REFRIGERATOR WITH DAMPER UNIT CONTROLLING FLOW OF COLD AIR

This invention relates to a refrigerator provided with a duct through which cold air generated by an evaporator and a damper unit which is disposed in the duct to control flow of the cold air.

Household refrigerators have conventionally been provided with an evaporator disposed in an evaporator compartment defined by a lower inner part of rear wall of the refrigerator body. A duct is also defined along the inner rear wall of the refrigerator body so as to extend upward from the evaporator compartment. Cold air generated by the evaporator is supplied into storage compartments such as a mode-changeable compartment in which an interior temperature is changeable according to refrigeration modes. A damper unit is incorporated in the damper to control flow of cold air supplied into the storage compartments.

For example, JP-H10-205957A discloses a refrigerator provided with a damper unit of the above-mentioned type. FIG. 10 illustrates an appearance of the disclosed damper unit 1. The damper unit 1 comprises a frame 2 which is disposed so as to vertically divide an interior of a duct (not shown) into two parts. The frame 2 is formed with an opening 2a. The damper unit 1 further comprises a baffle plate 4 closing and opening the opening 2a of the frame 2. A drive mechanism 3 is provided for pivotally moving the baffle plate 4. The frame 2, drive mechanism 3 and baffle plate 4 are integrated into a unit.

The drive mechanism 3 includes a vertically long rectangular box-shaped case 6 made from a synthetic resin and

a damper motor 7 and a gear mechanism (not shown) provided in the case 6. The case 6 has an inner face 6a directed to the inside of the duct. The inner face 6a includes a lower rear end from which a rotational shaft 8 horizontally protrudes. The rotational shaft 8 is rotatively moved by the damper motor 7 and the gear mechanism.

The baffle plate 4 is made from a synthetic resin and formed into the shape of a rectangular plate. The baffle plate 4 is connected to the rotational shaft 8. Furthermore, the baffle plate 4 includes an inner face (underside) on which is provided a sealing member 5 closely adhering to a periphery of the opening 2a when the opening has been closed. The frame 2 is made from a synthetic resin and formed into the shape of a rectangular frame. The frame 2 is formed integrally with the case 6 so as to extend from the inner face 6a of the case 6 of the drive mechanism 3 horizontally toward the inside.

In the damper unit 1 unitized as described above, the drive mechanism 3 is built into the damper unit 1 so as to be fitted into a recess of the heat-insulating material constituting a wall of the duct although this construction is not shown. In this case, the case 6 is disposed so that the inner face 6a thereof facing the interior of the duct. A control device (not shown) controls the damper motor 7 so that the baffle plate 4 is opened and closed, whereby cold air is controlled so as to flow along the duct toward a storage compartment.

A cooling efficiency is reduced with increase in an amount of frost formed on the evaporator in the above-described refrigerator. Accordingly, a cooling operation is interrupted

and a defrosting operation for energizing a defrosting heater is carried out periodically or when a cumulative operating time has reached a predetermined period of time, for example. In the defrosting operation, the frost formed on the cooler is melted by heat generated by the heater. As a result, a cooler compartment and the duct are filled with damp air with relatively higher temperature.

The temperature in the storage compartment side is lower than in the cooler compartment during the defrosting operation. With this, most components of the above-described conventional damper unit 1 are made from synthetic resin, whereas the damper motor 7 having a metal motor frame is provided in the case 6. Accordingly, since the case 6 has a larger heat capacity than the other part, the temperature of the case 6 is not increased so high even during the defrosting operation, whereupon the temperature remains low.

As a result, dew condenses on the inner face 6a of the case 6 when the baffle plate 4 is opened after completion of the defrosting operation. Dew condensation water sometimes flows down, collecting on the rotational shaft 8. When collecting near the rotational shaft 8, the dew condensation water freezes up upon re-start of the cooling operation after defrosting such that the rotational shaft 8 sticks to the case 6 or the frame 2. Consequently, there is a possibility that the opening/closing operation of the baffle plate 4 may be affected. A heater for heating the case 6 of the drive mechanism 3, for example, a sheet heater comprising a cord heater attached to an aluminum foil sheet has been attempted for the purpose of preventing dew condensation

on the damper unit 1. However, addition of a heater would complicate the construction of the refrigerator and increase the costs of the refrigerator.

Embodiments of the present invention seek to provide a refrigerator which includes a damper unit provided in a duct and which can prevent dew condensation on the damper unit and freeze-up of the baffle plate by a simplified and cost-effective construction.

In accordance with a first aspect of the present invention, there is provided a refrigerator comprising a storage compartment, an evaporator provided for producing cold air, a duct provided for supplying the cold air from the evaporator into the storage compartment, a damper unit provided in the duct and including a damper motor serving as a drive source and a baffle plate opened and closed by the damper motor, and a control device provided for controlling the damper motor so that the baffle plate is opened and closed, thereby controlling flow of the cold air into the storage compartment, the control device further controlling the damper motor so that the damper motor is energized for self-heating.

The control device controls the damper motor so that the damper motor is energized for self-heating as well as so that the baffle plate is opened and closed for control of flow of the cold air into the storage compartment. The damper motor (or motor coil) generates heat as the result of energization for self-heating. The heat generation can increase the temperature of a motor frame of the damper motor and therefore the temperature around the motor frame, whereupon dew condensation can be restrained on the damper unit. In this case, no heater needs

to be added, and occurrence of dew condensation and therefor freeze-up can be prevented by energization of the damper motor. Furthermore, prevention of dew condensation and freeze-up can be achieved by a simplified and cost-effective construction.

Other objects, features and advantages of the present invention will become clear upon reviewing the following description of the embodiment with reference to the accompanying drawings, in which:

FIG. 1 is a flowchart showing operating procedure for control of self-heating energization of a damper motor in a refrigerator of one embodiment of the present invention;

FIG. 2 is a schematic longitudinal side section of the overall refrigerator;

FIG. 3 is an enlarged longitudinal side section of an evaporator compartment and its neighborhood construction;

FIG. 4 is a perspective view of a damper unit;

FIG. 5A shows a frame format of the coil arrangement of the damper motor;

FIG. 5B shows a manner of energizing the coil of the damper motor;

FIG. 6 is a block diagram showing an electrical arrangement of the refrigerator;

FIG. 7 is a view showing an arrangement of the refrigerating cycle;

FIG. 8 is a graph showing experimental results regarding temperature changes of the damper unit;

FIG. 9 is a view similar to FIG. 1, showing another embodiment; and

FIG. 10 is a view similar to 4, showing a conventional construction.

One embodiment of the present invention will be described with reference to FIGS. 1 to 8. Referring to FIG. 2, a body 11 of the refrigerator in accordance with the invention is shown. The refrigerator body 11 includes a heat-insulating housing 12 having an interior divided by heat-insulating partition walls 12a, 12b and 12c into vertically aligned compartments. Thus, storage compartments or a refrigerating compartment 13, ice-making compartment 14, vegetable compartment 15 and freezing compartment 16 are defined in the heat-insulating housing 12 sequentially from an upper compartment. Furthermore, a mode-changeable compartment 17 (see FIG. 3) is juxtaposed with the ice-making compartment 14. A temperature in the mode-changeable compartment 17 can be changed among a plurality of temperature zones with operation by a user. Accordingly, the mode-changeable compartment 17 can serve as a freezing compartment, partial freezing compartment, chilling compartment or refrigerating compartment.

A door 18 is hingedly mounted on a front of the refrigerating compartment 13. Slide-out doors 19, 20 and 21 are mounted on fronts of the ice-making compartment 14, vegetable compartment 15 and freezing compartment 16 respectively. An ice storage container 22 is connected to a rear or inner wall of the door 19. Two storage containers 23 and 24 are connected to rear or inner walls of the doors 20 and 21 respectively. A refrigerating compartment temperature sensor 25 is mounted in the refrigerating compartment 13 for detecting a temperature therein.

A freezing compartment temperature sensor 26 is mounted in the freezing compartment 16 for detecting a temperature therein. Additionally, a mode-changeable compartment temperature sensor 27 (see FIG. 6) is mounted in the mode-changeable compartment 17 for detecting a temperature therein.

A refrigerating compartment evaporator compartment 28 and a freezing compartment evaporator compartment 29 are defined by a rear wall of the vegetable compartment 15 so as to be disposed back and forth as shown in shown in FIGS. 2 and 3. A refrigerating compartment evaporator 30 and a refrigerating storage blowing fan 31 are enclosed in the refrigerating compartment evaporator compartment 28 for cooling atmospheres in the refrigerating storage and vegetable compartments 13 and 15. Furthermore, a freezing compartment evaporator 32 and a freezing blowing fan 33 (see FIG. 3) are enclosed in the freezing compartment evaporator compartment 29 for cooling atmospheres in the freezing, ice-making and mode-changeable compartments 16, 14 and 17. The refrigerating compartment evaporator 30 and blowing fan 31 and the freezing compartment evaporator 32 and blowing fan 33 are spaced right and left from each other. A defrosting heater 34 (shown only in FIG. 6) is attached to the freezing compartment evaporator 32.

Upon drive of the refrigerating blowing fan 31, cold air produced by the refrigerating compartment evaporator 30 is supplied from the upper interior of the refrigerating compartment evaporator compartment 28 through a blowing duct 35 and a plurality of supply openings into the refrigerating compartment 13 and further into the vegetable compartment 15,

as shown in FIG. 2. Thereafter, the cold air is returned into the lower interior of the refrigerating compartment evaporator compartment 28 and thus circulated. As a result, the atmosphere in each of the refrigerating and vegetable compartments 13 and 15 is cooled in a refrigerating temperature range from 3°C to 5°C.

Furthermore, upon drive of the freezing blowing fan 33, cold air produced by the freezing compartment evaporator 32 is supplied from the upper interior of the freezing compartment evaporator compartment 29 through a blowing duct 36 into the ice-making compartment 14 (and the mode-changeable compartment 17) and further into the freezing compartment 16, as shown in FIG. 3. Thereafter, the cold air is returned into the lower interior of the freezing compartment evaporator compartment 29 and thus circulated. As a result, the atmosphere in each of the freezing and ice-making compartments 16 and 14 is cooled in a freezing temperature range of -18°C or below.

The aforesaid duct 36 is disposed so as to extend upward from the freezing compartment evaporator compartment 29 and then so as to be connected to the rear of the mode-changeable compartment 17. The duct 36 has a generally rectangular cross section. A damper unit 37 is provided in the duct 36 for controlling supply of cold air into the mode-changeable compartment 17 or opening and closing the passage of the duct 36. The damper unit 37 will be described in detail later.

A refrigeration cycle 38 (see FIG. 7) is built in the refrigerator body 11. An equipment compartment 39 is defined in a lower rear interior of the body 11. In the equipment

compartment 39 are provided a compressor 40, condenser 41, cooling fan 42 (see FIGS. 6 and 7) for cooling the compressor and condenser, and the like. In the refrigeration cycle 38, the compressor 40, condenser 41 an inlet 43a of a changeover valve 43 comprising a three-way valve are connected by a refrigerant pipe sequentially in this order. The changeover valve 43 has one inlet 43a and two outlets 43b and 43c. To the first outlet 43b are connected a first capillary tube 44, the freezing compartment evaporator 32, an accumulator 45 and a check valve 46 by a refrigerant pipe sequentially in this order. The check valve 46 is connected to the compressor 40, whereby a closed loop is established. A second capillary tube 47 and the refrigerating compartment evaporator 30 are by a refrigerant pipe between the second outlet 43c of the changeover valve 43 and a connection point of the check valve 46 and the compressor 40 so as to be parallel with the freezing compartment evaporator 32 and the like. The changeover valve 43 is controlled by a control device 48 (see FIG. 6) mainly comprised of a microcomputer.

When the changeover valve 43 is switched to the first outlet 43b side, the compressor 40 is driven so that the refrigerant passes through the condenser 41, and thereafter, the refrigerant is supplied through the first capillary tube 44 into the freezing compartment evaporator 32. Subsequently, the refrigerant of the freezing compartment evaporator 32 is returned through the accumulator 45 and check valve 46 in turn into the compressor 40 (freezing compartment cooling mode). On the other hand, when the changeover valve 43 is switched to the second outlet 43c side, the compressor 40 is driven so that the refrigerant passes through

the condenser 41 and thereafter, the refrigerant is supplied through the second capillary tube 47 into the refrigerating compartment evaporator 31. Subsequently, the refrigerant is returned into the compressor 40 (refrigerating compartment cooling mode).

The damper unit 37 will now be described in detail. The damper unit 37 includes a frame 49 disposed so as to divide the duct interior into upper and lower interiors as shown in FIGS. 3 and 4. The frame 49 is formed with a rectangular opening 49a as shown in FIG. 4. The damper unit 37 further includes a baffle plate 50 opening and closing the opening 49a of the frame 49 and a drive mechanism 51 for rotatively moving the baffle plate 50. The frame 49, baffle plate 50 and drive mechanism 51 are unitized.

The drive mechanism 51 includes a slightly vertically long rectangular box-shaped case 52 made of a synthetic resin and enclosing a damper motor 53 and gear mechanism (not shown). The case 52 has an inner surface 52a facing to the inside of the duct 36. The inner surface 52a includes a lower rear end from which a rotating shaft 54 protrudes horizontally. The rotating shaft 54 is rotatively moved by the damper motor 53 and gear mechanism. The case 52 further has an outer wall provided with a connector (not shown) via which the damper motor 53 is connected to a drive circuit.

The baffle plate 50 is made of a synthetic resin and formed into the shape of a rectangular plate. The baffle plate 50 is connected to the rotating shaft 54. The baffle plate 50 has an inner surface (underside) provided with a sealing member 55 which adheres closely to the periphery of the opening 49a when the

opening 49a of the frame 49 is closed. The frame 49 is made of a synthetic resin and formed into the shape of a rectangular container having a three-way rising wall. The frame 49 is formed integrally with the case 52 so as to horizontally extend from the lower part of the inner surface 52a toward the inside. The opening 49a is formed in a central bottom wall of the frame 49.

The damper unit 37 which is unitized as described above is mounted inside the duct 36 so that the drive mechanism 51 is fitted in a recess formed in a heat-insulating material constituting the wall of the duct. In this case, the inner surface 52a of the case 52 is disposed so as to face the interior of the duct 36. The damper motor 53 is controlled via the drive circuit (not shown) by the control device 48 so that the baffle plate 50 is opened and closed, whereby flow of cold air supplied from duct 36 into the mode-changeable compartment 17 is controlled.

A two-phase excitation stepping motor is used as the aforesaid damper motor 53 in the embodiment. The two-phase excitation stepping motor provides for high output torque and smooth operation. The damper motor 53 has a phase A coil and a phase B coil which are out of phase with each other by mechanical angle 90°. Pulse signals are applied alternately to terminals A1 and A2 of the phase A coil 56 and terminals B1 and B2 of the phase B coil 57 in a pattern as shown in FIG. 5, whereby the damper motor is rotated.

When the baffle plate 50 is changed from the closed state to the open state, energization is carried out in the sequence of steps 1, 2, 3 and 4 (from the left to the right in FIG. 5B) so that the damper motor 53 is rotated clockwise. On the other

hand, when energization is carried out in the sequence of steps 4, 3, 2 and 1 (from the right to the left in FIG. 5B) so that the damper motor 53 is rotated counter-clockwise thereby to rotatively move the baffle plate 50 from the open state to the closed state. The damper motor 53 is de-energized after the baffle plate 50 has been closed or opened. Even in the de-energized state of the damper motor 53, a magnet detent force of the damper motor 53 is maintained in the open or closed state.

FIG. 6 schematically shows an electrical arrangement of the refrigerator body 11 with the control device 48 being centered.

Signals are supplied from the refrigerating compartment temperature sensor 25, freezing compartment temperature sensor 26 and mode-changeable compartment temperature sensor 27 to the control device 48. With this, a signal is supplied from the defrosting sensor 58 to the control device 48. Furthermore, a signal is supplied from an outside air temperature sensor 59 to the control device. The defrosting sensor 58 is attached to an accumulator 45 located near the freezing compartment evaporator 32. Based on the aforesaid input signals, the control device 48 controls the compressor 40, changeover valve 43, refrigerating blowing fan 31, freezing blowing fan 33, cooling fan 42, defrosting heater 34, damper motor 53, and the like according to a previously stored operation control program.

The control device 48 carries out the cooling operation while changing the cooling mode alternately between the refrigerating compartment cooling mode and the freezing compartment cooling mode by the changeover operation of the changeover valve 43 with the use of software configuration.

Consequently, the temperature in each of the compartments 13 to 16 is maintained substantially at the set temperature while the atmospheres of the refrigerating compartment 13 (and the vegetable compartment 15) and the freezing compartment 16 (and the ice-making compartment 14) are alternately cooled. Furthermore, regarding the mode-changeable compartment 17, the control device 48 controls the damper unit 37 (the opening and closure of the baffle plate 50 by the damper motor 53), based on the selected temperature range and the temperature detected by the mode-changeable compartment temperature sensor 27.

In the above-described case, the control device 48 sets ON and OFF temperatures which have predetermined temperature widths relative to set (target) temperatures respectively, basically switching the changeover valve 43 based on results of detection by the refrigerating and freezing compartment temperature sensors 25 and 26. More specifically, the control device 48 sets the ON temperature at 5°C and the OFF temperature at 2°C in the refrigerating compartment 13, for example, and the ON temperature at -18°C and the OFF temperature at -21°C in the freezing compartment 16, for example. The conditions for mode changeover include case (1) where the temperature detected in the compartment for which the cooling operation is in execution has reached the OFF temperature, case (2) where a predetermined time (10 minutes, for example) has elapsed from the previous mode changeover and the temperature detected in the compartment for which the cooling operation is in non-execution has been increased to the ON temperature, or case (3) where a predetermined period of time (60 minutes, for example) has elapsed from the

previous mode changeover. The compressor 40 is turned off (the cooling operation is stopped) when the temperatures detected in the refrigerating and freezing compartments are equal to or lower than the OFF temperatures respectively.

Furthermore, the aforesaid refrigerating blowing fan 31 is turned on when the refrigerant is flowing into the refrigerating compartment evaporator 30 (the refrigerating compartment cooling mode). In addition, the refrigerating blowing fan 31 is also turned on when the freezing compartment cooling mode is carried out. As a result, frost formation is suppressed on the refrigerating compartment evaporator 30. The freezing blowing fan 33 is turned on when the refrigerating compartment cooling mode is carried out as well as while the refrigerant is flowing into the freezing compartment evaporator 32. As the result of the control manner, the surface temperature of the freezing compartment evaporator 32 is sufficiently low even during execution of the refrigerating compartment cooling mode. Accordingly, when the freezing blowing fan 33 is driven, cold air can be supplied into the freezing compartment 16 and the ice-making compartment (an ice-making tray not shown in the drawings) so as to contribute to certain cooling. The cooling fan 42 turned on while the compressor 40 is being driven.

Furthermore, the control device 48 carries out a defrosting operation every time an integrated value of execution time of the freezing compartment cooling mode reaches a predetermined period of time. Furthermore, a precooling operation before the defrosting operation in the embodiment. In the precooling operation, firstly, the set temperature of the freezing

compartment 16 and ice-making compartment 14 is shifted by 3 deg to the low temperature side, for example. In the shifted state, the compressor 40 is continuously driven at high speeds so that the freezing compartment cooling mode is carried out, whereby the atmosphere of the freezing compartment 16 and the like are force-cooled. Subsequently, the operation mode is switched to the refrigerating compartment cooling mode so that the atmosphere of the refrigerating compartment 13 and the like are force-cooled.

The aforesaid defrosting operation is carried out by energizing the defrosting heater 34 when the compressor 40 and fans 31, 33 and 42 are turned off. Subsequently, the defrosting operation is completed when the defrosting sensor 58 has detected a temperature equal to or larger than a predetermined temperature (8°C, for example). The baffle plate 50 of the damper unit 37 is closed during the defrosting operation. Furthermore, no frost needs to be melted down since almost no frost is formed on the refrigerating compartment evaporator 30 as described above. However, a defrosting heater and a defrosting sensor may be provided so that heat is applied to the refrigerating compartment evaporator 30 in the same manner as descried above.

The freezing compartment evaporator compartment 29 and duct 36 are filled with relative higher-temperature moist air since frost adherent to the freezing compartment evaporator 32 is melted down by the heat of the defrosting heater 34 during the defrosting operation. In the case where the inner surface 52a of the case 52 has a low temperature when the baffle plate 50 of the damper unit 37 is opened after completion of the defrosting

operation, hot and humid air is brought into contact with the inner surface 52a, resulting in dew condensation. In the embodiment, the control device 48 controls energization of the damper motor 53 for the opening/closure of the baffle plate 50 of the damper unit 37 (control of flow of cold air into the mode-changeable compartment 17). In addition to this control, the control device 48 further carries out energization of the damper motor 53 for the self-heating without opening/closure of the baffle plate 50 at the time other than when the baffle plate 50 is opened/closed, as will be described in the description of operation. Accordingly, the control device 48 serves as an energization control device for controlling energization of the damper motor 53.

More specifically, energization of the phase A coil 56 and energization of the phase B coil 57 of the damper motor 53 are alternately executed each for a predetermined time when the energization for the self-heating is carried out. In this case, an energization pattern is the same as the last energization pattern for opening/closing the baffle plate 50. That is, DC current is caused to flow into the terminals A1 and A2 of the phase A coil 56 and the terminals B1 and B2 of the phase B coil 57. For example, the phase A coil 56 is energized so that the terminal A1 is positively charged and the terminal A2 is negatively charged when the last energized state is shown as a right pattern in FIG. 5B in the case where the baffle plate 50 was closed at a previous time. The phase B coil 57 is energized so that the terminal B1 is negatively charged and the terminal B2 is positively charged.

Furthermore, the timing of the above-described energization for the self-heating will now be described. The self-heating energization of the damper motor 53 starts during the precooling operation. The energization of the damper motor 53 is continued during the defrosting operation. When the operation mode has switched from the defrosting operation to the normal cooling operation, the energization of the damper motor 53 for the self-heating is completed. Subsequently, the control mode for the damper motor 53 is returned to the control of normal opening/closure operation.

The operation of the refrigerator will now be described. FIG. 1 is a flowchart showing operating procedure for control of self-heating energization of a damper motor in a refrigerator. More specifically, firstly at step S1, the control device 48 determines whether the precooling operation has been started. Upon start of the precooling operation (Yes at step S1), the control device 48 advances to step S2 to start energization of the coils 56 and 57 of the damper motor 53 for self-heating. As described above, energization of the phase A coil 56 and energization of the phase B coil 57 of the damper motor 53 are alternately executed each for a predetermined time of time.

The precooling operation is completed (step S3) when a predetermined time period timed by the integrating timer has elapsed from the start of the precooling operation. Then, the defrosting heater 34 is turned on and the baffle plate 50 of the damper unit 37 is closed so that the defrosting operation is started (step S4). The aforesaid self-heating energization is continued during the defrosting operation. At subsequent step

S5, the control device 48 determined whether the end timing of the defrosting operation has reached. When the defrosting sensor 58 has detected a temperature (8°C, for example) equal to or higher than the predetermined temperature, the control device 48 determines that the defrosting operation has been completed. Furthermore, the control device 48 determines that the defrosting operation has ended when the predetermined temperature has not been detected but a predetermined time period (20 minutes, for example) has elapsed from start of the defrosting operation.

When determining that the defrosting operation has ended (Yes at step S5), the control device 48 advances to step S6 to turn off the defrosting heater 34. The control device 48 then advances to step S7 to turn on the compressor 40 after lapse of time T1 (6 minutes, for example). A desirable pressure balance can be obtained between the evaporators 30 and 32 when the compressor 40 is started with lag of time T1. Subsequently, the control device 48 advances to step S8 to drive the freezing blowing fan 33 (normal rotation) after lapse of time T2 (4 minutes, for example). The control device further advances to step S9 where the freezing blowing fan 33 is reverse rotated after lapse of time T3 (1 minute, for example). As a result, warm air resulting from the defrosting operation is caused to flow without remaining in the duct 36 (the lower part of the damper unit 37).

The refrigerator is switched to a normal cooling operation after lapse of time T4 (2 minutes, for example) at step S10. In this case, the energization of the damper motor 53 for self-heating ends and the normal opening/closing control of the

damper unit 37 starts. Furthermore, the freezing blowing fan 33 is returned to the normal rotation.

As the result of the above-described control manner, the damper motor 53 is energized for the self-heating without opening/closing of the baffle plate 50, whereupon the coils 56 and 57 of the damper motor 53 generate heat. This heat generation increases the temperature of the motor frame of the damper motor 53 and accordingly the temperature of the part around the motor frame, so that occurrence of dew condensation on the damper unit 37 can be restricted. In this case, the energization of the damper motor 53 for the self-heating is carried out during the defrosting operation which tends to result in dew condensation on the damper unit 37. Consequently, dew condensation can effectively be prevented during and immediately after the defrosting operation. Furthermore, since the energization for the self-heating of the damper motor 53 is started during the precooling operation, the temperature around the damper motor 33 is sufficiently high upon start of the defrosting operation. As a result, the self-heating is more effective.

FIG. 8 shows the results of an experiment in which the temperature changes of the case surface (the inner surface 52a) of the damper unit 37 during and immediately after the defrosting operation. Curve a in FIG. 8 denotes the temperature changes in the case where the control of the embodiment (the energization for self-heating) was carried out. Curve b denotes the temperature changes in the conventional construction in which the energization for self-heating is not carried out. Curb c denotes the temperature changes in the duct 36 (the lower part

of the damper unit 37.

As obvious from the experimental results, it can be understood that the dew condensation can be prevented by increasing the temperature of the damper unit 37 to a relatively higher value. Furthermore, in particular, the dew-condensation preventing effect can be increased by retarding the timing for opening the baffle plate 50 by the control in steps S7 to S9.

According to the above-described embodiment, the damper motor 53 is energized for the self-heating without opening/closing operation of the baffle plate 50 in the refrigerator with the damper unit 37 being disposed in the duct 36. Consequently, occurrence of dew condensation can be prevented on the damper unit 37 and accordingly, the baffle plate 50 can be prevented from freeze-up. Moreover, no individual heaters need to be added, and the dew condensation and freeze-up can be prevented by the control of energization of the damper motor 53. Consequently, dew condensation and freeze-up can be prevented by a simplified and cost-effective construction.

The energization of the damper motor 53 is carried out at the most effective time particularly in the foregoing embodiment. Consequently, electric energy can be saved while occurrence of dew condensation is effectively prevented. Furthermore, energization of the phase A coil 56 and energization of the phase B coil 57 of the damper motor 53 are alternately carried out when the damper motor is energized for the self-heating. Consequently, only either coil can be prevented from being wasted up, whereby a reduction of service life of each coil can be restricted.

FIG. 9 illustrates another embodiment of the invention. The second embodiment differs from the first embodiment in the timing of energization of the damper motor for the self-heating. The control device 48 carries out energization of the damper motor 53 based on a signal generated by an outside air temperature sensor 59 detecting a temperature outside the refrigerator and the set temperature range of the mode-changeable compartment 17. Of course, the control device 48 also carries out the normal control, that is, the control for opening/closing the baffle plate 50.

More specifically, at step S21, the control device 48 determines whether a temperature detected by the outside air temperature 59 is equal to or lower than a predetermined temperature (10°C, for example). When the temperature detected by the outside air temperature 59 is equal to or lower than a predetermined temperature (Yes at step S21), the control device 48 advances to subsequent step S22 to determine whether the setting of the mode-changeable compartment 17 is outside the freezing compartment temperature range. When the setting of the mode-changeable compartment 17 is outside the freezing compartment temperature range (Yes at step S22), the control device 48 advances to step S23 to carry out energization of the damper motor 53 for self-heating.

Subsequently, the control device 48 advances to step S24 to determine whether the temperature detected by the outside air temperature 59 is equal to or lower than a predetermined temperature (10°C, for example). When the detected temperature has exceeded the predetermined temperature (No at step S24), the

control device 48 advances to step S25 to stop energization of the damper motor 53 for the self-heating. Subsequently, the processing from step S21 on is repeated.

When the set temperature of the mode-changeable compartment 17 is within the freezing compartment temperature range, the baffle plate 50 of the damper unit 37 is open in almost any time such that cold air is normally supplied into the duct 36. Accordingly, dew condensation hardly occurs on the case 52. On the other hand, when the temperature of the mode-changeable compartment 17 is set at a temperature belonging to a relatively higher temperature range such as of the refrigerating compartment or chilling compartment, the baffle plate 50 is closed at almost any time. Since cold air is stagnant within the duct 36 (near the damper unit 37) in this case, dew condensation tends to occur when the baffle plate 50 is opened. The temperature of the damper unit 37 tends to be low in winter when the temperature outside the refrigerator is low, or the like, whereupon dew condensation tends to occur on the case 52.

In view of the foregoing circumstances, energization of the damper motor 53 for the self-heating is carried out when the mode-changeable compartment 17 is set at a temperature out of the freezing compartment temperature range. Consequently, reduction in the temperature of the damper unit 37 can be suppressed such that the occurrence of dew condensation can effectively be prevented on the damper motor 53. In this case, electric energy saving can be achieved as compared with the case where the energization of the damper motor is usually carried out. Furthermore, no individual heaters need to be added, and

dew condensation and freeze-up can be prevented by a simplified and cost-effective construction.

Several modified forms of the above-described embodiments will be described as follows although not shown in the drawings. Firstly, the timing of self-heating energization of the damper motor 53 may have the following modified forms. When the refrigerator is provided with a failure detector detecting failure of the defrosting sensor 58, the self-heating energization of the damper motor 53 may normally be carried out when a failure of the defrosting sensor 58 has been detected by the failure detector. Consequently, occurrence of dew condensation can reliably be prevented on the damper unit 37 when the defrosting sensor 58 has failed.

The self-heating energization of the damper motor 53 may be carried out either continuously or intermittently while the baffle plate 50 is open. Consequently, the damper motor 53 can be caused to generate heat while the baffle plate 50 is open and cold air is flowing into a part of the damper unit 37 on which dew condensation tends to occur. As a result, the temperature of the part where the dew condensation tends to occur can be prevented from being reduced and a dew-condensation preventing effect can be improved.

Furthermore, the temperatures in the respective storage compartments 13 to 17 are relatively higher after the power has been connected to the refrigerator. Accordingly, it is important to quickly reduce the temperatures of the respective storage compartments to certain lower temperatures. With this, the temperature of the damper 37 is relatively higher in a

pulldown period. Accordingly, since there is little possibility of occurrence of dew condensation, the self-heating energization need not be carried out.

The aforesaid pulldown period can be determined by any one of the following definitions. That is, firstly, the pulldown period refers to a predetermined period after power-on of the refrigerator (150 minutes, for example). Secondly, the pulldown period refers to a period required for a cycle of the freezing compartment cooling mode and refrigerating compartment cooling mode at a predetermined number of times (3 times, for example). Thirdly, the pulldown period refers to a time period required for the freezing compartment evaporator 32 to reach a predetermined temperature (20°C, for example). Fourth, the pulldown period refers to a time period required for the interior of the freezing compartment 13 (or the ice-making compartment 14) to reach a predetermined temperature (-10°C, for example).

The self-heating energization of the damper motor 53 may be forbidden during the pulldown period starting after power-on of the refrigerator and ending when the control device determines that the temperatures of the respectively storage compartments 13 to 17 has dropped to a predetermined temperature. Consequently, power saving can be achieved by forbidding energization when there is no possibility of occurrence of dew condensation.

Furthermore, as a pattern in which the self-heating energization of the damper motor 53 is carried out, when the baffle plate 50 is closed, the two-phase coils 56 and 57 may be energized in a pattern in which the baffle plate is closed. When

the baffle plate 50 is open, the two-phase coils 56 and 57 may be energized in a pattern in which the baffle plate is opened. Consequently, step displacement due to repeated opening/closure of the baffle plate 50 can be resolved while the intended purpose has been achieved, whereupon the effect of retightening can be obtained.

The configuration or arrangement of each compartment in the refrigerator may be modified in various manners. Positions of the evaporators may also be changed. Furthermore, although the damper unit has been described which controls flow of cold air into the mode-changeable compartment, the invention can be applied to a damper unit which controls flow of cold air into a refrigerating compartment in a refrigerator provided with a single evaporator. Furthermore, when flow of cold air into two storage compartments is to be controlled, two damper units may be provided. However, the two damper units may be composed into a single unit, instead. Specific values such as set temperatures and time in the foregoing embodiments are mere examples but may be changed suitably.

The foregoing description and drawings are merely illustrative of the principles of the present invention and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill in the art. All such changes and modifications are seen to fall within the scope of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A refrigerator comprising:

a storage compartment;

an evaporator provided for producing cold air;

a duct provided for supplying the cold air from the evaporator into the storage compartment;

a damper unit provided in the duct and including a damper motor serving as a drive source and a baffle plate opened and closed by the damper motor; and

a control device provided for controlling the damper motor so that the baffle plate is opened and closed, thereby controlling flow of the cold air into the storage compartment, the control device further controlling the damper motor so that the damper motor is energized for self-heating.

2. The refrigerator according to claim 1, wherein the control device controls the damper motor so that the damper motor is energized for self-heating during a defrosting operation for the evaporator.

3. The refrigerator according to claim 2, wherein the control dev ice controls the damper motor so that the damper motor is energized for self-heating during a precooling operation executed prior to the defrosting operation.

4. The refrigerator according to claim 2, further comprising a defrosting sensor provided for determining a

completion time of the defrosting operation and a failure detector provided for detecting a failure of the defrosting sensor, wherein when a failure of the defrosting sensor is detected by the failure detector, the control device controls the damper motor so that the damper motor is normally energized for self-heating.

5. The refrigerator according to claim 3, further comprising a defrosting sensor provided for determining a completion time of the defrosting operation and a failure detector provided for detecting a failure of the defrosting sensor, wherein when a failure of the defrosting sensor is detected by the failure detector, the control device controls the damper motor so that the damper motor is normally energized for self-heating.

6. The refrigerator according to claim 1, wherein the control device controls the damper motor so that the damper motor is energized for self-heating while the baffle plate is open.

7. The refrigerator according to claim 1, further comprising an outside air temperature sensor for detecting an air temperature outside the refrigerator, wherein when the outside air temperature sensor has detected the outside air temperature which has a predetermined value or a value larger than the predetermined value, the control device controls the damper motor so that the damper motor is energized for self-heating.

8. The refrigerator according to claim 1, wherein the control device prohibits energization of the damper motor for self-heating during a pulldown period which starts at power-on and continues until a temperature in the storage compartment is determined to be equal to or lower than a predetermined temperature.

9. The refrigerator according to claim 2, wherein the control device prohibits energization of the damper motor for self-heating during a pulldown period which starts at power-on and continues until a temperature in the storage compartment is determined to be equal to or lower than a predetermined temperature.

10. The refrigerator according to claim 3, wherein the control device prohibits energization of the damper motor for self-heating during a pulldown period which starts at power-on and continues until a temperature in the storage compartment is determined to be equal to or lower than a predetermined temperature.

11. The refrigerator according to claim 4, wherein the control device prohibits energization of the damper motor for self-heating during a pulldown period which starts at power-on and continues until a temperature in the storage compartment is determined to be equal to or lower than a predetermined temperature.

12. The refrigerator according to claim 5, wherein the control device prohibits energization of the damper motor for self-heating during a pulldown period which starts at power-on and continues until a temperature in the storage compartment is determined to be equal to or lower than a predetermined temperature.

13. The refrigerator according to claim 6, wherein the control device prohibits energization of the damper motor for self-heating during a pulldown period which starts at power-on and continues until a temperature in the storage compartment is determined to be equal to or lower than a predetermined temperature.

14. The refrigerator according to claim 7, wherein the control device prohibits energization of the damper motor for self-heating during a pulldown period which starts at power-on and continues until a temperature in the storage compartment is determined to be equal to or lower than a predetermined temperature.

15. The refrigerator according to any one of claims 1 to 14, wherein the damper motor comprises a two-phase excitation stepping motor provided with two phase coils, and the control device alternately changes energization of one coil of the damper motor and energization of the other coil of the damper motor.

16. The refrigerator according to any one of claims 1 to

14, wherein the damper motor comprises a two-phase excitation stepping motor provided with two phase coils, and while the baffle plate is closed, the control device controls the damper motor so that the two-phase coils are energized in a first pattern used for closing the baffle plate and while the baffle plate is open, the control device controls the damper motor so that the two-phase coils are energized in a second pattern for opening the baffle plate.