is arranged in the lowest portion in the evaporator chamber. Reference numeral 9 designates a drain tube which is connected to the trough. Reference numeral 10 designates a defrosting sensor which is attached to the surface of the receiver 4.

Figure 2 is the time chart showing the controls of the compressor and the heating element during the defrosting operation of the refrigerator. Reference T designates a standstill time of the compressor during a defrosting operation. Reference t designates a momentary operation time of the compressor during the defrosting operation. Reference a designates a temperature at which the momentary operation of the compressor should be ceased. Reference b designates a temperature at which defrosting has been completed.

The normal refrigerating operation is carried out like the conventional refrigerator. The refrigerating cycle is operated to cool the inside of the refrigerator, and the defrosting operation is periodically carried out like the conventional refrigerator.

Now, the defrosting control according to the first embodiment will be described in detail with reference to

the time chart of Figure 2.

When the defrosting operation starts, the heating element 6 is energized to start heating. At the same time, the operation of the compressor 12 in the refrigerating cycle is switched from a normal successive driving operation or a control operation based on the temperature in the refrigerator to an momentary operation which is done for a short time t at predetermined intervals T .

10 The momentary operation of the compressor 12 is intermittently repeated until that the temperature detected by the defrosting sensor 10 reaches the point a at which it is judged that the frost formed on the outer surface of the receiver has been melted. Until the temperature detected by the sensor 10 reaches the point of a , the pressure in the evaporator remains saturation pressure at a temperature 0°C at which frost melts.

As a result, even if the momentary operation of the compressor 12 is done, there is substantially no effect due to the intake operation of the compressor, and the momentary operation can move part of the refrigerant, which is heated in the lower portion of the evaporator 3 near to the heating element 6, to the outlet side of the evaporator 3 apart from the heating element 6 without decreasing the evaporation temperature in the evaporator. The movement of the heated part of the refrigerant allows thermal energy from the heating

element 6 to be transferred to an upper portion of the evaporator 3 apart from the heated element 6 and to the receiver 4 through the inside of a pipe in the evaporator. The upper portion of the evaporator and the receiver are not likely to receive the thermal energy by free convection. The part of the refrigerant which has moved through the pipe becomes another heat source for the upper portion of the evaporator and the receiver to melt the frost by thermal conduction from inside of the pipe, thereby allowing the frost on the outer surfaces of the upper portion of the evaporator 3 apart from the heating element 6 and the receiver 4 to melt rapidly.

Such defrosting operation is continued until the temperature detected by the sensor 10 reaches the point b (about 10°C) which is higher than the temperature at which frost melts.

The reason why the defrosting operation is continued until the detection temperature reaches the point b is that the time required for the melted frost to drop from the evaporator 3 to the trough 8 in droplets of water and further flow to the drain tube 9 is maintained to prevent the droplets from icing on the outer surface of the evaporator 3 and remaining as ice on it. During the time between the point a and the point b wherein the melted frost has flowed away, the pressure and the temperature in the evaporator 3 are rising. For this reason, if the compressor is driven under the momentary operation during

this time, the evaporation temperature is instantly lower due to an decrease in pressure caused by the intake of the compressor, thereby adversely effecting the detection temperature by the defrosting sensor 10. Therefore, it is preferable that the momentary operation of the compressor 12 is repeated between the initiation of the defrosting operation and the point a at which the frost has melted and at which the sensor 10 detects a temperature of 1-3°C. Such control allows the time required for defrosting to be shortened.

Because the frost which is formed on the evaporator in the refrigerating cycle is caused by cooled air which is produced by the refrigerant flowing through the evaporator, using the refrigerant as a thermal source ensures that the thermal source is carried to a location with frost. In addition, there is no possibility that a portion of the evaporator, which does not require defrosting, or the refrigerating compartment is heated until the defrosting operation terminates. Then when the frost has disappeared, use of the refrigerant as the thermal source is stopped, i.e. the heating element is dennergized. In this way, there is no possibility that the use of the refrigerant as the thermal source causes any thermally adverse effect.

The standstill time T of the compressor 12 is required for part of the refrigerant in the evaporator 3

near to the heating element 6 to absorb heat from the heating element 6, and for another part of the refrigerant in the evaporator 3 apart from the heating element 6 and in the receiver 4 to transfer the absorbed thermal energy to the frost formed on the outer surfaces of the tube walls.

In order to prevent the heat radiation to parts or elements except for the frost, the standstill time T can be set so that the refrigerant, which has absorbed heat after the frost on the evaporator 3 near to the heating element 6 is removed, does not hold the thermal energy to be radiated after the refrigerant has passed through locations with frost formed on them.

The momentary operation time t of the compressor 12 is required for the heat-absorbing part of the refrigerant near to the heating element 6 to be transmitted to a location with the frost formed on it, for a new part of the refrigerant to be drawn into a location near to the heating element for heat absorption, and for the heat-adsorbing part of the refrigerant to be drawn into a location apart from the heating element 6 to enable heat to be radiated there.

The momentary operation time t is preferably set so that part of the refrigerant which has absorbed heat is completely replaced by new part of the refrigerant which has not yet absorbed heat, thereby to carry out uniform defrosting.

In accordance with the first embodiment, the compressor is driven for a short time at predetermined intervals during the defrosting operation by the heating element. The part of the refrigerant which is located in the evaporator at a position near to the heating element and is locally heated by thermal energy from the heating element is gradually moved to portions of the evaporator apart from the heating element and the receiver by the compressor. As a result, the heated and moved part of the refrigerant functions as a new heat source for portions of the evaporator to melt frost formed on the outer surface of the tube through which the heated part of the refrigerant is moving, offering the advantage wherein it is ensured that frost which is formed at locations apart from the heating element can be removed in a short time.

Secondly, a second embodiment according to the present invention, wherein the refrigerating circuit includes a refrigerant control valve and a check valve, will be explained with reference to Figures 3 through 5.

In the second embodiment, there are provided a refrigerant control valve 16, between the outlet of the condenser 13 and the inlet of the expansion device 14, and a check valve 17 between the outlet of the evaporator 3 and the inlet of the compressor 12 as shown in Figure 3. A refrigerator with such a refrigerating circuit opens and closes the refrigerant control valve 16 in synchronism with the ON and the OFF operation of the

compressor 12 to minimize loss in efficiency of the compressor during a normal refrigerating operation as shown in the time chart of Figure 5.

When the defrosting operation is carried out using
5 the heating element 6, the refrigerant control valve 16 is kept open regardless of the ON and the OFF operation of the compressor 12 as shown in the time chart of Figure 4. During the period from the initiation of the defrosting operation to the time when the defrosting
10 sensor 10 detects the temperature a ($1-3^{\circ}\text{C}$) of not less than the melting point of frost, the compressor 12 is driven for a short time t at predetermined intervals T , thereby obtaining a similar effect to the first embodiment.

CLAIMS

1. A method for controlling a defrosting operation in a refrigerating cycle wherein a compressor, a condenser, an expansion device, an evaporator and a receiver are connected
5 together by use of refrigerating piping, the evaporator or the receiver is provided with a defrosting sensor and a heating element is provided in the vicinity of the evaporator, comprising:

10 energizing the heating element for a period from the initiation of the defrosting operation to the time when the defrosting sensor detects a temperature of not less than the melting point of frost, and

driving the compressor for a momentary period of time at predetermined intervals in such period to assist
15 refrigerant movement around the piping.

2. A method according to Claim 1, wherein the heating element is provided in the vicinity of the refrigerant inlet side of the evaporator.

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3. A method for controlling a defrosting operation in a refrigerating cycle wherein a compressor, a condenser, an expansion device, an evaporator and a receiver are connected together by use of refrigerating piping, the evaporator or
25 the receiver is provided with a defrosting sensor, a heating element is provided in the vicinity of the evaporator, a refrigerant control valve is provided in the pipe connecting the condenser and the expansion device and a check valve is provided in the pipe connecting the evaporator and the
30 compressor to prevent the refrigerant from flowing from the compressor back to the evaporator, comprising:

energizing the heating element for a period from the initiation of the defrosting operation to the time when the defrosting sensor detects a temperature of not less than the
35 melting point of frost,

driving the compressor for a momentary period of time at predetermined intervals in such period to assist refrigerant movement around the piping, and



keeping the refrigerant control valve open regardless of the ON and OFF operations of the compressor in such period.

- 5 4. A method according to Claim 3, wherein the heating element is provided in the vicinity of the refrigerant inlet side of the evaporator.
 - 10 5. A method for controlling a defrosting operation in a refrigerating cycle substantially as hereinbefore described with reference to and as shown in Figures 1 and 2 or Figures 3 and 4 of the accompanying drawings.
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