

DESCRIPTION

Title of Invention

REFRIGERATOR

5 Technical Field

[0001]

The present invention relates to a refrigerator, and more particularly, to a technology for removing frost adhered to a cooler.

Background Art

10 [0002]

A refrigerator includes a storage compartment, an airflow path communicating with the storage compartment, a cooler provided in the airflow path, and other components. The refrigerator cools air flowing from the storage compartment into the airflow path, with the cooler and returns this cooled air to the storage

15 compartment so as to cool, for example, food in the storage compartment. When a door of the storage compartment is opened and closed for taking in or out, for example, food or for some other purpose, wet air outside the refrigerator flows into the storage compartment. Further, moisture is also generated from, for example, the food stored in the storage compartment. For this reason, as the operation of the refrigerator is continued, moisture contained in return air from the storage
20 compartment to the cooler is formed into frost and adheres to the cooler.

[0003]

Accordingly, there has hitherto been proposed a refrigerator, which includes a heater for heating the cooler and heats the cooler with the heater to perform a
25 defrosting operation on the cooler. For example, in Patent Literature 1, as a refrigerator for performing the defrosting operation while reducing its power consumption, there is proposed a refrigerator, which has temperature detection elements of two systems mounted in a cooler, and determines an actual frost formation state based on a difference in temperature between the two systems, to

control a defrosting interval from the previous defrosting operation to the present defrosting operation.

Citation List

Patent Literature

5 [0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2001-215077

Summary of Invention

Technical Problem

10 [0005]

In the refrigerator described in Patent Literature 1, at the time of performing the defrosting operation, heating capacity [W] of a heater, namely, power consumption thereof, is constant regardless of the amount of frost formation on the cooler. Thus, the refrigerator described in Patent Literature 1 has such problems as follows.

15 [0006]

On the cooler, frost first begins to be deposited at an air inlet in which return air, which contains moisture and is returned from the storage compartment, touches the cooler, that is, on the upstream side of an air flow in the cooler. After that, the frost formation range on the cooler expands from the air inlet toward an air outlet. At the end, frost is deposited on the entire cooler. That is, at a stage at which a small amount of frost is deposited on the cooler, the amount of frost formation on the air outlet side of the cooler is smaller than the amount of frost formation on the air inlet side of the cooler. For this reason, in the refrigerator described in Patent Literature 1 in which the heating capacity of the heater is constant regardless of the amount of frost formation, when the cooler at the stage at which a small amount of frost is deposited is to be defrosted, the heating capacity of the heater is excessively large with respect to the amount of frost formation on the cooler, and at the end of defrosting on the air inlet side of the cooler, the temperature on the air outlet side of the cooler, where defrosting has already ended, rises excessively. Thus, the refrigerator described in Patent Literature 1 has a problem in that, when the operation

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is returned to a normal operation after defrosting of the cooler at the stage at which a small amount of frost is deposited, the air to be supplied to the storage compartment is heated on the air outlet side of the cooler, to cause a rise in temperature inside the storage compartment. Further, the refrigerator described in Patent Literature 1 has a problem in that it is required to consume power to cool again the air in the storage compartment with its temperature having risen, thereby increasing power consumption.

[0007]

In order to solve the above-mentioned problems, reduction of the heating capacity of the heater is conceivable. However, in such a case in which the heating capacity of the heater is reduced, in the refrigerator described in Patent Literature 1 in which the heating capacity of the heater is constant regardless of the amount of frost formation, the defrosting takes long time when the cooler with a large amount of frost formation thereon is to be defrosted. That is, the cooled air cannot be supplied to the storage compartment over a long period of time. Thus, the refrigerator described in Patent Literature 1 has a problem in that the temperature inside the storage compartment rises even when the heating capacity of the heater is reduced. Further, the refrigerator described in Patent Literature 1 has a problem in that it is required to consume power to cool again the air in the storage compartment with its temperature having risen, thereby increasing the power consumption.

[0008]

The present invention has been made to solve such problems as described above, and it is an object of the present invention to provide a refrigerator capable of preventing a rise in temperature inside a storage compartment due to a defrosting operation as compared to the related art.

Solution to Problem

[0009]

According to one embodiment of the present invention, there is provided a refrigerator, including: a storage compartment; an airflow path, which communicates with the storage compartment; a cooler, which is provided in the airflow path, and is

configured to cool air flowing in the airflow path; and a heater, which is configured to heat the cooler in a first frost formation state in which frost is deposited on the cooler and in a second frost formation state in which less frost is deposited on the cooler than in the first frost formation state, the refrigerator being configured to perform, with the heater: a first defrosting operation for heating the cooler in the first frost formation state; and a second defrosting operation for heating the cooler in the second frost formation state, in the first defrosting operation, heating capacity of the heater being a first capacity, and in the second defrosting operation, heating capacity of the heater being a second capacity, the second capacity being smaller than the first capacity.

Advantageous Effects of Invention

[0010]

In the refrigerator according to the one embodiment of the present invention, in the first frost formation state in which a large amount of frost is deposited on the cooler, the heating capacity of the heater can be increased to perform the defrosting operation. For this reason, when the cooler with a large amount of frost formation is to be defrosted, the refrigerator according to the one embodiment of the present invention can prevent the defrosting from taking long time and prevent the temperature inside the storage compartment from rising. Further, in the refrigerator according to the one embodiment of the present invention, in the second frost formation state in which a small amount of frost is deposited on the cooler, the heating capacity of the heater is made smaller than in the first frost formation state, to perform the defrosting operation. Therefore, when the cooler with a small amount of frost formation is to be defrosted, the refrigerator according to the one embodiment of the present invention can prevent a rise in temperature on the air outlet side of the cooler. That is, the refrigerator according to the one embodiment of the present invention can prevent a rise in temperature inside the storage compartment even when the cooler with a small amount of frost formation is to be defrosted.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a longitudinal sectional side view for illustrating one example of a refrigerator according to Embodiment 1 of the present invention.

[Fig. 2] Fig 2 is a diagram for illustrating one example of an electric circuit of the refrigerator according to Embodiment 1 of the present invention.

5 [Fig. 3] Fig 3 is a diagram for illustrating one example of the electric circuit of the refrigerator according to Embodiment 1 of the present invention.

[Fig. 4] Fig 4 is a perspective view for illustrating the inside of an airflow path of the refrigerator according to Embodiment 1 of the present invention.

10 [Fig. 5] Fig 5 is a graph for showing a change in temperature of a cooler in a state in which a small amount of frost is deposited at the time of defrosting the cooler in a related-art method.

[Fig. 6] Fig 6 is a graph for showing a change in temperature of a cooler in a state in which a small amount of frost is deposited at the time of defrosting the cooler in the refrigerator according to Embodiment 1 of the present invention.

15 [Fig. 7] Fig 7 is a graph for illustrating another example of a defrosting operation in the state in which a small amount of frost is deposited in the refrigerator according to Embodiment 1 of the present invention.

20 [Fig. 8] Fig 8 is a graph for showing a change in temperature of the cooler at the time of energizing a radiant heater in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 9] Fig. 9 is a flowchart for illustrating one example of a method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

25 [Fig. 10] Fig. 10 is a graph for showing a relationship between the operation time from the end of the defrosting operation and the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 11] Fig. 11 is a graph for showing a relationship between the frequency of opening/closing of a door and the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 12] Fig. 12 is a longitudinal sectional side view for illustrating one example of the refrigerator according to Embodiment 1 of the present invention.

[Fig. 13] Fig. 13 is a flowchart for illustrating one example of the method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 14] Fig. 14 is a graph for showing air flow-static pressure characteristics (P-Q characteristics) of a fan of the refrigerator according to Embodiment 1 of the present invention.

[Fig. 15] Fig. 15 is a longitudinal sectional side view for illustrating one example of the refrigerator according to Embodiment 1 of the present invention.

[Fig. 16] Fig. 16 is a flowchart for illustrating one example of the method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 17] Fig. 17 is a flowchart for illustrating one example of the method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 18] Fig. 18 is a graph for showing a relationship between humidity in a storage compartment and the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 19] Fig. 19 is a longitudinal sectional side view for illustrating one example of the refrigerator according to Embodiment 1 of the present invention.

[Fig. 20] Fig. 20 is a flowchart for illustrating one example of the method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 21] Fig. 21 is a longitudinal sectional side view for illustrating one example of a refrigerator according to Embodiment 2 of the present invention.

[Fig. 22] Fig. 22 is a perspective view for illustrating the inside of an airflow path of the refrigerator according to Embodiment 2 of the present invention.

[Fig. 23] Fig. 23 is a flowchart for illustrating one example of a method of determining the amount of frost formation on a cooler in the refrigerator according to Embodiment 2 of the present invention.

[Fig. 24] Fig. 24 is a graph for showing a relationship between the heating amount of the heater and the method of determining the amount of frost formation described in each of Embodiment 1 and Embodiment 2.

[Fig. 25] Fig. 25 is a graph for showing one example of a relationship between the heating amount of the heater and the method of determining the amount of frost formation according to the present invention.

[Fig. 26] Fig. 26 is a graph for showing one example of a relationship between the heating amount of the heater and the method of determining the amount of frost formation according to the present invention.

Description of Embodiments

[0012]

Embodiment 1

Fig. 1 is a longitudinal sectional side view for illustrating one example of a refrigerator according to Embodiment 1 of the present invention. In Fig. 1 and longitudinal sectional side views described later, a refrigerator 100 is illustrated with its front surface located on the left side.

The refrigerator 100 according to Embodiment 1 includes a storage compartment, an airflow path 3 communicating with the storage compartment, a cooler 54 provided in the airflow path 3, a radiant heater 11 configured to heat the cooler 54 during a defrosting operation, and other components.

[0013]

The storage compartment and the airflow path 3 are formed in a casing 1. This casing 1 is made up of an inner box 1a, an outer box 1b, a heat insulator provided between the inner box 1a and the outer box 1b, and other components. The casing 1 is formed into a box shape with the front surface side opened, and the inside of the inner box 1a in the housing 1 serves as the storage compartment. In Embodiment 1, the inside of the inner box 1a is divided by partition plates to form a

plurality of storage compartments. Specifically, as illustrated in Fig. 1, the refrigerator 100 according to Embodiment 1 includes a refrigerator compartment 21, a freezer compartment 22, and a vegetable compartment 23 as the storage compartments.

5 The types of storage compartments and the number of storage compartments are merely examples.

[0014]

10 The refrigerator compartment 21 is a storage compartment cooled to a refrigeration temperature zone of from 0 degrees Celsius to 5 degrees Celsius, and is positioned at the top part of the casing 1. The freezer compartment 22 is a storage compartment set in a freezing temperature zone of from -15 degrees Celsius to -20 degrees Celsius for freezing a storage material, and is positioned below the refrigerator compartment 21. The vegetable compartment 23 is a storage compartment set in a temperature zone of from 0 degrees Celsius to 5 degrees Celsius suitable for storage of vegetables, and is positioned below the freezer compartment 22.

[0015]

 A door for openably/closably covering an opening portion of each of those storage compartments is provided in each of those storage compartments.

20 Specifically, a door 24 for openably/closably covering the opening portion of the refrigerator compartment 21 is provided at that opening portion. A door 25 for openably/closably covering the opening portion of the freezer compartment 22 is provided at that opening portion. A door 26 for openably/closably covering the opening portion of the vegetable compartment 23 is provided at that opening portion.

25 Further, a temperature sensor configured to detect a temperature of each storage compartment is also provided in each of those storage compartments. Specifically, a temperature sensor 31 is provided in the refrigerator compartment 21, a temperature sensor 32 is provided in the freezer compartment 22, and a temperature sensor 33 is provided in the vegetable compartment 23.

30 [0016]

The airflow path 3 is provided on the rear surface side of the storage compartments. This airflow path 3 communicates with each storage compartment via a blowoff airflow path and a return airflow path. Specifically, the airflow path 3 and the refrigerator compartment 21 are connected to each other via a blowoff airflow path 4 and a return airflow path (not shown). The airflow path 3 and the freezer compartment 22 are connected to each other via a blowoff airflow path 5 and a return airflow path 7. The airflow path 3 and the vegetable compartment 23 are connected to each other via a blowoff airflow path 6 and a return airflow path 8.

[0017]

As described above, the cooler 54 is provided in the airflow path 3. This cooler 54 cools air flowing in the airflow path 3, more specifically, air flowing from the storage compartment into the airflow path 3 to be supplied to the storage compartment. In the airflow path 3, for example, above the cooler 54, the fan 10 is provided to send the air cooled by the cooler 54 to each storage compartment. Further, in the airflow path 3, for example, below the cooler 54, the radiant heater 11 is provided to heat the entire cooler 54 by a radiant heat during the defrosting operation.

[0018]

That is, the air cooled by the cooler 54 flows into the refrigerator compartment 21 through the blowoff airflow path 4 to cool, for example, food stored in the refrigerator compartment 21. This air having cooled, for example, food returns to the airflow path 3 through the return airflow path (not shown), and is then cooled again by the cooler 54. Further, the air cooled by the cooler 54 flows into the freezer compartment 22 through the blowoff airflow path 5 to cool, for example, food stored in the freezer compartment 22. This air having cooled, for example, food returns to the airflow path 3 through the return airflow path 7, and is then cooled again by the cooler 54. Moreover, the air cooled by the cooler 54 flows into the vegetable compartment 23 through the blowoff airflow path 6 to cool, for example, food stored in the vegetable compartment 23. This air having cooled, for example, food returns to the

airflow path 3 through the return airflow path 8, and is then cooled again by the cooler 54.

[0019]

In Embodiment 1, the return airflow path, through which each storage
5 compartment communicates with the airflow path 3, communicates with the airflow path 3 in a position below the cooler 54. That is, in Embodiment 1, the lower end of the cooler 54 serves as the air inlet and the upper end of the cooler 54 serves as the air outlet.

Further, in Embodiment 1, a damper 9a is provided in the blowoff airflow path
10 4, through which the airflow path 3 communicates with the refrigerator compartment 21. A damper 9b is provided in the blowoff airflow path 6, through which the airflow path 3 communicates with the vegetable compartment 23. That is, the amount of cooled air supplied to the refrigerator compartment 21 can be adjusted by opening or closing the damper 9a. Further, the amount of cooled air supplied to the vegetable
15 compartment 23 can be adjusted by opening or closing the damper 9b.

[0020]

The cooler 54 described above forms a refrigeration cycle circuit 50. This refrigeration cycle circuit 50 is formed by pipe-connecting a compressor 51, a radiator 52, a pressure reducing device 53, and the cooler 54.

20 [0021]

The compressor 51 sucks a low-temperature and low-pressure refrigerant having flowed out of the cooler 54 and compresses the refrigerant into a high-temperature and high-pressure gas refrigerant. This compressor 51 is provided in a machine room 2 formed on the lower rear surface side of the casing 1. The radiator
25 52 radiates the heat from the high-temperature and high-pressure gas refrigerant compressed by the compressor 51, to condense that gas refrigerant into a high-pressure liquid refrigerant. This radiator 52 is a fin-and-tube type heat exchanger, for example, and is provided in the machine room 2.

[0022]

The pressure reducing device 53 is a capillary tube, an electromagnetic expansion valve, or some other device, and expands the high-pressure liquid refrigerant having flowed out of the radiator 52 to a low-temperature and low-pressure two-phase gas-liquid refrigerant. This pressure reducing device 53 is provided in the machine room 2. The cooler 54 is a fin-and-tube type heat exchanger, for example, and exchanges heat between the low-temperature and low-pressure two-phase gas-liquid refrigerant having flowed out of the pressure reducing device 53 and the air having flowed out of each storage compartment, to cool the air.

[0023]

Further, the refrigerator 100 according to Embodiment 1 includes a controller 60 made up of a microcomputer, for example. This controller 60 is provided on the upper rear surface side of the casing 1, for example, and includes a control unit 61, a determination unit 62, a clock unit 63, a memory unit 64, and other units. In Fig. 1, the controller 60 is taken out in illustration for the sake of convenience.

[0024]

The control unit 61 controls the activation and stoppage of the compressor 51, the number of revolutions of the compressor 51, the activation and stoppage of the fan 10, the number of revolutions of the fan 10, the opening degrees of the dampers 9a and 9b, the opening degree of the pressure reducing device 53, whether or not to energize the radiant heater 11, heating capacity [W] of the radiant heater 11 during energization, namely, power consumption thereof, and other factors. The determination unit 62 determines the amount of frost formation on the cooler 54. In Embodiment 1, the determination unit 62 determines whether the frost formation state is a first frost formation state in which a large amount of frost is deposited on the cooler 54 or a second frost formation state in which a small amount of frost is deposited on the cooler 54. The clock unit 63 measures time such as the operation time of the refrigerator 100. The memory unit 64 stores a value, a mathematical expression, a table, and other factors to be used at the time when the control unit 61 controls a controlling object, at the time when the determination unit 62 determines the amount of frost formation, and at other times.

[0025]

In the refrigerator 100 according to Embodiment 1, the heating capacity of the radiant heater 11 is made different between the case in which a large amount of frost is deposited on the cooler 54 and the case in which a small amount of frost is deposited thereon. Thus, the refrigerator 100 has such an electric circuit as follows, for example.

[0026]

Fig 2 is a diagram for illustrating one example of an electric circuit of the refrigerator according to Embodiment 1 of the present invention.

In an electric circuit 70 illustrated in Fig. 2, a first wiring portion 72 having a resistor 74 and a second wiring portion 73 having no resistor are connected in parallel between the radiant heater 11 and a power source 71. The electric circuit 70 illustrated in Fig. 2 includes a switch 75 for switching between a closed circuit in which the power source 71, the first wiring portion 72, and the radiant heater 11 are connected, and a closed circuit in which the power source 71, the second wiring portion 73, and the radiant heater 11 are connected. The switch 75 is switched to form the closed circuit in which the power source 71, the second wiring portion 73, and the radiant heater 11 are connected, thereby being capable of increasing the heating capacity of the radiant heater 11. The switch 75 is switched to form the closed circuit in which the power source 71, the first wiring portion 72 having the resistor 74, and the radiant heater 11 are connected so that a current flowing in the radiant heater 11 decreases, thereby being capable of reducing the heating capacity of the radiant heater 11.

The control unit 61 causes the switch 75 to perform switching. Further, the second wiring portion 73 may be configured to have a lower resistance than the first wiring portion. Thus, a resistor with a lower resistance than the resistor 74 may be provided in the second wiring portion.

[0027]

Fig 3 is a diagram for illustrating one example of the electric circuit of the refrigerator according to Embodiment 1 of the present invention. Even with this

configuration of the electric circuit 70, the heating capacity of the radiant heater 11 can be made different between the case in which a large amount of frost is deposited on the cooler 54 and the case in which a small amount of frost is deposited thereon.

That is, the electric circuit 70 illustrated in Fig. 3 includes the switch 75 for switching between a closed circuit in which a first power source 76 and the radiant heater 11 are connected, and a closed circuit in which a second power source 77 and the radiant heater 11 are connected. When the supply voltage of the first power source 76 and the supply voltage of the second power source 77 are different, the heating capacity of the radiant heater 11 can be made different by switching the switch 75. The first power source 76 and the second power source 77 are not necessarily required to serve as components of the refrigerator 100. When two power sources that supply different voltages are in the installation place of the refrigerator 100, those power sources may be used as the first power source 76 and the second power source 77. Alternatively, for example, two transformers may be provided in the electric circuit 70 and those transformers may be connected to a commercial power source or some other power source to be used as the first power source 76 and the second power source 77. Alternatively, for example, one of the first power source 76 and the second power source 77 may be used as the commercial power source and the other may be used as the transformer.

[0028]

[Description of Operation]

The refrigerator 100 configured as described above is operated as follows.

[0029]

(Normal Operation)

A normal operation to cool, for example, food in the storage compartment is performed as follows.

The control unit 61 controls the compressor 51 such that a detected value of the temperature sensor 32 provided in the freezer compartment 22 is a set temperature stored in the memory unit 64. That is, the control unit 61 activates the compressor 51 when the detected value of the temperature sensor 32 is higher than

the set temperature. Further, the control unit 61 stops the compressor 51 when the detected value of the temperature sensor 32 is lower than the set temperature.

During the operation of the compressor 51, the number of revolutions of the compressor 51 may be changed depending on the difference between the detected value of the temperature sensor 32 and the set temperature.

[0030]

Further, the control unit 61 controls the opening degree of the damper 9a such that a detected value of the temperature sensor 31 provided in the refrigerator compartment 21 is a set temperature stored in the memory unit 64. That is, when the detected value of the temperature sensor 31 is higher than the set temperature, the control unit 61 opens the damper 9a and supplies cooled air to the refrigerator compartment 21. When the detected value of the temperature sensor 31 is lower than the set temperature, the control unit 61 closes the damper 9a. During the supply of the cooled air to the refrigerator compartment 21, the opening degree of the damper 9a may be changed depending on the difference between the detected value of the temperature sensor 31 and the set temperature.

[0031]

Similarly, the control unit 61 controls the opening degree of the damper 9b such that a detected value of the temperature sensor 33 provided in the vegetable compartment 23 is a set temperature stored in the memory unit 64. That is, when the detected value of the temperature sensor 33 is higher than the set temperature, the control unit 61 opens the damper 9b and supplies cooled air to the vegetable compartment 23. When the detected value of the temperature sensor 33 is lower than the set temperature, the control unit 61 closes the damper 9b. During the supply of the cooled air to the vegetable compartment 23, the opening degree of the damper 9b may be changed depending on the difference between the detected value of the temperature sensor 33 and the set temperature.

[0032]

(Defrosting Operation)

During the normal operation, when the door of the storage compartment is opened and closed for taking in or out, for example, food or for some other purpose, wet air outside the refrigerator flows into the storage compartment. Further, moisture is also generated from, for example, food stored in the storage compartment. Thus, air returned from the storage compartment to the airflow path 3 contains moisture generated from, for example, food. Therefore, as the normal operation continues, the moisture contained in the return air from the storage compartment is formed into frost and adheres to the cooler 54. With increase in amount of frost formation on the cooler 54, the cooling performance of the cooler 54 deteriorates. It is thus required to regularly remove the frost adhered to the cooler 54.

[0033]

In Embodiment 1, for example, when the operation time of the refrigerator 100 exceeds a prescribed time stored in the memory unit 64, the control unit 61 defrosts the cooler 54, that is, performs the defrosting operation on the cooler 54. This prescribed time is one day, for example. Further, the clock unit 63 measures the operation of the refrigerator 100.

For example, even when the inside of the freezer compartment 22 cannot be cooled to the set temperature despite continuation to drive the compressor 51 for a fixed time or longer, the control unit 61 performs the defrosting operation. Whether or not the compressor 51 has been continuing to drive for the fixed time or longer is determined by making a comparison between the operation time of the compressor 51 measured by the clock unit 63 and the prescribed time stored in the memory unit 64. For example, the control unit 61 or the determination unit 62 may make this determination.

[0034]

The refrigerator 100 according to Embodiment 1 includes a temperature sensor 34 configured to detect the temperature of the cooler 54. When a detected value of the temperature sensor 34 exceeds a prescribed temperature stored in the memory unit 64, the defrosting operation is completed. The prescribed temperature is 5

degrees Celsius, for example. That is, the control unit 61 stops energizing the radiant heater 11. As described later, frost begins to be deposited on the cooler 54 from the lower end side being the air inlet. When the defrosting operation is performed, the frost adhered to the lower end side of the cooler 54 finishes melting in the end. Thus, the temperature sensor 34 used for the determination to complete the defrosting operation is preferably provided in the vicinity of the lower end of the cooler 54.

The temperature sensor 34 corresponds to the first temperature sensor of the present invention.

[0035]

In the related-art refrigerator, at the time of performing the defrosting operation, heating capacity [W] of the heater is constant regardless of the amount of frost formation on the cooler. Thus, the related-art refrigerator has such problems as follows.

[0036]

Fig 4 is a perspective view for illustrating the inside of an airflow path of the refrigerator according to Embodiment 1 of the present invention. The white arrows illustrated in Fig. 4 indicate the direction of the flow of the air in the airflow path 3.

As described above, the return air from each storage compartment flows into the cooler 54 from the lower end of the cooler 54, which serves as the air inlet, and flows out of the upper end of the cooler 54, which serves as the air outlet. At this time, under a state in which no frost is deposited on the cooler 54, the return air from each storage compartment tends to flow into the cooler 54 from the vicinity of the center of the lower end of the cooler 54, in other words, a position apart from the side wall of the airflow path 3, in which the ventilation resistance is low. For this reason, frost begins to be deposited on the cooler 54 from the vicinity of the center of the lower end indicated as a range A in Fig. 4. As more frost is deposited in the range A, the ventilation resistance of the range A increases. Thus, in the cooler 54, as more frost is deposited in the range A, frost also begins to be deposited in a range B of the lower end. After deposition of frost in the ranges A and B, more frost is

deposited on the upper end side of the cooler 54, and hence frost is also deposited in a range C, resulting in that frost is deposited on the entire cooler 54.

[0037]

That is, at a stage at which a small amount of frost is deposited on the cooler 54, the amount of frost formation on the air outlet side of the cooler 54 is smaller than the amount of frost formation on the air inlet side of the cooler 54. Therefore, when the heating capacity of the radiant heater 11 is constant regardless of the amount of frost formation as in the related-art refrigerator, the temperature of the cooler 54 during the defrosting operation is as in Fig. 5 described below.

[0038]

Fig 5 is a graph for showing a change in temperature of the cooler in a state in which a small amount of frost is deposited at the time of defrosting the cooler in the related-art method. The thick solid line illustrated in Fig. 5 indicates the temperature of the cooler 54 in the vicinity of the upper end, namely, the vicinity of the air outlet. Further, the thick broken line illustrated in Fig. 5 indicates the temperature of the cooler 54 in the vicinity of the lower end, namely, the vicinity of the air inlet.

[0039]

When the defrosting operation is started and the cooler 54 is heated by the radiant heater 11, the temperature of the entire cooler 54 increases (state D). When the temperature reaches 0 degrees Celsius being the same as the temperature of frost, the temperature of the entire cooler 54 is kept at 0 degrees Celsius (state E) until the frost finishes melting. As described above, at the stage at which a small amount of frost is deposited on the cooler 54, the amount of frost formation on the upper end side of the cooler 54, which serves as the air outlet side, is smaller than the amount of frost formation on the lower end side of the cooler 54, which serves as the air inlet side. Thus, before the frost in the vicinity of the lower end of the cooler 54 finishes melting, the frost in the vicinity of the upper end of the cooler 54 finishes melting, and the temperature in the vicinity of the upper end of the cooler 54 increases (state F1). At this time, the frost has not finished melting in the vicinity of the lower end in which a larger amount of frost is deposited than in the vicinity of the

upper end, and the vicinity of the lower end is kept at 0 degrees Celsius. Thereafter, when the frost in the vicinity of the lower end of the cooler 54 also finishes melting, the temperature in the vicinity of the lower end of the cooler 54 begins to rise (state G1). When the detected value of the temperature sensor 34 provided to the cooler 54 exceeds the prescribed temperature which is, for example, 5 degrees Celsius, the defrosting operation is completed. That is, the control unit 61 stops energizing the radiant heater 11.

[0040]

At the time of performing the defrosting operation on the cooler 54 in the state in which a small amount of frost is deposited as thus described, when the heating capacity of the radiant heater 11 is constant regardless of the amount of frost formation as in the related-art refrigerator, the heating capacity is excessively large when the heating capacity has been set with the defrosting operation at the time of a large amount of frost formation taken as a reference. For this reason, the rate of rise in temperature increases in the vicinity of the upper end of the cooler 54 in the state F1. That is, the vicinity of the upper end of the cooler 54 is excessively heated before the temperature in the vicinity of the lower end of the cooler 54 rises. Thus, as indicated by Ta in Fig. 5, when the defrosting operation is completed, the temperature in the vicinity of the upper end of the cooler 54 has risen excessively. When the operation returns to the normal operation, air supplied to the storage compartment is therefore heated on the upper end side of the cooler 54 to cause a rise in temperature inside the storage compartment. Further, this leads to the need to consume power for cooling again the air in the storage compartment with its temperature having risen, thereby increasing power consumption.

[0041]

In order to solve the above-mentioned problems, reduction of the heating capacity of the radiant heater 11 is conceivable. However, in such a case where the heating capacity of the radiant heater 11 is reduced, in the related-art method in which the heating capacity of the radiant heater 11 is constant regardless of the amount of frost formation, the defrosting takes long time when the cooler 54 with a

large amount of frost formation thereon is to be defrosted. That is, the cooled air cannot be supplied to the storage compartment over a long period of time. Thus, in the case of performing the defrosting operation by the related-art method, the temperature inside the storage compartment increases even when the heating capacity of the radiant heater 11 is reduced. Further, this leads to the need to consume power for cooling again the air in the storage compartment with its temperature having risen, thereby increasing the power consumption.

[0042]

Therefore, in the refrigerator 100 according to Embodiment 1, the heating capacity of the radiant heater 11 is made different between a first defrosting operation in the first frost formation state in which a large amount of frost is deposited on the cooler 54 and a second defrosting operation in the second frost formation state in which a small amount of frost is deposited on the cooler 54. More specifically, in the refrigerator 100 according to Embodiment 1, a second capacity being the heating capacity of the radiant heater 11 during the second frost formation operation is made smaller than a first capacity being the heating capacity of the radiant heater 11 during the first frost formation operation. For example, the second capacity being the heating capacity of the radiant heater 11 during the second frost formation operation is set to 50% of the rated capacity, and the first capacity being the heating capacity of the radiant heater 11 during the first frost formation operation is set to 100% of the rated capacity.

[0043]

Fig 6 is a graph for showing a change in temperature of the cooler in the state in which a small amount of frost is deposited at the time of defrosting the cooler in the refrigerator according to Embodiment 1 of the present invention. The thick solid line illustrated in Fig. 6 indicates the temperature of the cooler 54 in the vicinity of the upper end, namely, the vicinity of the air outlet. Further, the thick broken line illustrated in Fig. 6 indicates the temperature of the cooler 54 in the vicinity of the lower end, namely, the vicinity of the air inlet.

[0044]

Also in the refrigerator 100 according to Embodiment 1, the change in temperature of the cooler 54 during the defrosting operation is basically the same as the related-art case. When the defrosting operation is started and the cooler 54 is heated by the radiant heater 11, the temperature of the entire cooler 54 increases (state D). When the temperature reaches 0 degrees Celsius being the same as the temperature of frost, the temperature of the entire cooler 54 is kept at 0 degrees Celsius (state E) until the frost finishes melting. As described above, in the second frost formation state in which a small amount of frost is deposited on the cooler 54, the amount of frost formation on the upper end side of the cooler 54, which serves as the air outlet side, is smaller than the amount of frost formation on the lower end side of the cooler 54, which serves as the air inlet side. Thus, before the frost in the vicinity of the lower end of the cooler 54 finishes melting, the frost in the vicinity of the upper end of the cooler 54 finishes melting, and the temperature in the vicinity of the upper end of the cooler 54 rises (state F2).

[0045]

At this time, in the refrigerator 100 according to Embodiment 1, the heating capacity of the radiant heater 11 is made smaller during the second defrosting operation in the second frost formation state in which a small amount of frost is deposited on the cooler 54. For this reason, in a state in which the rise in temperature in the vicinity of the lower end, in which the amount of frost formation is larger than in the vicinity of the upper end, has not started, the rise in temperature in the vicinity of the upper end of the cooler 54 is gentle. Consequently, the refrigerator 100 according to Embodiment 1 can prevent the rise in temperature in the vicinity of the upper end of the cooler 54 at the time when the defrosting operation is completed, as indicated by Tb in Fig. 6. That is, when the operation is returned to the normal operation, the refrigerator 100 according to Embodiment 1 can prevent the air supplied to the storage compartment from being heated on the upper end side of the cooler 54 and prevent the temperature inside the storage compartment from rising. The refrigerator 100 according to Embodiment 1 can also reduce the power

consumption for cooling again the air in the storage compartment with its temperature having risen.

[0046]

Further, the refrigerator 100 according to Embodiment 1 increases the heating capacity of the radiant heater 11 during the first defrosting operation in the first frost formation state in which a large amount of frost is deposited on the cooler 54. Thus, the refrigerator 100 according to Embodiment 1 can prevent the first defrosting operation from taking long time. That is, even when the operation is returned to the normal operation after the first defrosting operation, the refrigerator 100 according to Embodiment 1 can prevent the rise in temperature inside the storage compartment and reduce the power consumption for cooling again the air in the storage compartment with its temperature having risen.

[0047]

The heating capacity of the radiant heater 11 may be controlled as follows in the second defrosting operation in the second frost formation state in which a small amount of frost is deposited on the cooler 54.

[0048]

Fig 7 is a graph for showing another example of the defrosting operation in the state in which a small amount of frost is deposited in the refrigerator according to Embodiment 1 of the present invention.

For example, in the second defrosting operation in the second frost formation state in which a small amount of frost is deposited on the cooler 54, the heating capacity of the radiant heater 11 may be made larger than the second capacity until the frost in the vicinity of the upper end of the cooler 54, which serves as the air outlet side, finishes melting. For example, the heating capacity of the radiant heater 11 may be set to 100% of the rated capacity. Thereafter, the heating capacity of the radiant heater 11 may be reduced so as to be the second capacity. For example, the heating capacity of the radiant heater 11 may be set to 50% of the rated capacity. Through control of the heating capacity of the radiant heater 11 in this manner, the time for the second defrosting operation can be reduced, and the temperature inside

the storage compartment can be prevented from rising during the second defrosting operation.

[0049]

When the heating capacity of the radiant heater 11 is to be controlled as thus described, the heating capacity of the radiant heater 11 may be increased in a state in which the detected value of the temperature sensor 34, which is configured to detect the temperature of the cooler 54, is smaller than the prescribed value stored in the memory unit 64, and the heating capacity of the radiant heater 11 may be reduced after the detected value of the temperature sensor 34 increases to the prescribed value or more. The prescribed value here is lower than the prescribed temperature that is used for determining the completion of the defrosting operation, and is higher than 0 degrees Celsius, such as 1 degree Celsius. The detected value of the temperature sensor 34 and the prescribed value are compared by the control unit 61, for example.

[0050]

(Determination of Amount of Frost Formation)

The determination of the frost formation state of the cooler 54 as described above is made as follows, for example.

[0051]

Fig 8 is a graph for showing a change in temperature of the cooler at the time of energizing the radiant heater in the refrigerator according to Embodiment 1 of the present invention. Fig. 9 is a flowchart for illustrating one example of a method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[0052]

The heating capacity of the cooler 54 is determined based on a material used for the cooler 54, a size of the material, and other factors. When frost adheres to the cooler 54, the heating capacity of the cooler 54 is a value obtained by adding thereto the heating capacity of the frost. From the heating capacity of the cooler 54 and the heating capacity of the radiant heater 11, it is possible to estimate the amount of

temperature rise of the cooler 54 at the time of heating the cooler 54 with the radiant heater 11 just for a prescribed time t_1 . That is, as illustrated in Fig. 8, when the cooler 54 is heated with the radiant heater 11 just for the prescribed time t_1 , as the amount of frost formation increases, the amount of temperature rise of the cooler 54 is reduced. It is thus possible to determine the amount of frost formation on the cooler 54 by using this amount of temperature rise.

[0053]

In this case, the determination unit 62 determines the amount of frost formation on the cooler 54 in accordance with the flowchart of Fig. 9, for example.

When the operation is switched from the normal operation to the defrosting operation, that is, when the defrosting operation is started, the determination unit 62 starts determination of the amount of frost formation (Step S11). In Step S12, the determination unit 62 acquires a detected value T_1 of the temperature sensor 34, namely, a temperature T_1 of the cooler 54, before the radiant heater 11 is energized. After Step S12, in Step S13, the control unit 61 energizes the radiant heater 11 to start heating the cooler 54. The heating capacity of the radiant heater 11 at this time is freely selectable.

[0054]

After Step S13, in Step S14, the clock unit 63 measures the heating time of the radiant heater 11. When the measured time of the clock unit 63 reaches the prescribed time t_1 stored in the memory unit 64, in Step S15, the determination unit 62 acquires a detected value T_2 of the temperature sensor 34, namely, a temperature T_2 of the cooler 54, and calculates a temperature difference ΔT being a value obtained by subtracting T_1 from T_2 . Thereafter, in Step S16, the determination unit 62 makes a comparison to see whether or not the temperature difference ΔT is larger than a first determination value stored in the memory unit 64. When the temperature difference ΔT is larger than the first determination value, the determination unit 62 determines that the frost formation state of the cooler 54 is the second frost formation state in which a small amount of frost is deposited (Step S17). When the temperature difference ΔT is the first determination value or less, the determination

unit 62 determines that the frost formation state of the cooler 54 is the first frost formation state in which a large amount of frost is deposited (Step S18).

[0055]

Alternatively, for example, the determination of the frost formation state of the cooler 54 may be made as follows.

[0056]

Fig. 10 is a graph for showing a relationship between the operation time from the end of the defrosting operation and the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention. Fig. 11 is a graph for showing a relationship between the frequency of opening/closing of the door and the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention. Fig. 12 is a longitudinal sectional side view for illustrating one example of the refrigerator according to Embodiment 1 of the present invention. Fig. 13 is a flowchart for showing one example of the method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[0057]

When the normal operation is resumed after the completion of the defrosting operation, as shown in Fig. 10, with the lapse of time, the amount of frost formation on the cooler 54 increases in a linear functional manner, for example. When the door of the storage compartment is opened and closed, wet air outside the refrigerator 100 flows into the storage compartment. Thus, as shown in Fig. 11, the amount of frost formation on the cooler 54 increases in a stepwise manner every time the door is opened and closed. That is, the frequency of opening/closing of the door and the amount of frost formation on the cooler 54 are in a proportional relationship. It is thus possible to estimate, in other words, determine the amount of frost formation on the cooler 54 based on the time from the previous defrosting operation to the present defrosting operation and the frequency of opening/closing of the door during that time.

[0058]

In this case, as illustrated in Fig. 12, the refrigerator 100, there may be provided a door opening/closing sensor 35 configured to detect the opening/closing of the door 24 of the refrigerator compartment 21, a door opening/closing sensor 35 configured to detect the opening/closing of the door 25 of the freezer compartment 22, and a door opening/closing sensor 35 configured to detect the opening/closing of the door 25 of the vegetable compartment 23. Further, the determination unit 62 may determine the amount of frost formation on the cooler 54 in accordance with the flowchart of Fig. 13, for example.

[0059]

That is, when the defrosting operation is completed, the determination unit 62 starts determination of the amount of frost formation (Step S21). In Step S22, based on a detected value of the door opening/closing sensor 35, the determination unit 62 determines whether or not any of the doors of the storage compartments has been opened and closed. When any of the doors of the storage compartments has been opened and closed, in Step S24, the determination unit 62 adds "1" to the frequency of opening/closing of the door stored in the memory unit 64. The frequency of opening/closing of the door is "0" at the time point of start of the defrosting operation.

[0060]

In Step S23, the clock unit 63 measures elapsed time from the completion of the defrosting operation. Further, in Step S23, the determination unit 62 acquires the elapsed time measured by the clock unit 63. In Step S25, the determination unit 62 determines whether or not to start the defrosting operation. That is, the determination unit 62 determines whether or not the elapsed time measured by the clock unit 63 has exceeded the prescribed time stored in the memory unit 64. When the defrosting operation is not started, Step S22 to Step S25 are repeated.

[0061]

When the defrosting operation is started, in Step S26, the determination unit 62 estimates the amount of frost formation on the cooler 54 based on the time from the previous defrosting operation to the present defrosting operation and the frequency of opening/closing of the door during that time. The relationship between the elapsed

time from the completion of the defrosting operation and the amount of frost formation on the cooler 54, which is shown in Fig. 10, is stored in the memory unit 64 as a table or a mathematical expression. Further, the relationship between the frequency of opening/closing of the door and the amount of frost formation on the cooler 54, which is shown in Fig. 11, is stored in the memory unit 64 as a table or a mathematical expression. The determination unit 62 estimates an amount x of frost formation on the cooler 54 by using that table or mathematical expression.

[0062]

After Step S26, in Step S27, the determination unit 62 determines whether or not the estimated amount x of frost formation is larger than a second determination value stored in the memory unit 64. When the amount x of frost formation is larger than the second determination value, the determination unit 62 determines that the frost formation state of the cooler 54 is the first frost formation state in which a large amount of frost is deposited (Step S28). When the amount x of frost formation is the second determination value or less, the determination unit 62 determines that the frost formation state of the cooler 54 is the second frost formation state in which a small amount of frost is deposited (Step S29).

[0063]

The door opening/closing sensor 35 here is not necessarily required to be provided correspondingly to every door, and may be provided correspondingly to at least one door. When the door opening/closing sensor 35 is provided correspondingly to some of the doors, as compared to a case in which the door opening/closing sensor 35 is provided correspondingly to every door, the accuracy in estimation of the amount of frost formation on the cooler 54 deteriorates, but the number of the door opening/closing sensors 35 can be reduced, thereby enabling inexpensive manufacturing of the refrigerator 100. When the door opening/closing sensor 35 is provided correspondingly to some of the doors, the door opening/closing sensor 35 configured to detect the opening/closing of the door 24 of the refrigerator compartment 21 may be provided. The door 24 of the refrigerator compartment 21 is the door most likely to be opened and closed, and thus wet air outside the

refrigerator 100 is most likely to flow into the refrigerator compartment 21. That is, the wet air outside the refrigerator 100 having flowed into the refrigerator compartment 21 is most likely to be deposited on the cooler 54.

[0064]

5 Alternatively, for example, the determination of the frost formation state of the cooler 54 may be made as follows.

[0065]

Fig. 14 is a graph for showing air flow-static pressure characteristics (P-Q characteristics) of the fan of the refrigerator according to Embodiment 1 of the present invention. Fig. 15 is a longitudinal sectional side view for illustrating one example of the refrigerator according to Embodiment 1 of the present invention. Fig. 16 is a flowchart for illustrating one example of the method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

15 [0066]

When the normal operation is resumed after the completion of the defrosting operation, with the lapse of time, the amount of frost formation on the cooler 54 increases. The sectional area of the airflow path in the cooler 54 decreases as the amount of frost formation on the cooler 54 increases, and hence the ventilation resistance of air, which is sucked by the fan 10 and passes through the cooler 54, increases from H1 to H2, as shown in Fig. 14. Further, a current value that is input into the fan 10 also increases. It is thus possible to determine the amount of frost formation on the cooler 54 by using the current value that is input into the fan 10.

[0067]

25 In this case, as illustrated in Fig. 15, an input current detecting sensor 36 configured to detect a current value that is input into the fan 10 may be provided in the refrigerator 100. Further, the determination unit 62 may determine the amount of frost formation on the cooler 54 in accordance with the flowchart of Fig. 16, for example.

30 [0068]

That is, when the operation is switched from the normal operation to the defrosting operation, the determination unit 62 starts determination of the amount of frost formation (Step S31). Then, in Step S32, the determination unit 62 acquires a detected value y of the input current detecting sensor 36, namely, a current value y
5 that is input into the fan 10. Thereafter, in Step S33, the determination unit 62 makes a comparison to see whether or not the current value y is larger than a third determination value stored in the memory unit 64. When the current value y is larger than the third determination value, the determination unit 62 determines that the frost formation state of the cooler 54 is the first frost formation state in which a large
10 amount of frost is deposited (Step S34). When the current value y is the third determination value or less, the determination unit 62 determines that the frost formation state of the cooler 54 is the second frost formation state in which a small amount of frost is deposited (Step S35).

[0069]

15 The current value that is input into the fan 10 also changes depending on the number of revolutions of the fan 10. The number of revolutions of the fan 10 may be variably controlled depending on the temperature of the cooler 54. Thus, the third determination value may be changed depending on at least one of the number of revolutions of the fan 10 and the temperature of the cooler 54. That is, an
20 expression for obtaining the third determination value by using, as a variable, at least one of the number of revolutions of the fan 10 and the temperature of the cooler 54 may be stored into the memory unit 64.

[0070]

25 The current value that is input into the fan 10 and the power consumption of the fan 10 are in a correspondence relationship where the power consumption increases with increase in current value. For this reason, a sensor configured to detect the power consumption of the fan 10 may be provided in the refrigerator 100, and a detected value of the sensor and the third determination value are compared to determine the frost formation state of the cooler 54.

30 [0071]

Alternatively, for example, the determination of the frost formation state of the cooler 54 may be made as follows.

[0072]

Fig. 17 is a flowchart for illustrating one example of the method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[0073]

When the normal operation is resumed after the completion of the defrosting operation, with the lapse of time, the amount of frost formation on the cooler 54 increases. As described above, as the amount of frost formation on the cooler 54 increases, the ventilation resistance of the cooler 54 also increases. Further, as the amount of frost formation on the cooler 54 increases, the fin efficiency deteriorates due to frost deposited on the surface of the cooler 54 and the heat exchanging performance of the cooler 54 deteriorates. In the refrigeration cycle circuit 50, when the heat exchanging performance of the cooler 54 deteriorates, the temperature of the cooler 54, namely, an evaporating temperature of refrigerant flowing in the cooler 54, decreases. It is thus possible to determine the amount of frost formation on the cooler 54 by using the temperature of the cooler 54, namely, the detected value of the temperature sensor 34.

[0074]

In this case, the determination unit 62 determines the amount of frost formation on the cooler 54 in accordance with the flowchart of Fig. 17, for example.

That is, when the operation is switched from the normal operation to the defrosting operation, the determination unit 62 starts determination of the amount of frost formation (Step S41). In Step S42, the determination unit 62 acquires a detected value T3 of the temperature sensor 34, namely, a temperature T3 of the cooler 54. Thereafter, in Step S43, the determination unit 62 makes a comparison to see whether or not the detected value T3 is larger than a fourth determination value stored in the memory unit 64. When the detected value T3 is larger than the fourth determination value, the determination unit 62 determines that the frost formation

state of the cooler 54 is the second frost formation state in which a small amount of frost is deposited (Step S44). When the detected value T3 is the fourth determination value or less, the determination unit 62 determines that the frost formation state of the cooler 54 is the first frost formation state in which a large amount of frost is deposited (Step S45).

[0075]

When the number of revolutions of the compressor 51 is changed in a state before frost is deposited on the cooler 54, the temperature of the cooler 54, namely, the evaporating temperature of the refrigerant flowing in the cooler 54, changes.

The evaporating temperature of the refrigerant flowing in the cooler 54 may be changed depending on the set temperature of the freezer compartment 22. Thus, the fourth determination value may be changed depending on at least one of the number of revolutions of the compressor 51 and the set temperature of the freezer compartment 22. That is, an expression for obtaining the fourth determination value by using, as a variable, at least one of the number of revolutions of the compressor 51 and the set temperature of the freezer compartment 22 may be stored into the memory unit 64.

[0076]

Alternatively, for example, the determination of the frost formation state of the cooler 54 may be made as follows.

[0077]

Fig. 18 is a graph for showing a relationship between humidity in the storage compartment and the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention. Fig. 19 is a longitudinal sectional side view for illustrating one example of the refrigerator according to Embodiment 1 of the present invention. Fig. 20 is a flowchart for illustrating one example of the method of determining the amount of frost formation on the cooler in the refrigerator according to Embodiment 1 of the present invention.

[0078]

Each storage compartment of the refrigerator 100 is in a sealed state except for the time of opening and closing the door. Thus, the change in humidity in the storage compartment during operation of the refrigerator 100 is proportional to the amount of frost formation on the cooler 54. Specifically, as the humidity in the storage compartment increases, the amount of frost formation on the cooler 54 increases. For example, a line J1 shown in Fig. 18 indicates a state in which the humidity in the storage compartment is low. A line J2 shown in Fig. 18 indicates a state in which the humidity in the storage compartment is high. When a comparison is made between a value obtained by integrating values on the line J1 with respect to time and a value obtained by integrating values on the line J2 with respect to the same time, the integrated value of the line J2 is larger than the integrated value of the line J1. It is thus possible to determine the amount of frost formation on the cooler 54 by using the integrated value of the humidity in the storage compartment.

[0079]

In this case, as illustrated in Fig. 19, a humidity sensor 37 configured to detect the humidity in the refrigerator compartment 21 may be provided in the refrigerator compartment 21. Further, the determination unit 62 may determine the amount of frost formation on the cooler 54 in accordance with the flowchart of Fig. 20, for example.

[0080]

That is, when the defrosting operation is completed, the determination unit 62 starts determination of the amount of frost formation (Step S51). In Step S52, the determination unit 62 acquires detected values of the humidity sensor 37 and calculates an integrated value K of the detected values. After Step S52, in Step S53, the clock unit 63 measures elapsed time from the completion of the defrosting operation. Further, in Step S53, the determination unit 62 acquires the elapsed time measured by the clock unit 63. In Step S54, the determination unit 62 determines whether or not to start the defrosting operation. That is, the determination unit 62 determines whether or not the elapsed time measured by the clock unit 63 has exceeded the prescribed time stored in the memory unit 64. When the defrosting

operation is not started, Step S52 to Step S54 are repeated. That is, the determination unit 62 continues to integrate the detected values of the humidity sensor 37 to update the integrated value K. This integrated value K is stored into the memory unit 64, for example.

5 [0081]

When the defrosting operation is started, in Step S55, the determination unit 62 compares the integrated value K of the detected value of the humidity sensor 37 from the previous defrosting operation to the present defrosting operation and a fifth determination value stored in the memory unit 64. When the integrated value K is larger than the fifth determination value, the determination unit 62 determines that the frost formation state of the cooler 54 is the first frost formation state in which a large amount of frost is deposited (Step S56). When the integrated value K is the fifth determination value or less, the determination unit 62 determines that the frost formation state of the cooler 54 is the second frost formation state in which a small amount of frost is deposited (Step S57).

15 [0082]

The installation position of the humidity sensor 37 illustrated in Fig. 19 is merely an example. When the temperature of the air is 0 degrees Celsius or more, the humidity is easily detected, and the humidity sensor 37 may thus be provided in, for example, the vegetable compartment 23. Alternatively, for example, the humidity sensor 37 may be provided in every storage compartment. This improves the accuracy in estimation of the amount of frost formation on the cooler 54.

20 [0083]

Embodiment 2

25 In Embodiment 1, the radiant heater 11 configured to heat the entire cooler 54 by radiant heat is used for defrosting the cooler 54. However, the heater used for defrosting the cooler 54 is not limited to the radiant heater 11. For example, along with the radiant heater 11 or in place of the radiant heater 11, a contact type heater may be provided in contact with the cooler 54 in the refrigerator 100. Also in this case, the amount of frost formation on the cooler 54 may be determined by using the

method of determining the amount of frost formation, which is described above.

Then, in the first defrosting operation in the first frost formation state in which a large amount of frost is deposited on the cooler 54, the first capacity, namely, the heating capacity of the contact type heater, may be increased to 100% of the rated capacity,

5 for example. Then, in the second defrosting operation in the second frost formation state in which a small amount of frost is deposited on the cooler 54, the second capacity, namely, the heating capacity of the contact type heater, may be reduced to 50% of the rated capacity, for example. Therefore, as described in Embodiment 1, both in the first frost formation state and the second frost formation state, it is possible
10 to prevent the rise in temperature inside the storage compartment and reduce the power consumption for cooling again the air in the storage compartment with its temperature having risen.

[0084]

When the contact type heater is provided in the refrigerator 100, the amount of
15 frost formation on the cooler 54 can be determined by such a method as follows. A configuration not described in Embodiment 2 is considered similar to that in Embodiment 1, and the configuration similar to that in Embodiment 1 is denoted by the same reference symbol as in Embodiment 1.

[0085]

20 Fig. 21 is a longitudinal sectional side view for illustrating one example of a refrigerator according to Embodiment 2 of the present invention. Fig. 22 is a perspective view for illustrating the inside of an airflow path of the refrigerator according to Embodiment 2 of the present invention. Fig. 23 is a flowchart for illustrating one example of a method of determining the amount of frost formation on a
25 cooler in the refrigerator according to Embodiment 2 of the present invention.

[0086]

As illustrated in Fig. 21 and Fig. 22, the refrigerator 100 according to Embodiment 2 includes a contact type heater 12 provided in contact with the cooler 54, in place of the radiant heater 11. Further, a temperature sensor 38 configured to

detect the temperature of that contact type heater 12 is provided to the contact type heater 12.

The temperature sensor 38 here corresponds to the second temperature sensor of the present invention.

5 [0087]

In the refrigerator 100 as thus configured, at the time of defrosting operation, the cooler 54 is directly heated by the contact type heater 12 to defrost the cooler 54. The contact type heater 12 is in contact with the cooler 54, and is thus cooled by frost adhered to the cooler 54. Accordingly, when the contact type heater 12 is energized at the time of defrosting operation and the prescribed time t_1 elapses, as the amount of frost formation on the cooler 54 increases, the amount of temperature rise of the contact type heater 12 is reduced. It is thus possible to determine the amount of frost formation on the cooler 54 by using this amount of temperature rise.

[0088]

15 In this case, the determination unit 62 determines the amount of frost formation on the cooler 54 in accordance with the flowchart of Fig. 23, for example.

When the operation is switched from the normal operation to the defrosting operation, that is, when the defrosting operation is started, the determination unit 62 starts determination of the amount of frost formation (Step S61). In Step S62, the determination unit 62 acquires a detected value T_4 of the temperature sensor 38, namely, a temperature T_4 of the contact type heater 12, before the contact type heater 12 is energized. After Step S62, in Step S63, the control unit 61 energizes the contact type heater 12 to start heating the cooler 54. The heating capacity of the contact type heater 12 at this time is freely selectable.

25 [0089]

After Step S63, in Step S64, the clock unit 63 measures the heating time of the contact type heater 12. When the measured time of the clock unit 63 reaches the prescribed time t_1 stored in the memory unit 64, in Step S65, the determination unit 62 acquires a detected value T_5 of the temperature sensor 38, namely, a temperature T_5 of the contact type heater 12, and calculates a temperature difference ΔT being a

value obtained by subtracting T4 from T5. Thereafter, in Step S66, the determination unit 62 makes a comparison to see whether or not the temperature difference ΔT is larger than a sixth determination value stored in the memory unit 64. When the temperature difference ΔT is larger than the sixth determination value, the determination unit 62 determines that the frost formation state of the cooler 54 is the second frost formation state in which a small amount of frost is deposited (Step S67). When the temperature difference ΔT is the sixth determination value or less, the determination unit 62 determines that the frost formation state of the cooler 54 is the first frost formation state in which a large amount of frost is deposited (Step S68).

[0090]

In each Embodiment 1 and Embodiment 2 described above, the amount of frost formation on the cooler 54 is determined using one determination value. Then, as shown in Fig. 24, with the determination value taken as the reference, the heating capacity of the heater is increased when the amount of frost formation is larger than the determination value, and the heating capacity of the heater is reduced when the amount of frost formation is smaller than the determination value. However, the method of determining the amount of frost formation on the cooler 54 in the present invention is not limited to those methods.

[0091]

For example, as shown in Fig. 25, the amount of frost formation on the cooler 54 may be determined using a plurality of determination values. That is, with each determination value taken as a border, the heating capacity of the heater may be increased when the amount of frost formation is larger than the determination value, and the heating capacity of the heater may be reduced when the amount of frost formation is smaller than the determination value. It is possible to set the heating capacity of the heater to an appropriate value depending on the amount of frost formation on the cooler 54. That is, it is possible to further prevent the storage compartment from being warmed and further reduce the defrosting time. In this case, as for each determination value, the state in which the amount of frost formation is larger than the determination value corresponds to the first frost formation state of

the present invention, and the state in which the amount of frost formation is smaller than the determination value corresponds to the second frost formation state of the present invention.

[0092]

Further, each value that is compared to each determination value in determination of the amount of frost formation on the cooler 54 is in a proportional relationship to the amount of frost formation on the cooler 54 as described above. For this reason, for example, as shown in Fig. 26, the heating capacity of the heater may be continuously changed depending on each value compared to each determination value in determination of the amount of frost formation, namely, the amount of frost formation on the cooler 54. In other words, as the amount of frost formation decreases, the heating capacity of the heater may be reduced. In this case, assuming that an arbitrary state of the amount of frost formation is the first frost formation state of the present invention, a state in which a smaller amount of frost is deposited than in the above-mentioned state is the second frost formation state of the present invention.

[0093]

The method of determining the amount of frost formation on the cooler 54 described in each of Embodiment 1 and Embodiment 2 is not necessarily performed in an independent manner, but a plurality of methods of determining the amount of frost formation may be performed simultaneously. This enables more accurate determination of the amount of frost formation on the cooler 54.

Reference Signs List

[0094]

1 casing 1a inner box 1b outer box 2 machine room 3
airflow path 4 blowoff airflow path 5 blowoff airflow path 6 blowoff airflow
path 7 return airflow path 8 return airflow path 9a damper 9b damper 10
fan 11 radiant heater 12 contact type heater 21 refrigerator compartment 22
freezer compartment 23 vegetable compartment 24 door 25 door 26

door 31 temperature sensor 32 temperature sensor 33 temperature sensor 34
temperature sensor 35 door opening/closing sensor 36 input current
detecting sensor 37 humidity sensor 38 temperature sensor 50
refrigeration cycle circuit 51 compressor 52 radiator 53 pressure reducing
5 device 54 cooler 60 controller 61 control unit 62 determination
unit 63 clock unit 64 memory unit 70 electric circuit 71 power source 72
first wiring portion 73 second wiring portion 74 resistor 75 switch 76 first
power source 77 second power source 100 refrigerator

CLAIMS

[Claim 1]

A refrigerator comprising:

a storage compartment;

an airflow path which communicates with the storage compartment;

a cooler which is provided in the airflow path, and is configured to cool air flowing in the airflow path; and

a heater which is configured to heat the cooler in a first frost formation state in which frost is deposited on the cooler and in a second frost formation state in which less frost is deposited on the cooler than in the first frost formation state,

wherein the refrigerator is configured to perform with the heater:

a first defrosting operation for heating the cooler in the first frost formation state; and

a second defrosting operation for heating the cooler in the second frost formation state,

wherein, in the first defrosting operation, heating capacity of the heater is a first capacity, and in the second defrosting operation, heating capacity of the heater is a second capacity, and

wherein the second capacity is smaller than the first capacity.

[Claim 2]

The refrigerator of claim 1, wherein, in the second defrosting operation, the heating capacity of the heater is larger than the second capacity in a state in which a temperature of the cooler is lower than a prescribed value, and

the heating capacity of the heater becomes the second capacity after the temperature of the cooler increases to the prescribed value or more.

[Claim 3]

The refrigerator of claim 1 or 2, further comprising:

a first wiring portion which has a resistor;

a second wiring portion which has a lower resistance than a resistance of the first wiring portion, and is connected in parallel to the first wiring portion between the heater and a power source; and

a switch which is configured to switch between a closed circuit in which the power source, the first wiring portion, and the heater are connected, and a closed circuit in which the power source, the second wiring portion, and the heater are connected.

[Claim 4]

The refrigerator of claim 1 or 2, further comprising a switch which is configured to switch between a closed circuit in which a first power source and the heater are connected and a closed circuit in which a second power source which is configured to supply a different voltage from a voltage supplied by the first power source and the heater are connected.

[Claim 5]

The refrigerator of any one of claims 1 to 4, further comprising:

a determination unit which is configured to determine whether an amount of frost formation on the cooler is in the first frost formation state or in the second frost formation state; and

a control unit which is configured to control the heating capacity of the heater based on a determination result of the determination unit.

[Claim 6]

The refrigerator of claim 5, further comprising a first temperature sensor which is configured to detect a temperature of the cooler,

wherein the determination unit is configured to, at a start of the defrosting operation:

subtract a detected value of the first temperature sensor before energization of the heater from a detected value of the first temperature sensor after a lapse of a prescribed time from the energization of the heater;

determine that a state of frost formation on the cooler is the second frost formation state when a value obtained by the subtraction is larger than a first determination value; and

determine that the state of frost formation on the cooler is the first frost formation state when the value obtained by the subtraction is the first determination value or less.

[Claim 7]

The refrigerator of claim 5 or 6, further comprising:

a door which is configured to openably-closably cover an opening portion of the storage compartment; and

a door opening-closing sensor which is configured to detect opening-closing of the door,

wherein the determination unit is configured to estimate an amount of frost formation on the cooler based on time from a previous defrosting operation to a present defrosting operation and a frequency of opening-closing of the door during the time,

wherein the determination unit is configured to determine that a state of frost formation on the cooler is the second frost formation state when the estimated value is a second determination value or less, and

wherein the determination unit is configured to determine that the state of frost formation on the cooler is the first frost formation state when the estimated value is larger than the second determination value.

[Claim 8]

The refrigerator of any one of claims 5 to 7, further comprising:

a fan which is provided in the airflow path, and is configured to send air cooled by the cooler to the storage compartment; and

a sensor which is configured to detect a current value to be input into the fan or power consumption of the fan,

wherein the determination unit is configured to determine that a state of frost formation on the cooler is the second frost formation state when a detected value of the sensor is a third determination value or less, and

wherein the determination unit is configured to determine that the state of frost formation on the cooler is the first frost formation state when the detected value of the sensor is larger than the third determination value.

[Claim 9]

The refrigerator of any one of claims 5 to 8, further comprising a first temperature sensor which is configured to detect a temperature of the cooler,

wherein the determination unit is configured to determine that a state of frost formation on the cooler is the second frost formation state when a detected value of the first temperature sensor is larger than a fourth determination value, and

wherein the determination unit is configured to determine that the state of frost formation on the cooler is the first frost formation state when the detected value of the sensor is the fourth determination value or less.

[Claim 10]

The refrigerator of any one of claims 5 to 9, further comprising a humidity sensor which is configured to detect humidity in the storage compartment,

wherein the determination unit is configured to obtain an integrated value of detected values of the humidity sensor from a previous defrosting operation to a present defrosting operation,

wherein the determination unit is configured to determine that a state of frost formation on the cooler is the second frost formation state when the integrated value is a fifth determination value or less, and

wherein the determination unit is configured to determine that the state of frost formation on the cooler is the first frost formation state when the integrated value is larger than the fifth determination value.

[Claim 11]

The refrigerator of any one of claims 5 to 10,

wherein the heater includes a contact type heater which is provided in contact with the cooler,

wherein the refrigerator further comprises a second temperature sensor which is configured to detect a temperature of the contact type heater, and

5 wherein the determination unit is configured to, at a start of the defrosting operation:

 subtract a detected value of the second temperature sensor before energization of the contact type heater from a detected value of the second temperature sensor after a lapse of a prescribed time from the energization of the contact type heater;

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 determine that a state of frost formation on the cooler is the second frost formation state when a value obtained by the subtraction is larger than a sixth determination value; and

 determine that the state of frost formation on the cooler is the first frost formation state when the value obtained by the subtraction is the sixth determination value or less.

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