



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.08.2014 Bulletin 2014/32

(51) Int Cl.:
F25D 17/06 (2006.01)

(21) Application number: **14153113.7**

(22) Date of filing: **29.01.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **30.01.2013 KR 20130010501**
30.01.2013 KR 20130010503
30.01.2013 KR 20130010504

(71) Applicant: **LG Electronics, Inc.**
Seoul 150-721 (KR)

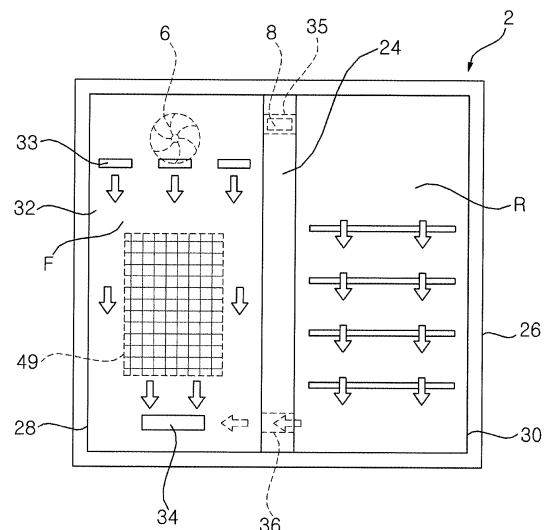
(72) Inventors:
• **Lee, Sungsub**
153-802 Seoul (KR)
• **Lee, Sungwoo**
153-802 Seoul (KR)
• **Lee, Taehee**
153-802 Seoul (KR)
• **Kim, Dongseok**
153-802 Seoul (KR)

(74) Representative: **Vossius & Partner**
Siebertstrasse 4
81675 München (DE)

(54) **Refrigerator**

(57) A refrigerator includes a refrigeration cycle system including a compressor, a condenser, an expansion device, and an evaporator through which a refrigerant sequentially passes; a blower fan sending air cooled by the evaporator to a freezer compartment and a refrigerator compartment; and a damper regulating air sent from the evaporator to the refrigerator compartment, in which when the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature is not satisfactory, the refrigerator operates in a concurrent operation mode in which the compressor is operated, the damper is opened, and first voltage is applied to the blower fan, and when the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature is satisfactory, the refrigerator operates in a freezer compartment single operation mode in which the compressor is operated, the damper is closed, and second voltage lower than the first voltage is applied to the blower fan. Accordingly, it is possible to minimize the power consumed in the freezer compartment single operation mode.

FIG 1



Description

[0001] The present disclosure relates to a refrigerator and a method of operating the same, particularly a refrigerator sending cold air to the storing compartment and a method of operating a refrigerator.

[0002] In general, refrigerators are apparatuses that cool storing chambers such as a refrigerator compartment and a freezer compartment, using a refrigeration cycle system composed of a compressor, a condenser, an expansion device, and an evaporator.

[0003] Refrigerators may include a body having a freezer compartment and a refrigerator compartment, a freezer compartment door connected with the body and opening/closing the freezer compartment, and a refrigerator compartment door opening/closing the refrigerator compartment. The refrigerators may be equipped with a blower fan sending air to the evaporator. The air cooled by the evaporator can be supplied to the freezer compartment and the refrigerator compartment, or to the freezer compartment by operating the blower fan. The refrigerators may include a refrigerator compartment damper that passes or stops the air supplied to the refrigerator compartment. In the refrigerators, with the refrigerator compartment damper open, some of the air cooled by the evaporator can flow into the refrigerator compartment and the other of the air can flow into the freezer compartment.

[0004] The blower fan may start with the start of the compressor and stops with the stop of the compressor. That is, the blower fan may enable the air in the freezer compartment or the refrigerator compartment to exchange heat with the low-temperature refrigerant passing through the evaporator by starting with the start of the compressor, and may stop with the stop of the compressor.

[0005] An effort has been made to provide a refrigerator that can minimize power consumption and a method of operating a refrigerator.

[0006] A refrigerator according to an embodiment of the present invention includes: a body having a freezer compartment and a refrigerator compartment formed therein; a refrigeration cycle system disposed in the body, including a compressor, a condenser, an expansion device, and an evaporator through which a refrigerant sequentially passes, and cooling air with the refrigerant; a blower fan sending the air cooled by the evaporator to the freezer compartment and the refrigerator compartment; and a damper regulating the air sent from the evaporator to the refrigerator compartment, in which when the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature is satisfactory, the refrigerator operates in a concurrent operation mode in which the compressor is operated, the damper is opened, and first voltage is applied to the blower fan, and when the freezer compartment temperature is not satisfactory and refrigerator compartment temperature is satisfactory in the concurrent operation mode, the refriger-

ator operates in a freezer compartment single operation mode in which the compressor is operated, the damper is closed, and second voltage lower than the first voltage is applied to the blower fan.

[0007] When the freezer compartment temperature becomes satisfactory in the freezer compartment single operation mode, the compressor may be stopped and the voltage applied to the blower fan may be stopped

[0008] When the freezer compartment temperature becomes satisfactory in the freezer compartment single operation mode, the refrigerator may operate in blower fan-additional operation in which the compressor is stopped and the blower fan keeps operating for a predetermined time.

[0009] When the predetermined time passes, the voltage applied to the blower fan may be stopped.

[0010] The second voltage may be applied to the blower fan in the blower fan-additional operation.

[0011] Third voltage lower than the second voltage may be applied to the blower fan in the blower fan-additional operation.

[0012] A method of operating a refrigerator according to an embodiment of the present invention includes: a step of operating a compressor, of opening a damper regulating air cooled by an evaporator and supplied to the refrigerator compartment, and of applying first voltage to a blower fan sending the air cooled by the evaporator to the freezer compartment and the refrigerator compartment, when the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature is not satisfactory; and a step of keeping the compressor operating, of closing the damper, and of applying second voltage lower than the first voltage to the blower fan, when the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature becomes satisfactory.

[0013] The method may further include a step of stopping the compressor and stopping the second voltage applied to the blower fan, when the freezer compartment temperature becomes satisfactory while the second voltage is applied to the blower fan.

[0014] The method may further include a step of stopping the compressor and keeping the blower fan operating for a predetermined time, when the freezer compartment temperature becomes satisfactory while the second voltage is applied to the blower fan.

[0015] When the predetermined time passes, the second voltage applied to the blower fan may be stopped.

[0016] The second voltage may be applied to the blower fan for the predetermined time.

[0017] Third voltage lower than the second voltage may be applied to the blower fan for the predetermined time.

[0018] A refrigerator according to an embodiment the present invention includes: a body having a freezer compartment formed therein; a refrigeration cycle system disposed in the body, including a compressor, a condenser, a hot line, an expansion device, and an evaporator

through which a refrigerant sequentially passes; a blower fan circulating the air in the freezer compartment through the evaporator and the freezer compartment; a condenser fan sending air to the condenser; and a humidity sensor sensing humidity, in which when the freezer compartment temperature is not satisfactory and the humidity sensed by the humidity sensor is less than a predetermined level, first power is inputted to the compressor and the condenser fan is operated in a first rotational speed, and when the freezer compartment temperature is not satisfactory and the humidity sensed by the humidity sensor is at a predetermined level or more, second power higher than the first power is inputted to the compressor and the condenser fan is rotated at a second rotational speed lower than the first rotational speed.

[0019] A method of operating a refrigerator according to an embodiment of the present invention includes: a step of sensing humidity with a humidity sensor; and a step of operating a condenser fan sending air to a condenser at a first rotational speed and of inputting first power to a compressor compressing a refrigerant, when the sensed humidity is less than predetermined humidity and the freezer compartment temperature is not satisfactory, and of operating the condenser fan at a second rotational speed lower than the first rotational speed and inputting second power higher than the first power to the compressor, when the sensed humidity is at the predetermined humidity or more and the freezer compartment temperature is not satisfactory.

[0020] A refrigerator according to an embodiment of the present invention includes: a body having a freezer compartment formed therein; a refrigeration cycle system disposed in the body and including a compressor, a condenser, a refrigerant control valve, an expansion device, and an evaporator through which a refrigerant sequentially passes; and a lower fan circulating the air in the freezer compartment through the evaporator and the freezer compartment, in which when the freezer compartment temperature is not satisfactory, the compressor and the blower fan are started first and then the refrigerant control valve is opened, and when freezer compartment temperature becomes satisfactory after the refrigerant control valve is opened, the refrigerant control valve is closed first and then the compressor and the blower fan are stopped.

[0021] The refrigerant control valve may be opened, when a first predetermined time passes after the compressor and the blower fan are started.

[0022] The compressor and the blower fan may be stopped, when a second predetermined time passes after the refrigerant control valve is closed.

[0023] The refrigerator may further include a condenser fan sending air to the condenser, in which the condenser fan may be operated with the compressor and stopped with closing of the refrigerant control valve.

[0024] A method of operating a refrigerator according to an embodiment of the present invention includes: a step of starting a compressor compressing a refrigerant

and of starting a condenser fan sending air to a condenser and a blower fan circulating air through an evaporator and the freezer compartment, when the freezer compartment temperature is not satisfactory; a step of opening a refrigerant control valve disposed between the condenser and the evaporator, when a first predetermined time passes after the compressor, the condenser fan, and the blower fan are started; a step of stopping the condenser fan and closing the refrigerant control valve, when the freezer compartment temperature becomes satisfactory; and a step of stopping the compressor and the blower fan when a second predetermined time passes after the refrigerant control valve is closed.

[0025] A refrigerator according to an embodiment of the present invention includes: a body having a freezer compartment formed therein; a refrigeration cycle system disposed in the body and including a compressor, a condenser, a refrigerant control valve, an expansion device, and an evaporator through which a refrigerant sequentially passes; and a blower fan sending air cooled by the evaporator to the freezer compartment, in which when the freezer compartment temperature is not satisfactory, the compressor is started first and then the refrigerant control valve is opened and the blower fan is started, and when freezer compartment temperature becomes satisfactory after the refrigerant control valve is opened, the refrigerant control valve is closed first and then the compressor and the blower fan are stopped.

[0026] The refrigerant control valve may be opened when a first predetermined time passes after the compressor is started, and the blower fan is started when the first predetermined time passes after the compressor may be started.

[0027] The compressor and the blower fan may be stopped, when a second predetermined time passes after the refrigerant control valve is closed.

[0028] The refrigerator may further include a condenser fan sending air to the condenser, in which the condenser fan may be operated with the compressor and stopped with closing of the refrigerant control valve.

[0029] A method of operating a refrigerator according to an embodiment of the present invention includes: a step of starting a compressor compressing a refrigerant and of starting a condenser fan sending air to a condenser, when the freezer compartment temperature is not satisfactory; a step of opening a refrigerant control valve disposed between the condenser and the evaporator, when a first predetermined time passes after the compressor, the condenser fan, and the blower fan are started; a step of stopping the condenser fan and closing the refrigerant control valve, when the freezer compartment temperature becomes satisfactory; and a step of stopping the compressor and the blower fan when a second predetermined time passes after the condenser fan is stopped.

[0030] Features and advantages of the present invention will be further understood with reference to the accompanying drawings described below with the following detailed description of embodiments of the present in-

vention, in which:

FIG. 1 is a front view showing the interior of the body the refrigerator according to a first embodiment of the present invention;

FIG. 2 is a cross-sectional plan view when cooling both of the freezer compartment and the refrigerator compartment of the refrigerator according to the first embodiment of the present invention;

FIG. 3 is a cross-sectional plan view when cooling only the freezer compartment of the refrigerator according to the first embodiment of the present invention;

FIG. 4 is a view showing a refrigeration cycle system of the refrigerator according to the first embodiment of the present invention;

FIG. 5 is a control block diagram of the refrigerator according to the first embodiment of the present invention;

FIG. 6 is a view illustrating the operation of a compressor, a blower fan, a refrigerator compartment damper, and a condenser fan, based on the temperatures of the freezer compartment and the refrigerator compartment of the refrigerator according to the first embodiment of the present invention;

FIG. 7 is a flowchart illustrating a method of operating a refrigerator according to the first embodiment of the present invention;

FIG. 8 is a view illustrating the operation of a compressor, a blower fan, a refrigerator compartment damper, and a condenser fan, based on the temperatures of the freezer compartment and the refrigerator compartment of a refrigerator according to a second embodiment of the present invention;

FIG. 9 is a flowchart illustrating a method of operating a refrigerator according to the second embodiment of the present invention;

FIG. 10 is a view illustrating the operation of a compressor, a blower fan, a refrigerator compartment damper, and a condenser fan, based on the temperatures of the freezer compartment and the refrigerator compartment of a refrigerator according to a third embodiment of the present invention;

FIG. 11 is a flowchart illustrating a method of operating a refrigerator according to the third embodiment of the present invention;

FIG. 12 is a control block diagram of a refrigerator according to a fourth embodiment of the present invention;

FIG. 13 is a view showing operation modes according to the temperature of the refrigerator compartment of the refrigerator according to the fourth embodiment of the present invention;

FIG. 14 is a flowchart illustrating a method of controlling the refrigerator according to the fourth embodiment of the present invention;

FIG. 15 is a view illustrating the operation of a compressor, a blower fan, a condenser fan, and a refrigerant control valve, based on the temperature of the freezer compartment of a refrigerator according to a fifth embodiment of the present invention;

FIG. 16 is a flowchart illustrating a method of controlling the refrigerator according to the fifth embodiment of the present invention;

FIG. 17 is a view illustrating the operation of a compressor, a blower fan, a condenser fan, and a refrigerant control valve, based on the temperature of the freezer compartment of a refrigerator according to a sixth embodiment of the present invention; and

FIG. 18 is a flowchart illustrating a method of controlling the refrigerator according to the sixth embodiment of the present invention.

[0031] Embodiments of the present invention will be described hereinafter with reference to the accompanying drawings. In the description of the embodiments, like components may be given like names and reference numerals and they may not be additionally described.

[0032] FIG. 1 is a front view showing the interior of the body the refrigerator according to a first embodiment of the present invention, FIG. 2 is a cross-sectional plan view when cooling both of the freezer compartment and the refrigerator compartment of the refrigerator according to the first embodiment of the present invention, FIG. 3 is a cross-sectional plan view when cooling only the freezer compartment of the refrigerator according to the first embodiment of the present invention, and FIG. 4 is a view showing a refrigeration cycle system of the refrigerator according to the first embodiment of the present invention.

[0033] The refrigerator includes a body 2, a refrigeration cycle system 4, a blower fan 6, and a refrigeration compartment damper 8. The refrigeration cycle system 4 is disposed in the body 2. The refrigeration cycle system 4 includes a compressor 40, a condenser 44, an expansion device 46, and an evaporator 49 through which a refrigerant sequentially passes. The refrigerant passing through the evaporator 49 can cool air.

[0034] A freezer compartment F and a refrigerator compartment R are formed in the body 2. The body 2 may include a freezer compartment door 21 opening/closing the freezer compartment F and a refrigerator compartment door 22 opening/closing the refrigerator compartment R. The body 2 may include a barrier 24 that separates the freezer compartment F and the refrigerator compartment R. The body 2 may include an outer casing 26 that defines the external appearance of the refrigerator, a freezer inner casing 28 that is disposed with the front open inside the outer casing 26 and includes the freezer compartment F therein, and a refrigerator inner casing 30 that is disposed inside the outer casing 26 and includes the refrigerator compartment R therein. A machine room (not shown) where the compressor 40 or the like can be installed can be formed in the body 2. A cooling chamber P where the evaporator 49 is installed may be formed in the body 2. Air can be cooled by the evaporator

49 while passing through the cooling chamber P. The cooling chamber P may communicate with at least one of the freezer compartment F and the refrigerator compartment R. The cooling chamber P may be formed inside one of the freezer inner casing 28 and the refrigerator inner casing 30. The cooling chamber P may be formed between the freezer inner casing 28 and the outer case 26. The cooling chamber P may be formed between the refrigerator inner casing 30 and the outer case 26. In the body 2, both of the freezer compartment F and the cooling chamber P may be formed inside the freezer inner casing 28. A discharge panel 32 may be disposed inside the freezer inner casing 28, the cooling chamber P may be formed between the back plate of the freezer inner casing 28 and the discharge panel 32, and the freezer compartment F may be formed ahead of the discharge panel 32. Cold air discharging-to-freezer compartment channels 33 through which the air cooled by the evaporator 49 is discharged to the freezer compartment F may be formed through the discharge panel 32. A freezer compartment cold air return channel 34 through which the air in the freezer compartment F flows into the cooling chamber P may be formed through the discharge panel 32. A cold air discharging-to-refrigerator compartment channel 35 through which the air in the cooling chamber P or the freezer compartment F is discharged into the refrigerator compartment R may be formed through the barrier 24. A refrigerator compartment cold air return channel 36 through which the air in the refrigerator compartment R is discharged into the cooling chamber P or the freezer compartment F may be formed through the barrier 24.

[0035] The compressor 40, condenser 44, expansion device 46, and evaporator 49 of the refrigeration cycle system 3 may be connected by refrigerant channels. The refrigerant channels may be formed by refrigerant tubes through which a refrigerant passes.

[0036] The compressor 40 can suck and compress the refrigerant evaporated by the evaporator 49 and then discharge the compressed refrigerant. The compressor 40 may be connected with the evaporator 49 through a compressor intake channel 41. The refrigerant in the evaporator 49 may be sucked into the compressor 40 through the compressor intake channel 41. The compressor 40 may be connected with the condenser 44 through a compressor discharge channel 42. The refrigerant compressed by the compressor 40 may be guided to the condenser 44 through the compressor discharge channel 42. The compressor 40 may be installed in the machine room formed in the body 2. The compressor 40 may be a rotary compressor, a scroll compressor, and a linear compressor. When the higher power of first power and second power is inputted, the compressor 40 can discharge a refrigerant higher in temperature and pressure than when the lower power is inputted. The power inputted to the compressor 40 may be changed by changing the current or the voltage. The compressor 40 can change the temperature and pressure of a refrigerant by changing the frequency. The compressor 40 can dis-

charge a high-temperature and high-pressure refrigerant, when the first frequency is applied, and it can discharge a refrigerant lower in temperature and pressure than when the first frequency is inputted to the compressor 40, when the second frequency lower than the first frequency is applied.

[0037] The condenser 44 can condense the refrigerant compressed by the compressor 40. The condenser 44 may be disposed in the machine room formed in the body 2 or may be disposed in the body 2 and exposed to the outside.

[0038] The refrigerator may further include a condenser fan 50 sending air to the condenser 44. The condenser fan 50 may be disposed in the machine room formed in the body 2 and can send the air outside the refrigerator to the condenser 44. The refrigerant passing through the condenser 44 can exchange heat with the air sent from the condenser fan 50. The condenser fan 50 may start with the start of the compressor 40 and stop with the stop of the compressor 40. The condenser fan 50 may include a motor and a blower rotated by the motor and it may be a centrifugal fan or an axial fan.

[0039] A condenser exit channel 45 guiding the refrigerant that has passed through the condenser 44 may be connected to the condenser 44. The refrigerant condensed by the condenser 44 may flow to the expansion device 46 through the condenser exit channel 45. The refrigeration cycle system 4 may further include a hot line 52 through which the refrigerant that has come out from condenser 44 passes. The hot line 52 can remove drops of the refrigerant condensed on the refrigerator after passing through the condenser 44 by evaporating them. The hot line 52 may be disposed after the condenser 44 in the refrigerant flow direction. The hot line 52 may be formed by a refrigerant tube disposed at the portion being in contact with the doors of the body 2. The hot line 52 may be disposed in the body 2 and discharge heat through the outer casing 26. The refrigerant that has passed through the condenser 44 may condense through the hot line 52 by discharging heat. The hot line 52 may be disposed where the body 2 and the freezer compartment door 21 are in contact or where the body 2 and the refrigerator compartment door 22 are in contact. The refrigerant drops on where the body 2 and the freezer compartment door 21 are in contact may be removed by the heat from the hot line 52. The refrigerant drops on where the body 2 and the refrigerator compartment door 22 are in contact may be removed by the heat from the hot line 52. In the refrigerator, a portion of the condenser exit channel 45 may be the hot line 52.

[0040] The expansion device 46 can expand the refrigerant condensed by the condenser 44. The expansion device 46 may include a capillary tube or an electronic expansion valve such as an EEV(Electric Expansion Valve) or an LEV(Linear Expansion Valve). The expansion device 46 may include a plurality of capillary tubes, for example, two capillary tubes of a first capillary tube 47 and a second capillary tube 48. The first capillary tube

47 and the second capillary tube 48 may be different in diameter. The first capillary tube 47 and the second capillary tube 48 may be different in length.

[0041] The refrigerator may further include a refrigerant control valve 54 that can control the refrigerant flowing toward the expansion device 46 in the refrigerant flow direction. The refrigerant control valve 54 may be disposed between the condenser 44 and the expansion device 46 in the refrigerant flow direction. The refrigerant control valve 54 may be disposed between the hot line 52 and the expansion device 46 in the refrigerant flow direction, when the refrigerator further includes the hot line 52. The refrigerant control valve 54 may be connected to the condenser exit channel 45. The refrigerant control valve 54 can pass and stop the refrigerant that has passed through the condenser 44. The refrigerant control valve 54 can guide the refrigerant, which has passed through the condenser 44, to the expansion device 46, when it is open (open mode). The refrigerant control valve 54 can stop the refrigerant, which has passed through the condenser 44, from flowing to the expansion device 46, when it is closed (close mode). The refrigerant control valve 54 may be an electronic valve. The refrigerant control valve 54 may be connected with the first capillary tube 47 through a first capillary tube connection channel 55. The refrigerant control valve 54 may be connected with the second capillary tube 48 through a second capillary tube connection channel 56. The refrigerant guided to the refrigerant control valve 54 may be guided to the first capillary tube 47 through the first capillary tube connection channel 55 and expanded through the first capillary tube 47 or may be guided to the second capillary tube 48 through the second capillary tube channel 56 and expanded through the second capillary tube 48. The first capillary tube 47 and the second capillary tube 48 may be connected with the evaporator 49 by a converging channel. The converging channel may include a first capillary tube exit channel 57 connected to the first capillary tube 47. The converging channel may include a second capillary tube exit channel 58 connected to the first capillary tube 48. The converging channel may include an evaporator inlet channel 59 to which the first capillary tube exit channel 57 and the second capillary tube exit channel 58 are connected and which is connected to the evaporator 49. The refrigerant expanded by the expansion device 46 may be guided to the evaporator 49 through the evaporator inlet channel 59. The expansion device 46 may be disposed in the machine room or in the cooling chamber P.

[0042] The evaporator 49 can evaporate the refrigerant expanded by the expansion device 46 by making it exchange heat with the inside of the refrigerator. The evaporator 49 may be connected with the compressor 40 through the compressor intake channel 41. The evaporator 49 may be disposed in the cooling chamber P. The evaporator 49 may be disposed with the blower fan 6 in the cooling chamber P. The evaporator 49 can cool the air sucked into the cooling chamber P from the freezer

compartment F. The evaporator 49 can cool the air sucked into the cooling chamber P from the refrigerator compartment R. The evaporator 49 can cool both of the air sucked into the cooling chamber P from the freezer compartment F and the air sucked into the cooling chamber P from the refrigerator compartment R. The evaporator 49 may be smaller in number than storing chambers F and R to be cooled and one evaporator may cool both of the freezer compartment F and the refrigerator compartment R.

[0043] The blower fan 6 can send the air cooled by the evaporator 49 to the freezer compartment F. The blower fan 6 can send the air cooled by the evaporator 49 to the freezer compartment F and the refrigerator compartment R. The blower fan 6 can enable air to exchange heat with the refrigerant passing through the evaporator 49 by sending the air to the evaporator 49 and may function as an evaporator fan that evaporates the refrigerant or a freezer compartment fan that cools the freezer compartment. The blower fan 6 may be disposed with the evaporator 49 in the cooling chamber P. The blower fan 6 may include a motor that is a driving source and a fan rotated by the motor. The blower fan 6 may be a centrifugal fan, or a sirocco fan or a turbo fan. The blower fan 6 may be an axial fan too. The motor of the blower fan 6 may be a shift motor. The blower fan 6 is variable in rotational speed, such that it can operate to send a large amount of air, when rotating at a first rotational speed and it can operate to send a small amount of air, when rotating a second rotational speed lower than the first rotational speed. The blower fan 6 may rotate at the first rotational speed in a concurrent operation mode of the freezer compartment F and the refrigerator compartment R. The blower fan 6 may rotate at the second rotational speed lower than the first rotational speed in a single operation mode of the freezer compartment F. The rotational speed of the blower fan 6 may change with a change in voltage. The amount of air sent by the blower fan 6 may be changed by the applied voltage. The higher the applied voltage, the more the amount of air is sent by the blower fan 6, and the lower the applied voltage, the less the amount of air is sent. High voltage (first voltage) is applied in simultaneous cooling of the freezer compartment F and the refrigerator compartment R, so the blower fan 6 sends a large amount of air. Low voltage (second voltage, second voltage < first voltage) is applied in cooling of only the freezer compartment F, so the blower fan 6 sends a small amount of air.

[0044] The refrigerator compartment damper 8 regulates the air sent to the refrigerator compartment R from the evaporator 49. The refrigerator compartment damper 8 may be disposed on the barrier 24 or in the refrigerator compartment R. When the refrigerator compartment damper 8 is disposed on the barrier 24, it may be positioned in cold air discharging-to-refrigerator compartment 35 and can pass or stop the cold air passing through the cold air discharging-to-refrigerator compartment 35. When the refrigerator compartment damper 8 is disposed

in the refrigerator compartment R, it may be positioned at the upper portion in the refrigerator compartment R and can communicate with the cold air discharging-to-refrigerator compartment 35. The refrigerator compartment damper 8 may pass or stop the cold air passing through the cold air discharging-to-refrigerator compartment 35 from the cooling chamber P. Cold air can flow into the refrigerator compartment R when the refrigerator compartment damper 8 opens, and it cannot flow into the refrigerator compartment R when the refrigerator compartment damper 8 closes.

[0045] FIG. 5 is a control block diagram of the refrigerator according to the first embodiment of the present invention and FIG. 6 is a view illustrating the operation of the compressor, the blower fan, the refrigerator compartment damper, and the condenser fan, based on the temperatures of the freezer compartment and the refrigerator compartment of the refrigerator according to the first embodiment of the present invention.

[0046] The refrigerator may include a control unit 90 controlling the blower fan 6, the refrigerator compartment damper 8, and the compressor 40. The control unit 90 may control the blower fan 6, the refrigerator compartment damper 8, and the compressor 40 on the basis of the freezer compartment temperature TF and the refrigerator compartment temperature TR. The control unit 90 may control the blower fan 6, the refrigerator compartment damper 8, and the compressor 40 on the basis of input from a user, the freezer compartment temperature TF, and/or the refrigerator compartment temperature TR. The control unit 90 may control the condenser fan 50 with one of the compressor 40 and the blower fan 6. When the refrigerator further includes the refrigerant control valve 54, the control unit 90 may control the refrigerant control valve 54.

[0047] The refrigerator may further include an input unit 92 that receives instructions inputted by a user. The refrigerator may include a freezer compartment temperature sensor 94 that senses the temperature of the freezer compartment F. The refrigerator may include a refrigerator compartment temperature sensor 96 that senses the temperature of the refrigerator compartment R.

[0048] The input unit 92 may receive power, a desired freezer compartment temperature, and/or a desired refrigerator compartment temperature and may output signals corresponding to inputted instructions to the control unit 90.

[0049] The freezer compartment temperature sensor 94 may be disposed in the freezer compartment F, and it can sense the freezer compartment temperature and output a signal corresponding to the sensed freezer compartment temperature to the control unit 90.

[0050] The refrigerator compartment temperature sensor 96 may be disposed in the refrigerator compartment R, and it can sense the refrigerator compartment temperature and output a signal corresponding to the sensed refrigerator compartment temperature to the control unit 90.

[0051] The refrigerator can supply the air cooled by the evaporator 49 (hereafter, referred to as "cold air") to at least one of the freezer compartment F and the refrigerator compartment R and may have a concurrent operation mode in which both of the freezer compartment F and the refrigerator compartment R are supplied with cold air and a freezer compartment single operation mode in which cold air is supplied only to the freezer compartment F and the cold air is stopped from flowing to the refrigerator compartment R.

[0052] The refrigerator may operate in the concurrent operation mode first and change to the freezer compartment single operation mode from the concurrent operation mode. The refrigerator may operate in the freezer compartment single operation mode first and change to a standby mode from the freezer compartment single operation mode. The refrigerator may change to the concurrent operation mode or the freezer compartment single operation mode from the standby mode.

[0053] The freezer compartment temperature sensor 94 can sense the temperature of the freezer compartment F and output a signal corresponding to the sensed temperature to the control unit 90, and then the control unit 90 can determine whether the freezer compartment temperature TF is satisfactory or not, in response to the signal from the freezer compartment temperature sensor 94.

[0054] The control unit 90 can determine whether the freezer compartment temperature TF is satisfactory or not on the basis of a desired freezer compartment temperature. When a user inputs a desired freezer compartment temperature to the input unit 92, the desired freezer compartment temperature may be the reference for determining whether the freezer compartment temperature TF is satisfactory or not, and when a user does not input a desired freezer compartment temperature to the input unit 92, the desired freezer compartment temperature that is initially set may be the reference for determining whether the freezer compartment temperature TF is satisfactory or not.

[0055] The control unit 90 may determine that the freezer compartment temperature TF is satisfactory, when the temperature sensed by the freezer compartment temperature sensor 94 is lower than the desired freezer compartment temperature, and it may determine that the freezer compartment temperature TF is not satisfactory, when the temperature sensed by the freezer compartment temperature sensor 94 is higher than the desired freezer compartment temperature.

[0056] The control unit 90 can determine whether the freezer compartment temperature TF is satisfactory or not on the basis of an upper limit and a lower limit of the desired freezer compartment temperature. The upper limit and the lower limit of the desired freezer compartment temperature is a deviation of the desired freezer compartment temperature, and for example, when the desired freezer compartment temperature is -17°C, the upper limit of the desired freezer compartment temper-

ature may be higher by a predetermined level than the desired freezer compartment temperature, for example, -16.5°C or -16°C, and the lower limit of the desired freezer compartment temperature may be lower by a predetermined level than the desired freezer compartment temperature, for example, -17.5°C or -18°C. The control unit 90 may determine that the freezer compartment temperature TF is satisfactory, when the temperature sensed by the freezer compartment temperature sensor 94 is lower than the lower limit of the desired freezer compartment temperature, and it may determine that the freezer compartment temperature TF is not satisfactory, when the temperature sensed by the freezer compartment temperature sensor 94 is higher than the upper limit of the desired freezer compartment temperature.

[0057] The refrigerator compartment temperature sensor 96 can sense the temperature of the refrigerator compartment R and output a signal corresponding to the sensed temperature to the control unit 90, and then the control unit 90 can determine whether the refrigerator compartment temperature TR is satisfactory or not, in response to the signal from the refrigerator compartment temperature sensor 96.

[0058] The control unit 90 can determine whether the refrigerator compartment temperature TR is satisfactory or not on the basis of a desired refrigerator compartment temperature. When a user inputs a desired refrigerator compartment temperature to the input unit 92, the desired refrigerator compartment temperature may be the reference for determining whether the refrigerator compartment temperature TR is satisfactory or not, and when a user does not input a desired refrigerator compartment temperature to the input unit 92, a refrigerator compartment temperature that is initially set may be the reference for determining whether the refrigerator compartment temperature TR is satisfactory or not.

[0059] The control unit 90 may determine that the refrigerator compartment temperature TR is satisfactory, when the temperature sensed by the refrigerator compartment temperature sensor 96 is lower than the desired refrigerator compartment temperature, and it may determine that the refrigerator compartment temperature TR is not satisfactory, when the temperature sensed by the refrigerator compartment temperature sensor 96 is higher than the desired refrigerator compartment temperature.

[0060] The control unit 90 can determine whether the refrigerator compartment temperature TR is satisfactory or not on the basis of a upper limit and a lower limit of the desired refrigerator compartment temperature. The upper limit and the lower limit of the desired refrigerator compartment temperature is a deviation of the desired refrigerator compartment temperature, and for example, when the desired refrigerator compartment temperature is 4°C, the upper limit of the desired refrigerator compartment temperature may be higher by a predetermined level than the desired refrigerator compartment temperature, for example, 4.5°C or 5°C, and the lower limit of the

desired refrigerator compartment temperature may be lower by a predetermined level than the desired refrigerator compartment temperature, for example, 3.5°C or 3°C. The control unit 90 may determine that the refrigerator compartment temperature TR is satisfactory, when the temperature sensed by the refrigerator compartment temperature sensor 96 is lower than the lower limit of the desired refrigerator compartment temperature, and it may determine that the refrigerator compartment temperature TR is not satisfactory, when the temperature sensed by the refrigerator compartment temperature sensor 96 is higher than the upper limit of the desired refrigerator compartment temperature.

[0061] In the refrigerator, the refrigerator compartment temperature TR may not be satisfactory without the freezer compartment temperature TF being satisfactory (simultaneously unsatisfactory condition), the refrigerator compartment temperature TR may be satisfactory without the freezer compartment temperature TF being satisfactory (freezer compartment-unsatisfactory condition), the refrigerator compartment temperature TR may not be satisfactory with the freezer compartment temperature TF being satisfactory (refrigerator compartment-unsatisfactory condition), and the refrigerator compartment temperature TR may be satisfactory with the freezer compartment temperature TF being satisfactory (simultaneously satisfactory condition).

[0062] The refrigerator may operate in the concurrent operation mode A, when the freezer compartment temperature TF is not satisfactory and the refrigerator compartment temperature TR is not satisfactory, in which the compressor 40 is operated, the refrigerator compartment damper 8 is opened, and the first voltage is applied to the blower fan 6. In the concurrent operation mode, voltage may be applied to the condenser fan 50 so that it may be operated.

[0063] When the compressor 40 operates, the compressor 40 can suck, compress, and discharge a refrigerant, the refrigerant compressed by the compressor 40 can be condensed by the condenser 44, the refrigerant condensed by the condenser 44 can be expanded by the expansion device 46, and the refrigerant expanded by the expansion device 46 can be evaporated by the evaporator 49. The blower fan 6 can rotate at the first number of revolutions and send the air in the freezer compartment F and the air in the refrigerator compartment R to the evaporator 49, when the first voltage is applied. The air flowing in the evaporator 49 can be cooled by exchanging heat with the evaporator 49. The cold air can be distributed to the freezer compartment F and the refrigerator compartment R and the freezer compartment F and the refrigerator compartment R can be simultaneously cooled. The refrigerator compartment temperature TR may decrease below the desired refrigerator compartment temperature of the lower limit of the below the desired refrigerator compartment temperature, in which the control unit 90 can determine that the refrigerator compartment temperature TR is satisfactory.

[0064] When the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature is satisfactory in the concurrent operation mode A, the refrigerator can stop the concurrent operation mode A and operate in the freezer compartment single operation mode B.

[0065] The freezer compartment single operation mode B may be performed, following the concurrent operation mode A. In the freezer compartment single operation mode B, the compressor 40 may operate, the refrigerator compartment damper 8 may be closed, and the second voltage lower than the first voltage may be applied to the blower fan 6. The blower fan 6 may operate at the second number of revolutions smaller than the first number of revolutions, when the second voltage is applied.

[0066] The compressor 40 that is operating in the concurrent operation mode A can keep operating in the freezer compartment single operation mode B and the refrigerant can keep circulate through the compressor 40, condenser 44, expansion device 46, and evaporator 49. The refrigerator compartment damper 8 stops the air cooled by the evaporator 49 from flowing any more to the refrigerator compartment R, by closing. The amount of air sent by the blower fan 6 becomes smaller than that when the freezer compartment temperature TF is not satisfactory and the refrigerator compartment temperature TR is not satisfactory, and the second voltage lower than the first voltage is applied to the blower fan 6, such that the power consumption of the refrigerator can be reduced. It is preferable that the second voltage is 30~70% of the first voltage and the minimum of the second voltage is set to a level by which cold air can be circulated through the freezer compartment F and the refrigerator compartment R. In the freezer compartment single operation mode B, cold air is not supplied to the refrigerator compartment B, but is kept supplied to the freezer compartment, such that the freezer compartment temperature TF can keep decreasing or can be maintained.

[0067] In the refrigerator, when the freezer compartment temperature TF is satisfied in the freezer compartment single operation mode B, the compressor 40 may be stopped and the voltage supplied to the blower fan 6 may be stopped. In the refrigerator, when the compressor 40 is turned off, the voltage applied to the condenser fan 50 may be stopped and the condenser fan 50 may be stopped. When the freezer compartment temperature TF is satisfied in the freezer compartment single operation mode B, the refrigerator can enter the standby mode C in which cold air is not forcibly sent any more to the freezer compartment F. When the compressor 40 is turned off, the refrigerant does not circulate any more through the compressor 40, condenser 44, expansion device 46, and evaporator 49 and the cold air is not forcibly sent any more to the freezer compartment F.

[0068] In the refrigerator, the freezer compartment temperature TF may become unsatisfactory and the refrigerator compartment temperature TR may become un-

satisfactory by a load in the standby mode C, in which the concurrent operation mode A may be started again. The refrigerator may repeat the modes in the order of the concurrent operation mode A, the freezer compartment single operation mode B, and the standby mode C.

[0069] In the refrigerator, when the freezer compartment temperature TF is not satisfactory and the refrigerator compartment temperature TR is not satisfactory in the standby mode C, the concurrent operation mode A and the freezer compartment single operation mode B may be sequentially performed, and when the freezer compartment temperature TF is not satisfactory and the refrigerator compartment temperature TR is satisfactory in the standby mode C, only the freezer compartment single operation mode B may be performed.

[0070] In the refrigerator, when the standby mode C changes to the freezer compartment single operation mode B, the refrigerator compartment damper 8 can be kept closed, the compressor 40 is operated, and the second voltage is applied and the blower fan 6 can be operated. Further, when the freezer compartment temperature TF becomes satisfactory with the refrigerator compartment damper 8 closed, the compressor 40 can be stopped and the voltage applied to the blower fan 6 can be stopped.

[0071] FIG. 7 is a flowchart illustrating a method of operating a refrigerator according to the first embodiment of the present invention.

[0072] In the method of operating a refrigerator according to the embodiment, when the freezer compartment temperature TF is not satisfactory and the refrigerator compartment temperature TR is not satisfactory, a step (that is, a concurrent cooling step) of starting the compressor 4, of opening the refrigerator compartment damper 8 regulating the supply of air cooled by the evaporator 49 to the refrigerator compartment, and of applying the first voltage to the blower fan 6 sending the air cooled by the evaporator 49 to the freezer compartment F and the refrigerator compartment R can be performed (S1)(S2)(S3).

[0073] When the compressor 40 is operated, the evaporator 49 can cool the air while the refrigerant circulates through the compressor 40, condenser 44, expansion device 46, and evaporator 49.

[0074] When the first voltage is applied to the blower fan 8, the blower fan 8 can send the air in the freezer compartment F and the air in the refrigerator compartment R to the evaporator 49 and the air that has exchanged heat with the evaporator 49 can be forcibly sent to the freezer compartment F and the refrigerator compartment R. Some of the air cooled by the evaporator 49 can flow to the freezer compartment F and cool the freezer compartment F and the other of the air can flow to the refrigerator compartment R and cool the refrigerator compartment R.

[0075] In the freezer compartment F and the refrigerator compartment R of the refrigerator, the temperature of the refrigerator compartment R may reach the desired

temperature first, and the refrigerator compartment TR may be satisfactory even though the freezer compartment temperature TF is not satisfactory yet in the concurrent operation mode of the freezer compartment F and the refrigerator compartment R.

[0076] When the freezer compartment temperature TF is not satisfactory and the refrigerator compartment TR is satisfactory in the step of cooling both of the freezer compartment F and the refrigerator compartment R, as described above, a step (that is, a freezer compartment single cooling step) of keeping the compressor 40 operating, of closing the refrigerator compartment damper 8, and of applying the second voltage lower than the first voltage to the blower fan 6 is performed (S4)(S5).

[0077] When the compressor 40 is operated, the refrigerant can keep circulating through the compressor 40, condenser 44, expansion device 46, and evaporator 49, and the refrigerator compartment damper 8 stops the air cooled by the evaporator 49 from flowing to the refrigerator compartment R by closing. As the second voltage is applied, the amount of air sent by the blower fan 6 reduces less than that when the first voltage is applied, the air in the freezer compartment F can circulate through the evaporator 49 and the freezer compartment F, and the temperature of the freezer compartment F keeps dropping.

[0078] When the freezer compartment temperature TF is satisfactory in the step of cooling only the freezer compartment F, as described above, a step of stopping the compressor 40 and stopping the voltage applied to the blower fan 6 is performed (S6)(S7). That is, when the freezer compartment temperature TF is satisfactory while the second voltage is applied, the second voltage is not supplied any more to the blower fan 6 and the blower fan 6 stops.

[0079] In the method of operating a refrigerator according to the embodiment, after the standby step (S6)(S7), the concurrent cooling step(S1)(S2)(S3), the freezer compartment single cooling step (S4)(S5), and the standby step (S6)(S7) can be sequentially repeated.

[0080] FIG. 8 is a view illustrating the operation of a compressor, a blower fan, a refrigerator compartment damper, and a condenser fan, based on the temperatures of the freezer compartment and the refrigerator compartment of a refrigerator according to a second embodiment of the present invention.

[0081] When the freezer compartment temperature TF is satisfactory in the freezer compartment single operation mode, the refrigerator can operate in a blower fan-additional operation mode C' in which the compressor 40 is stopped and the blower fan 6 stops after kept operating for a predetermined time T. The blower fan 6 may stop after further operating for the predetermined time T after the compressor 40 is stopped, without stopping with the compressor 40. The blower fan 6 can stop after further operating for a predetermined time T, even after the temperature of the freezer compartment F becomes satisfactory. The larger the size of the evaporator 49, the longer

er the predetermined time T may be set, and the smaller the size of the evaporator 49, the shorter the predetermined time T may be set. The predetermined time T may be set in proportion to the size of the evaporator 49. For example, when the predetermined time T is set to 2 minutes, the blower fan 6 can keep operating for 2 minutes after the compressor 40 stops, and it can stop when 2 minutes passes after the compressor 40 is turned off. The larger the capacity of the refrigerator, the size of the evaporator 49 may be and the predetermined time T may be set in proportion to the capacity of the refrigerator. The predetermined time T may be variously set in proportion to the capacity of the refrigerator, for example, 1 minute, 2 minutes, 3 minutes, 5 minutes, and 10 minutes.

[0082] The refrigerator may enter the standby mode C in which cold air is not forcibly supplied any more to the freezer compartment F after the blower fan-additional operation mode C'.

[0083] In the refrigerator, the concurrent operation mode A and the freezer compartment single operation mode B described in the first embodiment of the present invention may be sequentially performed, the blower fan-additional operation mode C' may be performed after the freezer compartment single operation mode B, and the standby mode C may be performed after the blower fan-additional operation mode C'.

[0084] When the freezer compartment temperature TF is not satisfactory and the refrigerator compartment temperature TR is not satisfactory, the concurrent operation mode A can be started, in which the compressor 40 is operated, the refrigerator compartment damper 8 is opened, and the first voltage is applied to the blower fan 6. In the concurrent operation mode A, voltage may be applied to the condenser fan 50 and it may be operated. In the concurrent operation mode A, cold air is supplied to the freezer compartment T and the refrigerator compartment R, and the freezer compartment temperature TF and the refrigerator compartment temperature TR may drop.

[0085] When the freezer compartment temperature TF becomes not satisfactory and the refrigerator compartment temperature TR becomes satisfactory in the concurrent operation mode A, the concurrent operation mode A can be finished and the freezer compartment single operation mode B can be started. In the freezer compartment single operation mode B, the compressor 40 keep operating, the refrigerator compartment damper 8 is closed, and the second voltage is applied to the blower fan 6. In the freezer compartment single operation mode B, the voltage is kept applied to the condenser fan 50, such that the condenser fan 50 can operate with the compressor. In the freezer compartment single operation mode B, cold air is not supplied any more to the refrigerator compartment R, but supplied to the freezer compartment T, such that the freezer compartment temperature TF may drop.

[0086] When the freezer compartment temperature TF becomes satisfactory in the freezer compartment single

operation mode B, the blower fan-additional operation mode C' may be started without immediately entering to the standby mode C. In blower fan-additional operation mode C', the compressor 40 stops, the refrigerator compartment damper 8 is closed, and the second voltage can be applied to the blower fan 6. In the blower fan-additional operation mode C', voltage may not be applied to the condenser fan 50 and the condenser fan 50 may be stopped with the compressor 40. In the blower fan-additional operation mode C', the blower fan 6 can circulate the air through the evaporator 49 and the freezer compartment F by keeping operating and the evaporator 49 can keep cooling the freezer compartment F even after the compressor 40 stops. With the blower fan-additional operation mode C' started, the refrigerant in the evaporator 49 can keep exchanging heat with air for the predetermined time T even after the compressor 40 stops and the cooling capacity remaining in the evaporator F can be transmitted as much as possible for the predetermined time T to the freezer compartment F.

[0087] When the predetermined time T passes after the blower fan-additional operation mode C' is started, the refrigerator may enter the standby mode C, in which the second voltage is not applied to the blower fan 6 and the blower fan 6 stops.

[0088] In the refrigerator, the blower fan 6 further operates for the predetermined time after the freezer compartment single operation mode B, such that restart of the concurrent operation mode A or the freezer compartment single operation mode B which can be performed after the standby mode C can be delayed as late as possible.

[0089] In the refrigerator, the freezer compartment temperature TF may become unsatisfactory and the refrigerator compartment temperature TR may become unsatisfactory by a load in the standby mode C, in which the concurrent operation mode A may be started again. The refrigerator may repeat the modes in the order of the concurrent operation mode A, the freezer compartment single operation mode B, the blower fan-additional operation mode C', and the standby mode C.

[0090] In the refrigerator, other configuration and operation, except that the blower fan-additional operation mode C' is performed after the freezer compartment single operation mode B and the blower fan-additional operation mode C' changes to the standby mode C after performing for a predetermined time, may be the same as or similar to those of the first embodiment of the present invention, the same reference numerals are used, and the detailed description is not provided.

[0091] FIG. 9 is a flowchart illustrating a method of operating a refrigerator according to the second embodiment of the present invention.

[0092] In the method of operating a refrigerator, a step (that is, a blower fan-additional operation step) of stopping the compressor 40 and keeping the blower fan 6 operating for the predetermined time T when the freezer compartment temperature TF becomes satisfactory in

the step (S4)(S5) that cools only the freezer compartment F can be performed (S6)(S7'), in which the second voltage can be applied to the blower fan 6 for the predetermined time T after the compressor 40 stops. In the refrigerator, when the predetermined time T passes, a step (that is, a standby step) of not supplying any more the second voltage to the blower fan 6 and stopping the blower fan 6 can be performed (S8)(S9).

[0093] In the method of operating a refrigerator according to the embodiment, after the standby step (S8)(S9), the concurrent cooling step(S1)(S2)(S3), the freezer compartment single cooling step (S4)(S5), the blower fan-additional operation step (S6)(S7'), and the standby step (S8)(S9) can be sequentially repeated.

[0094] In the method of operating a refrigerator according to the embodiment, other configuration and operation, except that the blower fan-additional operation step (S6)(S7') and the standby step (S8)(S9) are performed after the freezer compartment single cooling step (S4)(S5), are the same as or similar to the method of operating a refrigerator according to the first embodiment, such that the same reference numerals are used and the detailed description is not provided.

[0095] FIG. 10 is a view illustrating the operation of a compressor, a blower fan, a refrigerator compartment damper, and a condenser fan, based on the temperatures of the freezer compartment and the refrigerator compartment of a refrigerator according to a third embodiment of the present invention.

[0096] In the refrigerator, voltage lower than that in the freezer compartment single operation mode B may be applied to the blower fan 6 in a blower fan-additional operation mode C". In the refrigerator, other configuration and operation, except that voltage lower than that in the freezer compartment single operation mode B is applied to the blower fan 6 in the blower fan-additional operation mode C", are the same as or similar to those of the second embodiment of the present invention, such that the detailed description is not provided.

[0097] When the freezer compartment temperature TF is not satisfactory and the refrigerator compartment temperature TR is satisfactory, the second voltage may be applied to the blower fan 6, and when the freezer compartment temperature TF becomes satisfactory while the second voltage is applied to the blower fan 6, a third voltage lower than the second voltage may be applied to the blower fan 6. The amount of air sent by the blower fan 6 when the third voltage is applied is smaller than that when the second voltage is applied.

[0098] That is, in the blower fan-additional operation mode C", the third voltage lower than the second voltage can be applied to the blower fan 6 for the predetermined time T. The blower fan 6 may operate at the third number of revolutions smaller than the second number of revolutions for the predetermined time T.

[0099] In the refrigerator, as in the second embodiment of the present invention, the modes may be repeated in the order or the concurrent operation mode A, the freezer

compartment single operation mode B, the blower fan-additional operation mode C", and the standby mode C, and only the amount of air sent in the blower fan-additional operation mode C" may be smaller than that in the freezer compartment single operation mode B.

[0100] FIG. 11 is a flowchart illustrating a method of operating a refrigerator according to the third embodiment of the present invention.

[0101] In the method of operating a refrigerator, a step (that is, a blower fan-additional operation step) of stopping the compressor 40 and keeping the blower fan 6 operating for the predetermined time T when the freezer compartment temperature TF becomes satisfactory in the step (S4)(S5) that cools only the freezer compartment F can be performed (S6)(S7"), in which the third voltage lower than the second voltage can be applied to the blower fan 6 for the predetermined time T. The third voltage may be applied to the blower fan 6 for the predetermined time T, after the compressor 40 stops. In the refrigerator, when the predetermined time T passes, a step (that is, a standby step) of not supplying the third voltage to the blower fan 6 and stopping the blower fan 6 can be performed (S8)(S9).

[0102] In the method of operating a refrigerator according to the embodiment, after the standby step (S8)(S9), the concurrent cooling step(S1)(S2)(S3), the freezer compartment single cooling step (S4)(S5), the blower fan-additional operation step (S6)(S7"), and the standby step (S8)(S9) can be sequentially repeated.

[0103] Other configuration and operation in the method of operating a refrigerator according to the embodiment are the same as or similar to those of the method of operating a refrigerator according to the second embodiment of the present invention, such that the same reference numerals are used and the detailed description is not provided.

[0104] FIG. 12 is a control block diagram of a refrigerator according to a fourth embodiment of the present invention and FIG. 13 is a view showing operation modes according to the temperature of the refrigerator compartment of the refrigerator according to the fourth embodiment of the present invention.

[0105] The refrigerator may include the body 2, the refrigeration cycle system 4, the blower fan 6, and the condenser fan 50, and may further include a humidity sensor 110 that senses humidity.

[0106] The condenser fan 50 has a motor, which may be a shift motor and can change the rotational speed of the fan. The condenser fan may be operated at the first number of revolutions or the second number of revolutions. The condenser fan 50 can operate to send a large amount of air, when operating at the first rotational speed and it can operate to send a small amount of air, when operating at the second rotational speed lower than the first rotational speed. The condenser fan 50 can operate at the first rotational speed in a normal cooling mode and it can operate at the second rotational speed lower than the first rotational speed in an anti-dew-forming mode.

The rotational speed of the condenser fan 50 may change with a change in voltage. The amount of air sent by the condenser fan 50 may be changed by the applied voltage, the higher the voltage, the more the amount of air may be, and the lower the voltage, the less the amount of air may be.

[0107] The humidity sensor 110, which senses the humidity around the portions where dew-forming frequently occurs in the body, can sense the humidity outside the freezer compartment F. The humidity sensor 110 may be mounted on the freezer compartment door 21 or the refrigerator compartment door 22.

[0108] In the refrigerator, the control unit 90 can control the blower fan 6, the condenser fan 50, and the compressor 40 on the basis of the freezer compartment temperature TF and humidity. The control unit 90 can control the blower fan 6, the condenser fan 50, and the compressor 40 on the basis of input by a user, the freezer compartment temperature TF, and/or humidity.

[0109] In the refrigerator, the compressor 40 and the condenser fan 50 may be variably controlled on the basis of the freezer compartment temperature TF and/or humidity. In the refrigerator, when the freezer compartment temperature TF is not satisfactory and humidity is high, the compressor 40 and the condenser fan 50 can be controlled such that a high-temperature refrigerant flows through the hot line 52. In the refrigerator, when the freezer compartment temperature TF is not satisfactory and humidity is low, the compressor 40 and the condenser fan 50 can be controlled such that a refrigerant at relatively low temperature flows through the hot line 52.

[0110] The freezer compartment temperature sensor 92 can sense the temperature of the freezer compartment and output it to the control unit 90. The humidity sensor 110 can sense humidity and output it to the control unit 90. The control unit 90 can control all of the compressor 40, blower fan 6, and condenser fan 50 on the basis of the value (freezer compartment temperature) outputted from the freezer compartment temperature sensor 92 and the value (humidity) outputted from the humidity sensor 110. The control unit 90 can control the refrigerant control valve 54 and the compressor 40 together. The control unit 90 can control the refrigerant control valve 54 and the compressor 40 with a time difference.

[0111] (F) of FIG. 13 shows the operation of the blower fan 6, the condenser fan 50, the compressor 40, and the refrigerant control valve 54, when the freezer compartment temperature TF is not satisfactory and the humidity sensed by the humidity sensor 110 is less than a predetermined level. (G) of FIG. 13 shows the operation of the blower fan 6, the condenser fan 50, the compressor 40, and the refrigerant control valve 54, when the freezer compartment temperature TF is not satisfactory and the humidity sensed by the humidity sensor 110 is a predetermined level or more.

[0112] When the freezer compartment temperature TF is not satisfactory and the humidity sensed by the humid-

ity sensor 110 is less than a predetermined level, the refrigerator can operate in the normal cooling operation. When the freezer compartment temperature TF is not satisfactory and the humidity sensed by the humidity sensor 110 is less than a predetermined level, as shown in (F) of FIG. 13, the refrigerator can operate in the normal cooling operation in which first power is inputted to the compressor 40 and the condenser fan 50 is operated at the first rotational speed.

[0113] When the freezer compartment temperature TF is not satisfactory and the humidity sensed by the humidity sensor 110 is a predetermined level or more, the refrigerator can operate in the anti-dew-forming operation, not in the normal cooling operation. When the freezer compartment temperature TF is not satisfactory and the humidity sensed by the humidity sensor 110 is a predetermined level or more, as shown in (G) of FIG. 13, the refrigerator can operate in the anti-dew-forming operation in which second power higher than the first power is inputted to the compressor 40 and the condenser fan 50 is operated at the second rotational speed lower than the first rotational speed.

[0114] Other configuration and operation, except that the power inputted to the compressor 40 and the number of revolutions of the condenser fan 50 are different when the refrigerator operates in the normal cooling operation and in the anti-dew-forming operation, may be the same as or similar to one of those of the first to third embodiments, such that the same reference numerals are used and the detailed description is not provided.

[0115] A normal cooling is described hereafter in detail with reference to (F) of FIG. 13.

[0116] In the normal cooling operation of the refrigerator, the compressor 40 can be started, the blower fan 6 can be started, and the condenser fan 50 can be started. The refrigerant control valve 54 may keep closed, until a predetermined time T passes after the compressor 40 is started. The normal cooling may include a stabilizing mode A' and a normal cooling mode B'. In the normal cooling operation, the normal cooling mode B' may be performed, after the stabilizing mode A is performed first.

[0117] The refrigerator may operate in the stabilizing mode A' with the refrigerant control valve 54 closed and the compressor 40, blower fan 6, and condenser fan 50 operated. In the stabilizing mode A', the refrigerant in the evaporator 49 can be sucked into the compressor 40 and compressed therein and the refrigerant compressed by the compressor 40 can be collected in the hot line 52 and the condenser 44.

[0118] After the stabilizing mode A' is performed for a predetermined time, the refrigerant control valve 54 can be opened and the refrigerator can operate in the normal cooling mode B' with the compressor 40, blower fan 6, and condenser fan 50 operated and the refrigerant control valve 54 off. In the normal cooling mode B', the refrigerant can be sucked into the compressor 40 after sequentially passing through the compressor 40, condenser 44, hot line 52, refrigerant control valve 54, expansion

device 46, and evaporator 49. The condenser fan 50 can be operated at the first rotational speed in the normal cooling mode B' and can help the refrigerant passing through the condenser 44 condense by exchanging heat with air by sending the air to the condenser 44. The blower fan 6 can help the refrigerant passing through the evaporator 49 condense by exchanging heat with air, by sending the air to the evaporator 49. The refrigerant may condense while passing through the condenser 44, heat the portions around the hot line 52 while passing through the hot line 52, and evaporate through the evaporator 49. While the refrigerator operates in the normal cooling mode B', the temperature of the freezer compartment F may gradually drop. The normal cooling mode B' may be performed for a long time when the freezer compartment load is large, and it may be performed for a short time when the freezer compartment load is small. The refrigerant control valve 54 is kept open during the normal cooling mode B' and the freezer compartment temperature TF may drop during the normal cooling mode B'.

[0119] While the refrigerator operates in the normal cooling mode B', the freezer compartment temperature TF may become satisfactory. While the freezer compartment temperature TF becomes satisfactory in the normal cooling mode B', the refrigerator may finish the normal cooling operation. When the refrigerator finishes the normal cooling operation, the blower fan, condenser fan 50, and compressor 40 can be stopped and the refrigerant control valve 54 can be closed. The refrigerator may enter the standby mode C after finishing the normal cooling mode, the refrigerant does not flow any more in the standby mode C, and the air cooled by the evaporator 49 is not sent any more to the freezer compartment F.

[0120] In the standby mode C, the temperature of the freezer compartment F may gradually increase and the freezer compartment temperature TF may become unsatisfactory due to a change in the load in the standby mode C. In this case, when the humidity sensed by the humidity sensor 110 is less than a predetermined level, the refrigerator can repeat operating in the normal cooling operation, as shown in (F) of FIG. 13, and when the humidity sensed by the humidity sensor 110 is a predetermined level or more, the refrigerator can operate in the anti-dew-forming operation, as shown in (G) of FIG. 13.

[0121] When the refrigerator operates in the normal cooling operation, as in the first to third embodiment, the concurrent operation mode and the freezer compartment single operation mode may be sequentially performed and only the freezer compartment single operation mode may be performed. When the concurrent operation mode and the freezer compartment single operation mode are sequentially performed, the refrigerator can change from the stabilizing mode A' to the normal cooling mode B' in the concurrent operation mode A. When only the freezer compartment single operation mode is performed, the refrigerator can change from the stabilizing mode A' to the normal cooling mode B' in the freezer compartment single operation mode B.

[0122] The anti-dew-forming operation is described hereafter in detail with reference to (G) of FIG. 13.

[0123] In the anti-dew-forming operation of the refrigerator, the compressor 40 can be started, the blower fan 6 can be started, and the condenser fan 50 can be started. The refrigerant control valve 54 may be kept closed, until a predetermined time T passes after the compressor 40 is started. The anti-dew-forming operation of the refrigerator may include a stabilizing mode A' and an anti-dew-forming mode B". In the anti-dew-forming operation, the anti-dew-forming mode B" may be performed, after the stabilizing mode A is performed first.

[0124] The refrigerator may operate in the stabilizing mode A' with the refrigerant control valve 54 closed and the compressor 40, blower fan 6, and condenser fan 50 operated. In the stabilizing mode A', the refrigerant in the evaporator 49 can be sucked into the compressor 40 and compressed therein and the refrigerant compressed by the compressor 40 can be collected in the hot line 52 and the condenser 44.

[0125] In the refrigerator, after the stabilizing mode A' is performed for a predetermined time, the refrigerant control valve 54 can be opened, and the compressor 40, the blower fan 6, and the condenser fan 50 can be operated in the anti-dew-forming mode B" in which the temperature of the refrigerant flowing into the hot line 52 is higher than that in the normal cooling mode B' of the normal cooling operation. In the anti-dew-forming mode B", the compressor 40 can be operated to discharge a refrigerant at higher temperature and pressure than the normal cooling mode B'. In the anti-dew-forming mode B", second power higher than the first power can be inputted to the compressor 40 and a refrigerant at higher temperature and pressure than the normal cooling mode B' can be discharged from the compressor 40. In the anti-dew-forming mode B", the condenser fan 50 can be operated such that a refrigerant at higher temperature than the normal cooling mode B' is discharged from the condenser 44. In the anti-dew-forming mode B", the condenser fan 50 can be operated at the second rotational speed lower than the first rotational speed and the amount of air flowing to the condenser 44 is smaller than that in the normal cooling mode B', and a refrigerant at higher temperature than the normal cooling mode B' can be discharged from the condenser 44.

[0126] In the anti-dew-forming mode B", as in the normal cooling mode B', the refrigerant can be sucked into the compressor 40 after sequentially passing through the compressor 40, condenser 44, hot line 52, refrigerant control valve 54, expansion device 48, and evaporator 49. In the anti-dew-forming mode B", the blower fan 6 can help the refrigerant passing through the evaporator 49 condense by exchanging heat with air, by sending the air to the evaporator 49. The refrigerant may condense while passing through the condenser 44, heat the portions around the hot line 52 to higher temperature than the normal cooling mode B' while passing through the hot line 52, and evaporate through the evaporator 49.

[0127] The freezer compartment F can be cooled as in the normal cooling operation while the refrigerator operates in the anti-dew-forming mode B", the temperature of the freezer compartment F may gradually drop during the anti-dew-forming mode B", and the anti-dew-forming mode B" may be performed for a long time when the freezer compartment load is large and it may be performed for a short time when the freezer compartment load is small, as in the normal cooling mode B'. The refrigerant control valve 54 is kept open during the anti-dew-forming mode B" and the freezer compartment temperature TF may drop during the anti-dew-forming mode B".

[0128] While the refrigerator operates in the anti-dew-forming mode B", the freezer compartment temperature TF may become satisfactory. While the freezer compartment temperature TF becomes satisfactory in the anti-dew-forming mode B", the refrigerator may finish the anti-dew-forming operation. When the refrigerator finishes the anti-dew-forming operation, the blower fan, condenser fan 50, and compressor 40 can be stopped and the refrigerant control valve 54 can be closed. The refrigerator may enter the standby mode C after finishing the anti-dew-forming operation, as in the normal cooling mode, the refrigerant does not flow any more in the standby mode C, and the air cooled by the evaporator 49 is not sent any more to the freezer compartment F.

[0129] In the standby mode C, the temperature of the freezer compartment F gradually increases and the freezer compartment temperature TF may become unsatisfactory due to a change in the load in the standby mode C. In this case, when the sensed humidity is less than a predetermined level, the refrigerator operates in the normal cooling operation, and when the sensed humidity is a predetermined level or more, the anti-dew-forming operation can be repeated.

[0130] When the refrigerator operates in the anti-dew-forming operation, as in the first to third embodiment, the concurrent operation mode and the freezer compartment single operation mode may be sequentially performed and only the freezer compartment single operation mode may be performed. When the concurrent operation mode and the freezer compartment single operation mode are sequentially performed, the refrigerator can change from the stabilizing mode A' to the anti-dew-forming mode B" in the concurrent operation mode A. When only the freezer compartment single operation mode is performed, the refrigerator can change from the stabilizing mode A' to the anti-dew-forming mode B" in the freezer compartment single operation mode B.

[0131] FIG. 14 is a flowchart illustrating a method of controlling the refrigerator according to the fourth embodiment of the present invention.

[0132] The method of operating a refrigerator includes a step of sensing humidity with the humidity sensor 110(S11). The humidity sensor 110 can sense the interior temperature and output it to the control unit 90.

[0133] The method of operating a refrigerator includes

a step of operating the condenser fan 50 sending air to the condenser 44 at the first rotational speed and inputs the first power to the compressor 40 compressing a refrigerant, when the freezer compartment temperature TF is not satisfactory and the sensed humidity is less than predetermined humidity, and of operating the condenser fan 50 at the second rotational speed lower than the first rotational speed and inputting the second power higher than the first power to the compressor 40 (S12)(S13)(S14)(S15).

[0134] When the freezer compartment temperature TF is not satisfactory and the sensed humidity is less than predetermined humidity, the refrigerator can operate in the normal cooling operation in which the condenser fan 50 is operated at the first rotational speed and the first power is inputted to the compressor 40 (S12)(S13)(S14).

[0135] When the freezer compartment temperature TF is not satisfactory and the sensed humidity is predetermined humidity or more, the refrigerator can operate in the normal cooling operation in which the condenser fan 50 is operated at the second rotational speed lower than the first rotational speed and the second power higher than the first power is inputted to the compressor 40 (S12)(S13)(S15).

[0136] In the method of operating a refrigerator, the normal cooling operation and the anti-dew-forming operation can be selectively performed.

[0137] In the method of operating a refrigerator, when a predetermined time passes after the normal cooling operation or the anti-dew-forming operation is started, the refrigerant control valve 54 can be opened (S16).

[0138] The refrigerant control valve 54 can be opened while the refrigerator operates in the normal cooling operation or in the anti-dew-forming operation, and when the refrigerant control valve 54 is opened, the refrigerant can be sucked into the compressor 40 after sequentially passing through the compressor 40, condenser 44, hot line 52, refrigerant control valve 54, and expansion device 46.

[0139] When the refrigerant control valve 54 is opened in the normal cooling operation, a refrigerant at lower temperature and pressure than the anti-dew-forming operation flows into the condenser 44, a larger amount of air than the anti-dew-forming operation can be sent, and a refrigerant at lower temperature and pressure than the anti-dew-forming operation can pass through the hot line 52.

[0140] When the refrigerant control valve 54 is opened in the normal cooling operation, a refrigerant at higher temperature and pressure than the normal cooling operation flows into the condenser 44, a smaller amount of air than the normal cooling operation can be sent, and a refrigerant at higher temperature and pressure than the normal cooling operation can pass through the hot line 52. The refrigerant passing through the hot line 52 in the anti-dew-forming operation can minimize dew-forming which may occur due to high humidity, by heating the portions around the hot line 52.

[0141] The freezer compartment temperature TF may become satisfactory while the refrigerator operates in the normal cooling operation or the anti-dew-forming operation, and when the freezer compartment temperature TF is satisfactory, the method of operating a refrigerator may further include a step of stopping the compressor 40, blower fan 6, and condenser fan 50 and closing the refrigerant control valve 54 (S17)(S18).

[0142] When the compressor 40 is stopped, the refrigerant does not circulate through the compressor 40, condenser 44, hot line 52, refrigerant control valve 54, and expansion device 46, the air in the freezer compartment F is not sent to the evaporator 49, and the refrigerator can be kept in the standby state before the freezer compartment temperature TF becomes unsatisfactory. Thereafter, the method of operating a refrigerator described above can be repeated.

[0143] FIG. 15 is a view illustrating the operation of a compressor, a blower fan, a condenser fan, and a refrigerant control valve, based on the temperature of the freezer compartment of a refrigerator according to a fifth embodiment of the present invention.

[0144] A refrigerator may include the body 2, the refrigeration cycle system 4, the blower fan 6, and the refrigeration compartment damper 8 of the first embodiment of the present invention. A control unit 90 can control the blower fan 6, the compressor 40, and the refrigerant control valve 54 on the basis of the freezer compartment temperature TF. A control unit 90 can control the blower fan 6, the compressor 40, and the refrigerant control valve 54 on the basis of input by a user and/or the freezer compartment temperature TF. The refrigerator may further include the condenser fan 50 of the first embodiment of the present invention and the controller 90 can control the condenser fan 50 on the basis of the freezer compartment temperature TF.

[0145] In the refrigerator, when the freezer compartment temperature TF is unsatisfactory, the compressor 40 and the blower fan 6 can be started first and then the refrigerant control valve 54 can be opened. The refrigerant control valve 54 may be controlled with a time difference from the compressor 40 and the blower fan 6, when it is opened. The refrigerant control valve 54 may be opened, when a first predetermined time T1 passes after the compressor 40 and the blower fan 6 are started.

[0146] The refrigerator may include a stabilizing mode A' with unsatisfactory freezer compartment temperature TF and with the compressor 40 and the blower fan 6 operated and the refrigerant control valve 54 closed, and can operate in the stabilizing mode A' for the first predetermined time T1 after the compressor 40 and the blower fan 6 are started. In the stabilizing mode A', the condenser fan 50 can be operated with the compressor 40. The stabilizing mode A' may be an initial stabilizing mode. In the stabilizing mode A', the compressor 40 can suck and compress the refrigerant in the evaporator 49, and the refrigerant compressed by the compressor 40 is collected in the condenser 44 because the refrigerant control valve

54 is closed.

[0147] In the refrigerator, after the stabilizing mode A' is performed for the first predetermined time T1, the refrigerant control valve 54 is opened. When the refrigerant control valve 54 is opened, the refrigerant can be sucked into the compressor 40 after sequentially passing through the compressor 40, condenser 44, refrigerant control valve 54, expansion device 46, and evaporator 49, and the refrigerator can operate in the normal cooling mode B' for cooling the freezer compartment F. The normal cooling mode may be a freezer compartment cooling mode for circulating the cold air in the freezer compartment F to the evaporator 49 and the freezer compartment F, using the blower fan 6 while the refrigerant normally circulates through the compressor 40, condenser 44, refrigerant control valve 54, expansion device 46, and evaporator 49. In the normal cooling mode B', the condenser fan 50 may keep operating. The normal cooling mode B' may be performed for a long time when the freezer compartment load is large, and it may be performed for a short time when the freezer compartment load is small. The refrigerant control valve 54 is kept open during the normal cooling mode B' and the freezer compartment temperature TF may drop during the normal cooling mode B'.

[0148] While the refrigerator operates in the normal cooling mode B', the freezer compartment temperature TF may become satisfactory.

[0149] In the refrigerator, when the freezer compartment temperature TF is satisfactory after the refrigerant control valve 54 is opened, the refrigerant control valve 54 is closed first and then the compressor 40 and the blower fan 6 are stopped. The condenser fan 50 may be stopped with closing of the refrigerant control valve 54. The compressor 40 and the blower fan 6 may be stopped with a time difference from the refrigerant control valve 54. The compressor 40 and the blower fan 6 may be stopped, when a second predetermined time T2 passes after the refrigerant control valve 54 is closed.

[0150] The refrigerator may include a freezer compartment-additional cooling mode D in which the freezer compartment temperature TF is satisfactory, the refrigerant control valve 54 is closed, and the compressor 40 and the blower fan 6 does not stop, but is kept operating from the normal cooling mode B'. The condenser fan 50 can be stopped during the freezer compartment-additional cooling mode D. The freezer compartment-additional cooling mode D may be a mode for additionally cooling the freezer compartment F while the freezer compartment temperature TF is satisfactory. In the freezer compartment-additional cooling mode D, the compressor 40 and the blower fan 6 does not stop, but is kept operating from the normal cooling mode B', in which the refrigerant control valve 54 may be kept closed. In the freezer compartment-additional cooling mode D, the refrigerant in the evaporator 49 is sucked and compressed in the compressor 40 by additionally operating the compressor 40 and the refrigerant is gradually collected in the condenser

44 as time passes. The refrigerator may operate in the freezer compartment-additional cooling mode D for a second predetermined time and the refrigerant in the evaporator 49 gradually reduces for the second predetermined time. The reduction of the refrigerant in the evaporator 49 may help stabilization of the next cycle that is started after a standby mode, which is described below. In the freezer compartment-additional cooling mode D, the blower fan 6 may be operated for the second predetermined time so that the evaporator 49 is additionally cooled, and the air cooled by the evaporator 49 can additionally cool the freezer compartment F, flowing to the freezer compartment F. The larger the capacity of the refrigerator, the longer the second predetermined time may be, and it may be set in the range of 30 seconds to 180 seconds.

[0151] When the second predetermined time passes after the freezer compartment-additional cooling mode D is started, the refrigerator enters the standby mode C in which the compressor 40 and the blower fan 6 are stopped, the refrigerant does not flow any more, and the air cooled by the evaporator 49 is not sent any more to the freezer compartment F.

[0152] In the standby mode C, the temperature of the freezer compartment F gradually increases and the freezer compartment temperature TF may become unsatisfactory due to a change in the load in the standby mode C, in which the stabilizing mode A may be started again. The refrigerator may go back to the standby mode C after the stabilizing mode A, after sequentially performing the normal cooling mode B', and the freezer compartment-additional cooling mode D, and the stabilizing mode A, after sequentially performing the normal cooling mode B', and the freezer compartment-additional cooling mode D, and the standby mode C can be repeated.

[0153] In the refrigerator, other configuration and operation except the stabilizing mode A, the normal cooling mode B', and the freezer compartment-additional cooling mode D may be the same as of similar to those in the first embodiment of the present invention, such that the same reference numerals are used and the detailed description is not provided.

[0154] In the refrigerator, as in the first embodiment of the present invention, the concurrent operation mode A and the freezer compartment single operation mode B may be sequentially performed and only the freezer compartment single operation mode B may be performed. When the concurrent operation mode A and the freezer compartment single operation mode B are sequentially performed, the refrigerator changes from the stabilizing mode A' to the normal cooling mode B' in the concurrent operation mode A, and after the concurrent operation mode A is finished, the freezer compartment-additional cooling mode D may be performed. When only the freezer compartment single operation mode B is performed, the refrigerator changes from the stabilizing mode A' to the normal cooling mode B' in the freezer compartment single operation mode B, and after the freezer compartment

single operation mode B, the freezer compartment-additional cooling mode D may be performed.

[0155] FIG. 16 is a flowchart illustrating a method of operating a refrigerator according to the fifth embodiment of the present invention.

[0156] The method of operating a refrigerator according to the embodiment may perform a step (initializing step) of starting the compressor 40 that compresses a refrigerant and of starting the condenser fan 50 that sends air to the condenser 44 and the blower fan 6 that circulates the air in the freezer compartment F through the evaporator 49 and the freezer compartment F, when the freezer compartment temperature TF is not satisfactory (S21)(S22).

[0157] The compressor 40 can suck and compress the refrigerant in the evaporator 49, the blower fan 6 can send the air in the freezer compartment F to the evaporator 49 and send it back to the freezer compartment F, and the condenser fan 50 can send air to the condenser 44. While the compressor 40, condenser fan 50, and blower fan 6 are operated, the refrigerant control valve 54 is closed and the refrigerant compressed by the compressor 40 is collected in the condenser 44.

[0158] The method of operating a refrigerator may perform a step (freezer compartment cooling step) of opening the refrigerant control valve 54 between the condenser 44 and the evaporator 49, when a first predetermined time T1 passes after the compressor 40, condenser fan 50, and blower fan 6 are started (S23)(S24).

[0159] When the refrigerant control valve 54 is opened, the refrigerant in the condenser 44 can flow to the expansion device 46 through the refrigerant control valve 54 and can be sucked into the compressor 40 after passing the compressor 40, condenser 44, refrigerant control valve 54, expansion device 46, and evaporator 49. The evaporator 49 can make the air sent by the blower fan 6 exchange heat with the refrigerant and the air cooled by the evaporator 49 can be supplied to the freezer compartment and cool the freezer compartment. As time passes, the freezer compartment F can gradually decrease in temperature and freezer compartment temperature TF may become satisfactory.

[0160] The method of operating a refrigerator can perform a step (freezer compartment-additional cooling step) of stopping the condenser fan 50 and closing the refrigerant control valve 54, when the freezer compartment temperature TF is satisfactory (S25)(S26).

[0161] In the refrigerator, the compressor 40 and the blower fan 6 may keep operating without stopping even with the freezer compartment temperature TF satisfactory and the refrigerant control valve 54 closed, the refrigerant in the evaporator 49 is sucked and compressed in the compressor 40 by the operation of the compressor 40, and the refrigerant may be collected in the condenser 44 as time passes. Further, as the blower fan 6 keeps operating without stopping, the air cooled by the evaporator 49 is kept sent to the freezer compartment F.

[0162] The method of operating a refrigerator can per-

form a step (standby step) of stopping the compressor 40 and the blower fan 6, when a second predetermined time passes after the refrigerant control valve 54 is closed (S27)(S28).

[0163] When the compressor 40 is stopped, the refrigerant does not flow any more and the air cooled by the evaporator 49 is not sent any more to the freezer compartment F. The refrigerator enters the standby state.

[0164] In the refrigerator, as time passes, the temperature of the freezer compartment F gradually increases, the freezer compartment temperature TF may become unsatisfactory due to a change in load during the standby step, the method of operating a refrigerator may restart from the initializing step, and the method of operating a refrigerator may repeat the initializing step, the freezer compartment cooling step, the freezer compartment-additional cooling step, and the standby step.

[0165] FIG. 17 is a view illustrating the operation of a compressor, a blower fan, a condenser fan, and a refrigerant control valve, based on the temperature of the freezer compartment of a refrigerator according to a sixth embodiment of the present invention.

[0166] The present invention is the same as or similar to the fifth embodiment of the present invention except that when the freezer compartment temperature TF is not satisfactory, the compressor 40 is started first, and then the refrigerant control valve 54 is opened and the blower fan 6 is started, and when the freezer compartment temperature TF becomes satisfactory after the refrigerant control valve 54 is opened, the refrigerant control valve 54 is closed first, and then the compressor 40 is stopped and the blower fan 6 is stopped, so the same reference numerals are used and the detailed description is not provided. The refrigerator, as in the fifth embodiment of the present invention, may further include an condenser fan 50 sending air to the condenser 44. The condenser fan 50 may be operated with the compressor 40 and stopped with closing of the refrigerant control valve 54.

[0167] The refrigerant control valve 54 may be controlled with a time difference from the compressor 40, when it is opened. The refrigerant control valve 54 may be opened, when a first predetermined time T1 passes after the compressor 40 is started. The blower fan 6 may be started when the first predetermined time passes after the compressor 40 is started.

[0168] The refrigerator may include a stabilizing mode A" with unsatisfactory freezer compartment temperature TF and with the compressor 40 operated, the refrigerant control valve 54 closed, and the blower fan 6 stopped, and can operate in the stabilizing mode A" for the first predetermined time T1 after the compressor 40 is started. In the stabilizing mode A", the condenser fan 50 can be operated with the compressor 40. The stabilizing mode A" may be an initial stabilizing mode. In the stabilizing mode A", the compressor 40 can suck and compress the refrigerant in the evaporator 49, and the refrigerant compressed by the compressor 40 is collected in the con-

denser 44 because the refrigerant control valve 54 is closed. In the stabilizing mode A", the blower fan 6 is kept in stop without operating. If the blower fan 6 is started while the compressor 40 is operated after started, it means that the blower fan 6 is started without the temperature of the evaporator 49 sufficiently decreased yet, so the heat exchange efficiency of the evaporator 49 is low and power is consumed for operating the blower fan 6. In contrast, when the refrigerant control valve 54 is closed and the blower fan 6 is stopped in the stabilizing mode A", it is possible to reduce the time for stabilizing the cycle of the refrigerant and decrease the power consumption for operating the blower fan 6.

[0169] In the refrigerator, after the stabilizing mode A' is performed for the first predetermined time T1, the refrigerant control valve 54 is opened and the blower fan 6 is started. When the refrigerant control valve 54 is opened, the refrigerant can be sucked into the compressor 40 after sequentially passing through the compressor 40, condenser 44, refrigerant control valve 54, expansion device 46, and evaporator 49, and the refrigerator can operate in the normal cooling mode B' for cooling the freezer compartment F. The normal cooling mode B' is the same as the normal cooling mode B' of the fifth embodiment of the present invention, so the detailed description is not provided.

[0170] The freezer compartment temperature TF may become satisfactory in the normal cooling mode B', and when the freezer compartment temperature TF becomes satisfactory, the refrigerator may operate in a freezer compartment-additional cooling mode D, which is the same as that in the fifth embodiment of the present invention, and a standby mode C may be performed after the freezer compartment-additional cooling mode D, as in the fifth embodiment of the present invention. The freezer compartment-additional cooling mode D and the standby mode C are the same as the freezer compartment-additional cooling mode D and the standby mode C in the fifth embodiment of the present invention, so the detailed description is not provided. Further, in the refrigerator, when the freezer compartment temperature TF becomes unsatisfactory due to a change in load of the standby mode C, the stabilizing mode A" may be started again. The refrigerator may go back to the standby mode C after the stabilizing mode A", after sequentially performing the normal cooling mode B', and the freezer compartment-additional cooling mode D, and the stabilizing mode A", after sequentially performing the normal cooling mode B', and the freezer compartment-additional cooling mode D, and the standby mode C can be repeated.

[0171] FIG. 18 is a flowchart illustrating a method of controlling the refrigerator according to the sixth embodiment of the present invention.

[0172] The method of operating a refrigerator according to the embodiment may perform a step (initializing step) of starting the compressor 40 that compresses a refrigerant and of starting the condenser fan 50 that

sends air to the condenser 44, when the freezer compartment temperature TF is not satisfactory (S21)(S22').

[0173] The compressor 40 can suck and compress the refrigerant in the evaporator 49 and the condenser fan 50 can send air to the condenser 44. When the compressor 40 and the condenser fan 50 are started, the refrigerant control valve 54 between the condenser 44 and the evaporator 49 has been closed, the blower fan 6 circulating air through the evaporator 49 and the freezer compartment F is in stop, and the refrigerant compressed by the compressor 40 is collected in the condenser 44.

[0174] The method of operating a refrigerator can perform a step (freezer compartment cooling step of starting the blower fan 6 and opening the refrigerant control valve 54, when a first predetermined time passes after the compressor 40 is started (S23')(S24').

[0175] When the refrigerant control valve 54 is opened, the refrigerant in the condenser 44 can flow to the expansion device 48 through the refrigerant control valve 54 and can be sucked into the compressor 40 after passing the compressor 40, condenser 44, refrigerant control valve 54, expansion device 46, and evaporator 49. With the blower fan 6 operating, the air in the freezer compartment F can flow to the evaporator 49 and exchange heat with the refrigerant and the air cooled by the evaporator 49 can be supplied to the freezer compartment F and cool the freezer compartment F. As time passes, the freezer compartment F can gradually decrease in temperature and freezer compartment temperature TF may become satisfactory.

[0176] The method of operating a refrigerator can perform a step (a freezer compartment-additional cooling step) of stopping the condenser fan 50 and closing the refrigerant control valve 54, when the freezer compartment temperature is satisfactory (S25)(S26). Further it can perform a step (standby step) of stopping the compressor 40 and the blower fan 6, when a second predetermined time passes after the condenser fan 50 is stopped (S27)(S28).

[0177] The freezer compartment-additional cooling step and the stand by step are the same as or similar to those in the fifth embodiment of the present invention, so the detailed description is not provided. The temperature of the freezer compartment F gradually increases in the standby step of the refrigerator, the freezer compartment temperature TF may become unsatisfactory due to a change in load in the standby step of the refrigerator, the method of operating a refrigerator may start again the initializing step (S21)(S22), and the method of operating a refrigerator may repeat the initializing step (S21)(S22), the freezer cooling steps (S23)(S24'), the freezer compartment temperature is satisfactory (S25)(S26), and the standby step (S27)(S28).

Claims

1. A refrigerator comprising:

- a body having a freezer compartment and a refrigerator compartment formed therein;
 a refrigeration cycle system disposed in the body, including a compressor, a condenser, an expansion device, and an evaporator through which a refrigerant sequentially passes, and to cool air with the refrigerant;
 a blower fan to send the air cooled by the evaporator to the freezer compartment and the refrigerator compartment; and
 a damper to regulate the air sent from the evaporator to the refrigerator compartment, wherein when the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature is satisfactory, the refrigerator operates in a concurrent operation mode in which the compressor is operated, the damper is opened, and first voltage is applied to the blower fan, and
 when the freezer compartment temperature is not satisfactory and refrigerator compartment temperature is satisfactory in the concurrent operation mode, the refrigerator operates in a freezer compartment single operation mode in which the compressor is operated, the damper is closed, and second voltage lower than the first voltage is applied to the blower fan.
2. The refrigerator of claim 1, wherein when the freezer compartment temperature becomes satisfactory in the freezer compartment single operation mode, the compressor is stopped and the voltage applied to the blower fan is stopped.
 3. The refrigerator of claim 1, wherein when the freezer compartment temperature becomes satisfactory in the freezer compartment single operation mode, the refrigerator operates in a blower fan-additional operation mode in which the compressor is stopped and the blower fan is kept operating for a predetermined time.
 4. The refrigerator of claim 3, wherein when the predetermined time passes, the voltage applied to the blower fan is stopped.
 5. The refrigerator of claim 3, wherein the second voltage is applied to the blower fan in the blower fan-additional operation mode.
 6. The refrigerator of claim 3, wherein third voltage lower than the second voltage is applied to the blower fan in the blower fan-additional operation mode.
 7. The refrigerator of claim 1, further comprising:
 a condenser fan to send air to the condenser; and
 8. The refrigerator of claim 1, further comprising a refrigerant control valve disposed between the condenser and the expansion device in the refrigerant flow direction,
 wherein when the freezer compartment temperature is not satisfactory, the compressor is started first and then the refrigerant control valve is opened and the blower fan is started, and
 when freezer compartment temperature becomes satisfactory after the refrigerant control valve is opened, the refrigerant control valve is closed first and then the compressor and the blower fan are stopped.
 9. The refrigerator of claim 8, wherein when a first predetermined time passes after the compressor and the blower fan are started, the refrigerant control valve is opened, and
 the compressor and the blower fan are stopped, when a second predetermined time passes after the refrigerant control valve is closed.
 10. The refrigerator of claim 1, further comprising:
 a refrigerant control valve disposed between the condenser and the expansion device in the refrigerant flow direction,
 wherein when freezer compartment temperature is not satisfactory, the compressor is started first and then the refrigerant control valve is opened and the blower fan is started, and
 when the freezer compartment temperature becomes satisfactory after the refrigerant control valve is opened, the refrigerant control valve is closed first and then the compressor and the blower fan are stopped.
 11. The refrigerator of claim 10, wherein when a first predetermined time passes after the compressor is started, the refrigerant control valve is opened, the blower fan is started, when the first predetermined time passes after the compressor is operated, and
 the compressor and the blower fan are stopped,
- a humidity sensor to sense humidity,
 wherein when the freezer compartment temperature is not satisfactory and the humidity sensed by the humidity sensor is less than a predetermined level, first power is inputted to the compressor and the condenser fan is operated in a first rotational speed, and
 when the freezer compartment temperature is not satisfactory and the humidity sensed by the humidity sensor is at the predetermined level or more, second power higher than the first power is inputted to the compressor and the condenser fan is rotated at a second rotational speed lower than the first rotational speed.

when a second predetermined time passes after the refrigerant control valve is closed.

12. A method of operating a refrigerator comprising:

operating a compressor, opening a damper regulating air cooled by an evaporator and supplied to the refrigerator compartment, and applying first voltage to a blower fan sending the air cooled by the evaporator to the freezer compartment and the refrigerator compartment, when the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature is not satisfactory; and
keeping the compressor operating, closing the damper, and applying second voltage lower than the first voltage to the blower fan, when the freezer compartment temperature is not satisfactory and the refrigerator compartment temperature becomes satisfactory.

13. The method of claim 12, further comprises stopping the compressor and stopping the second voltage applied to the blower fan, when the freezer compartment temperature becomes satisfactory while the second voltage is applied to the blower fan.

14. The method of claim 12, further comprises stopping the compressor and keeping the blower fan operating for a predetermined time, when the freezer compartment temperature becomes satisfactory while the second voltage is applied to the blower fan.

15. The method of claim 14, wherein third voltage lower than the second voltage is applied to the blower fan for the predetermined time.

5

10

15

20

25

30

35

40

45

50

55

FIG. 1

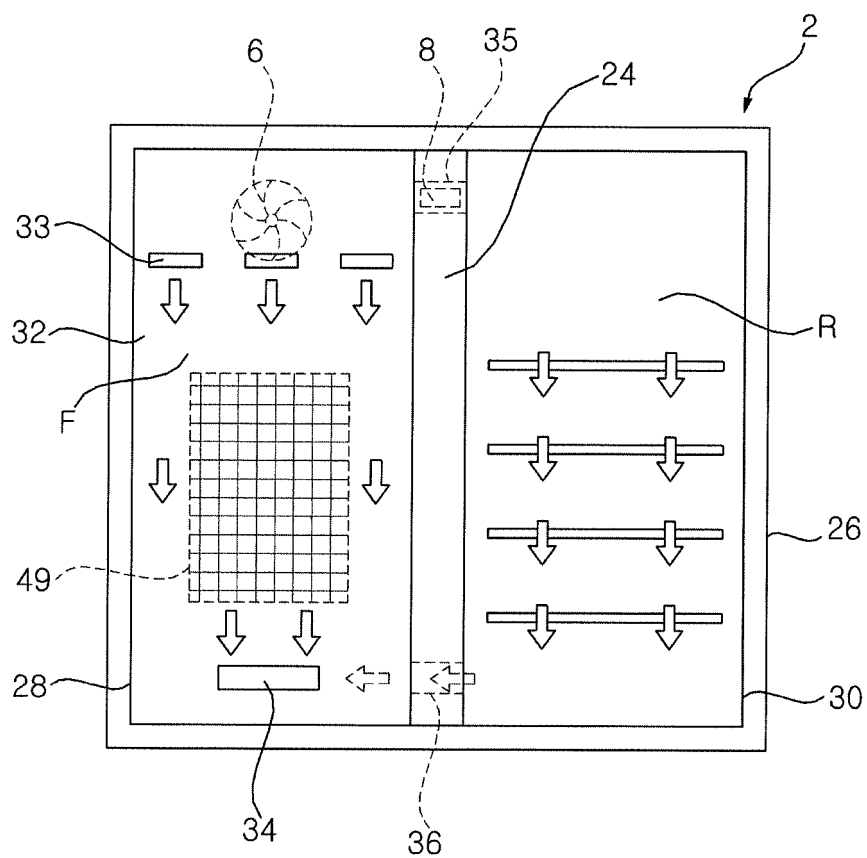


FIG. 2

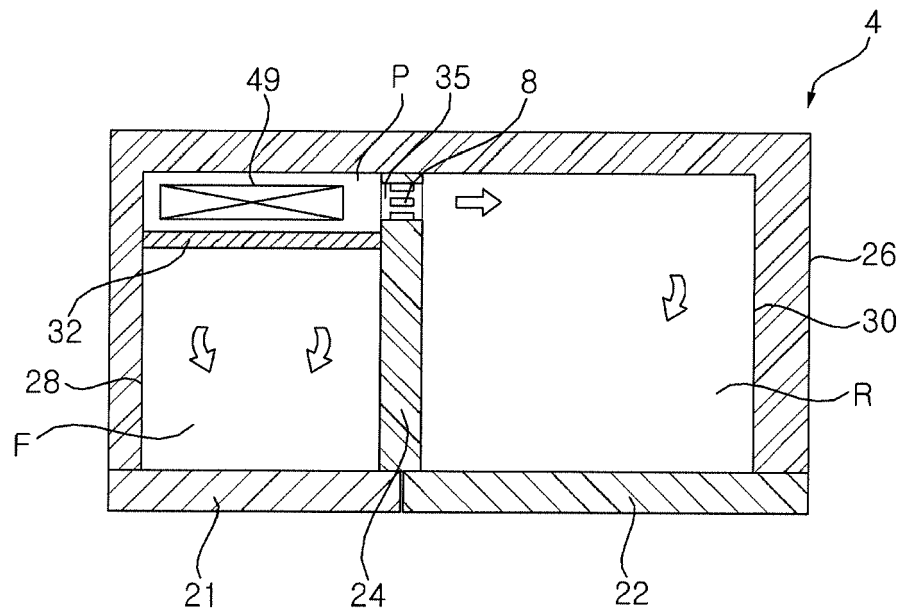


FIG. 3

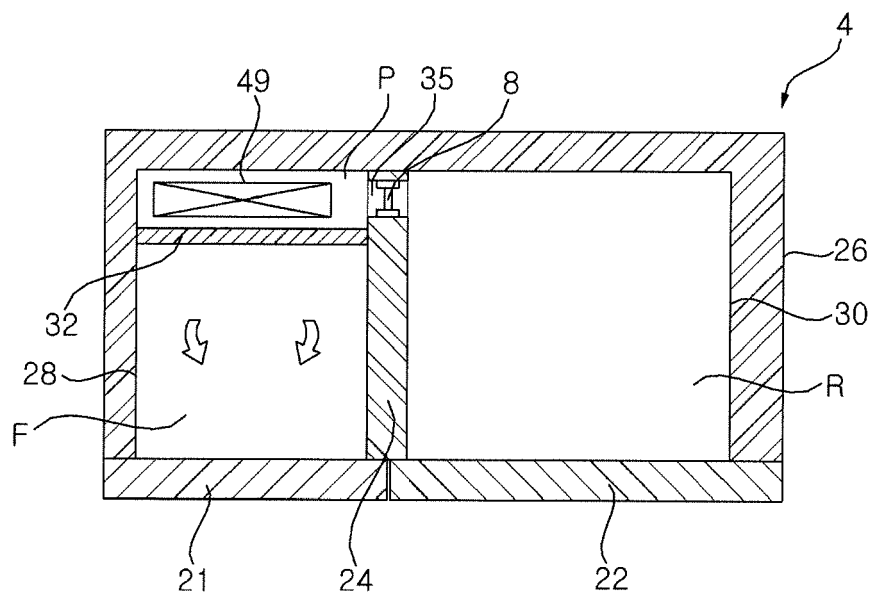


FIG. 4

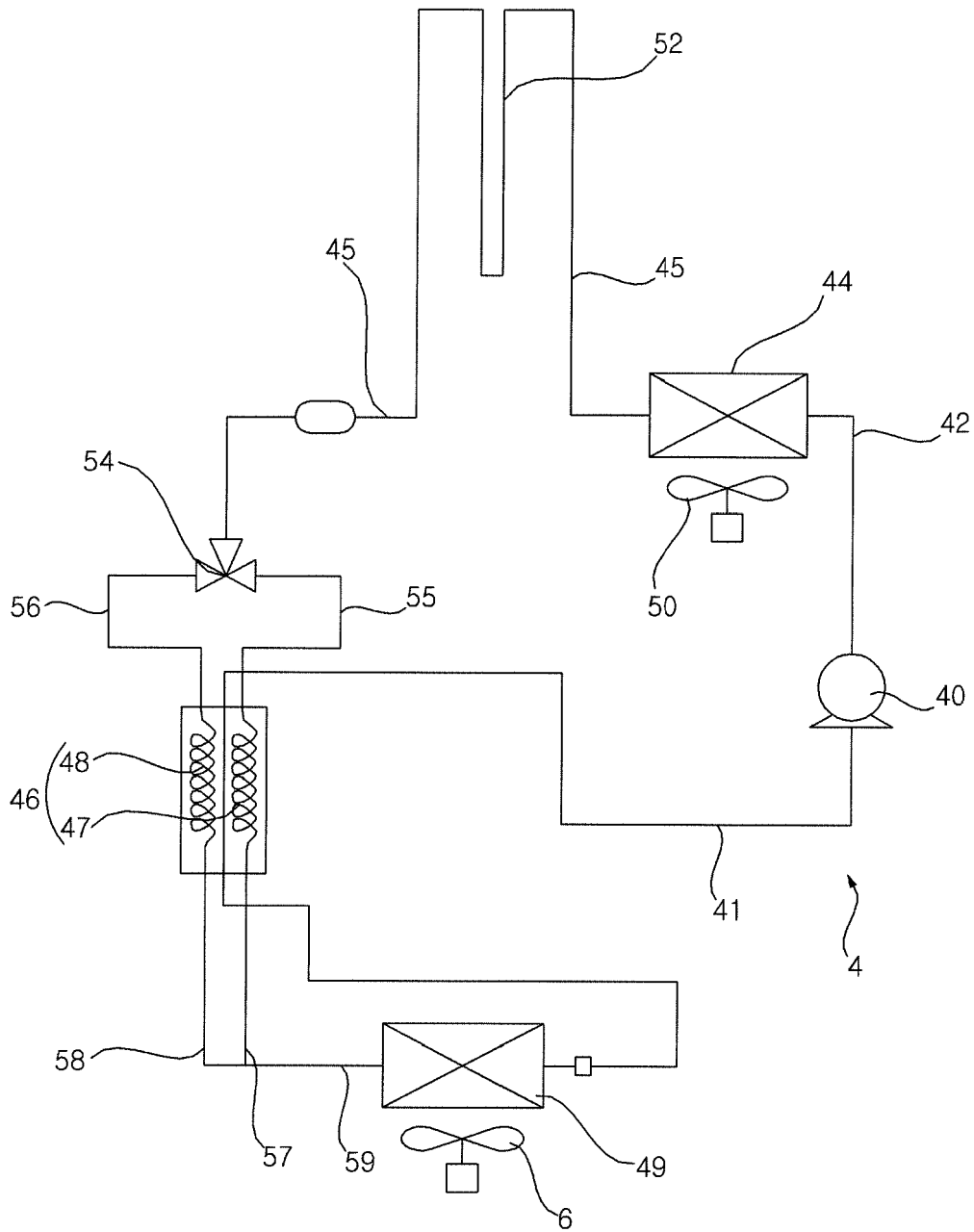


FIG. 5

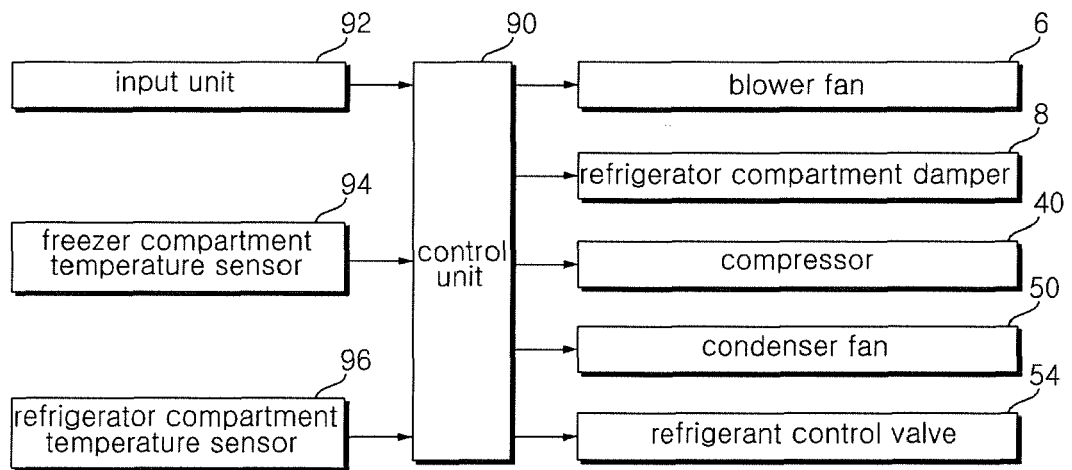


FIG. 6

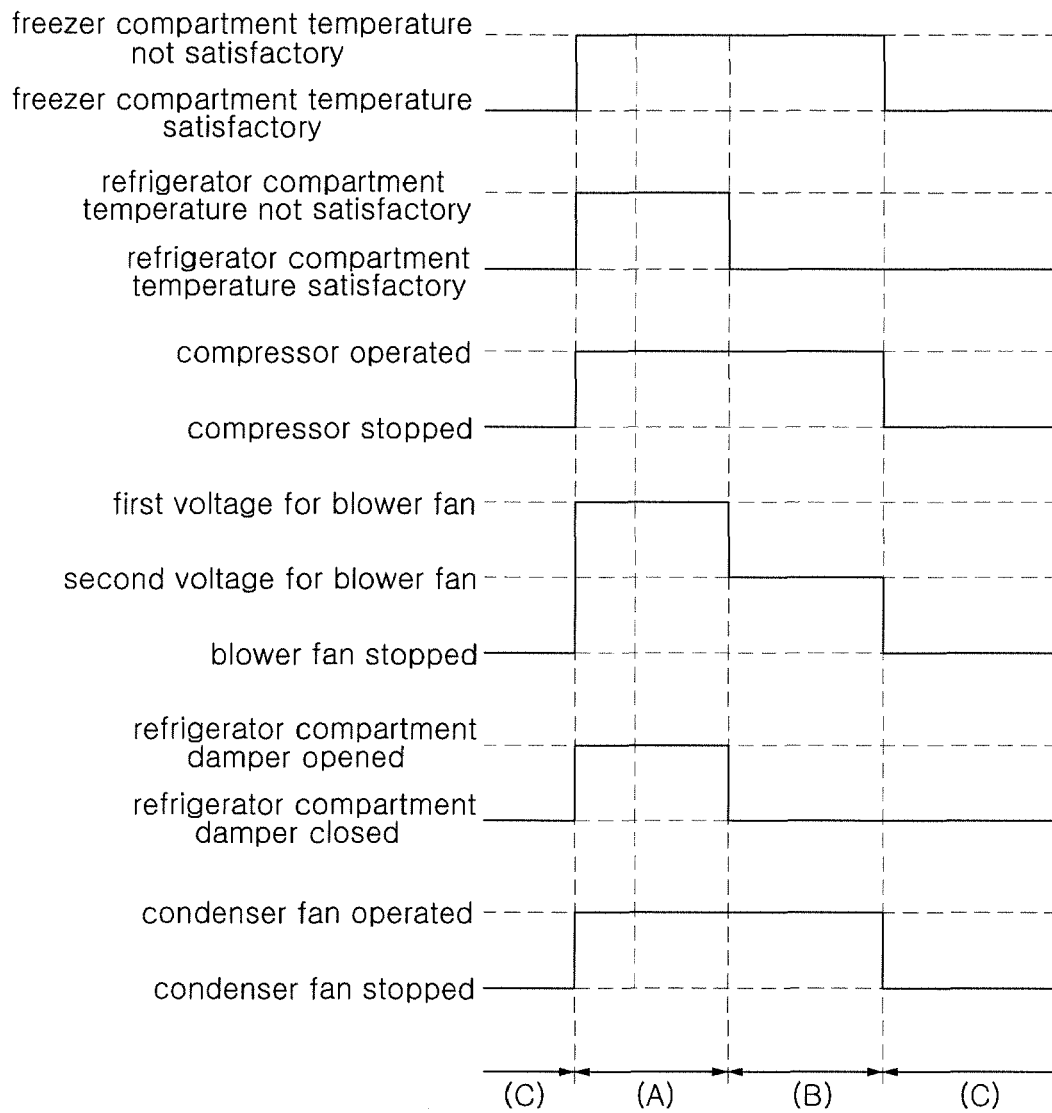


FIG. 7

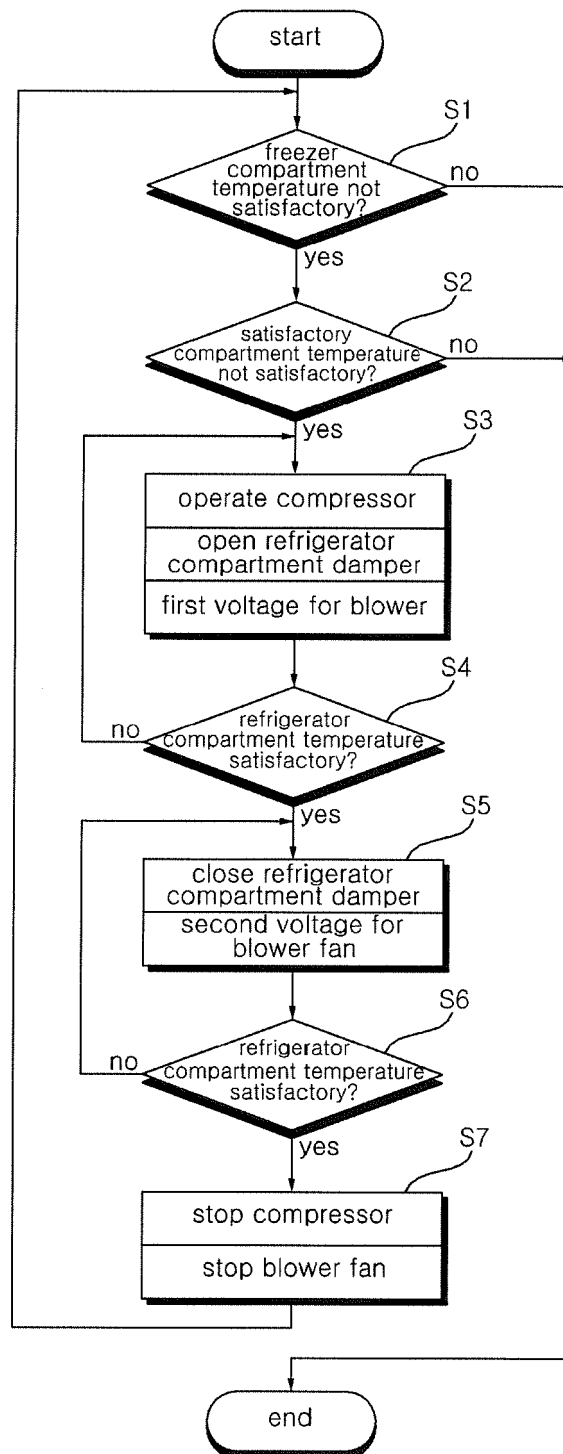


FIG. 8

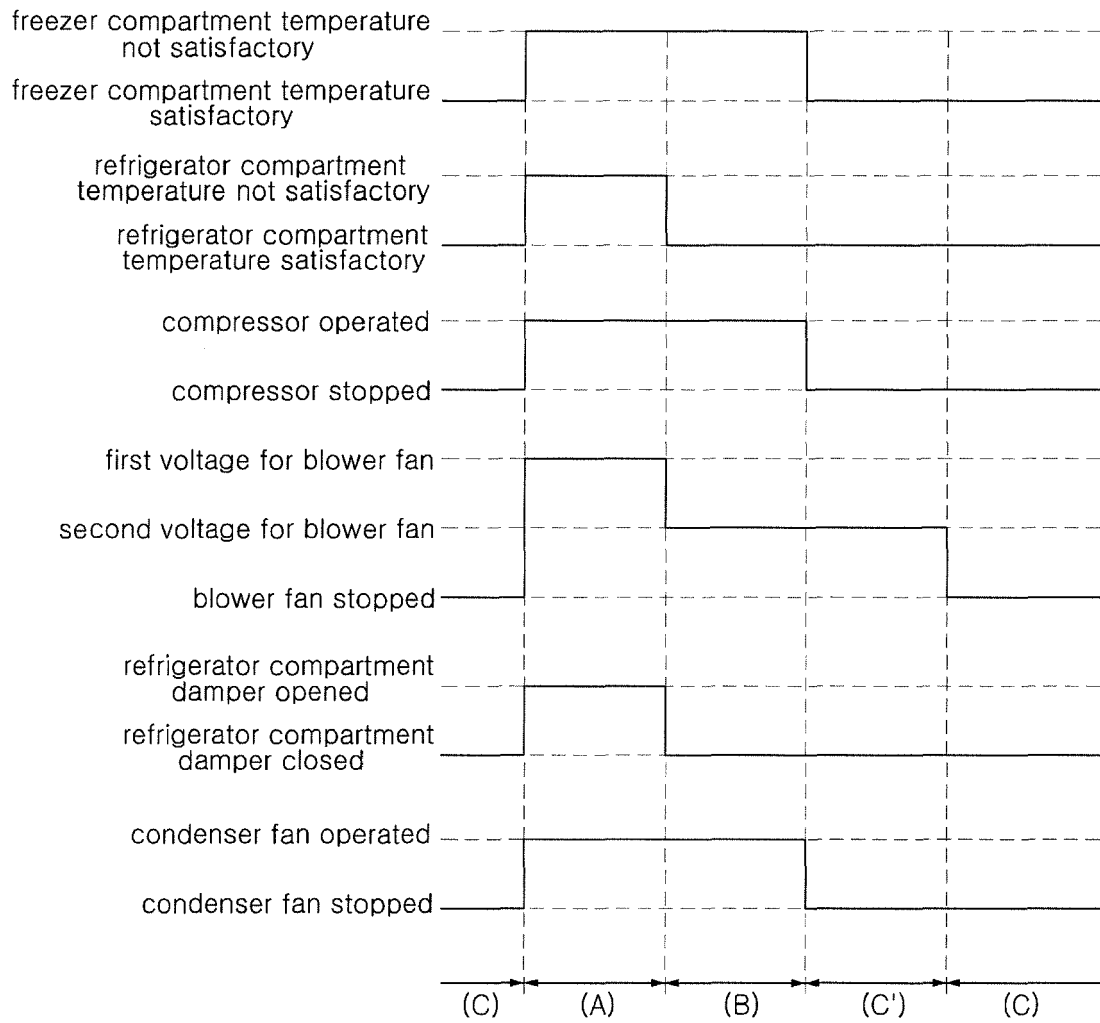


FIG. 9

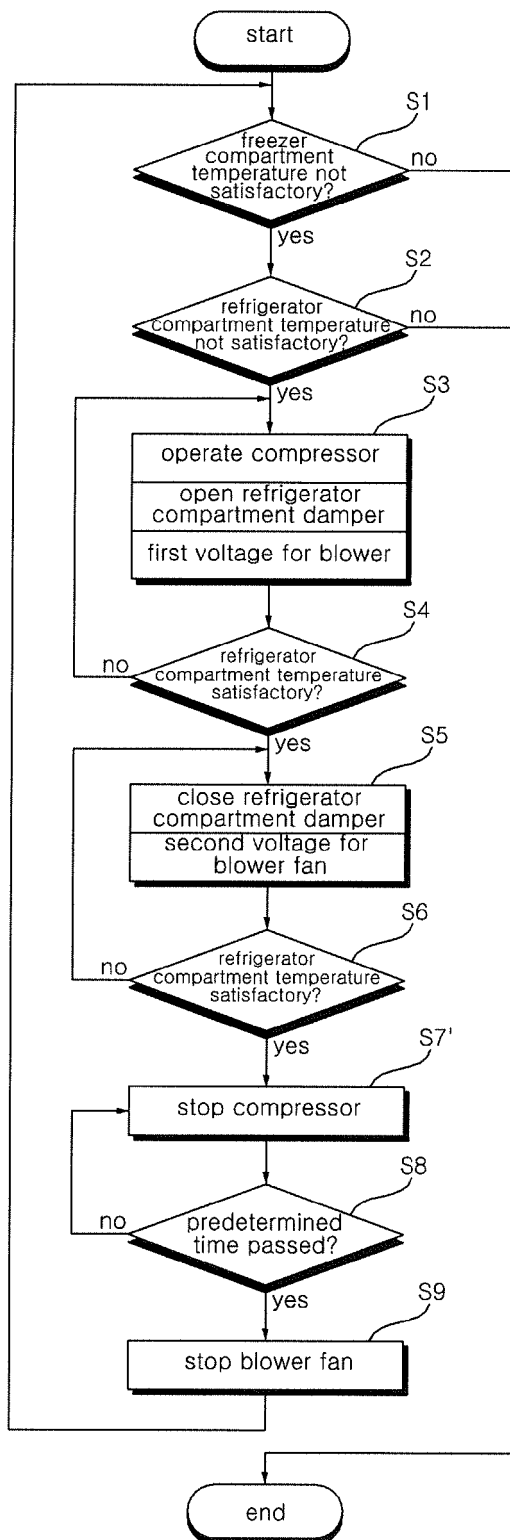


FIG. 10

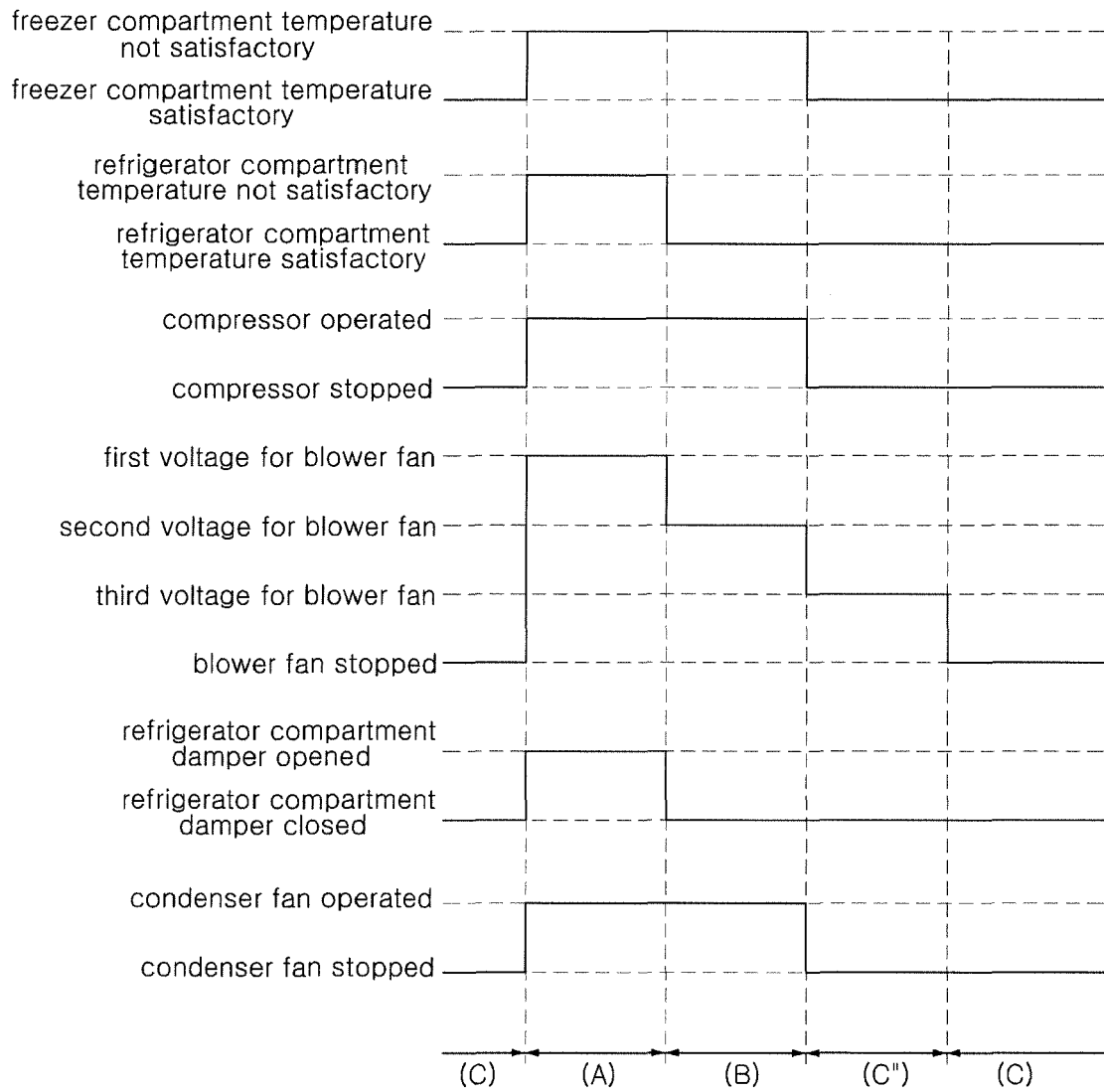


FIG. 11

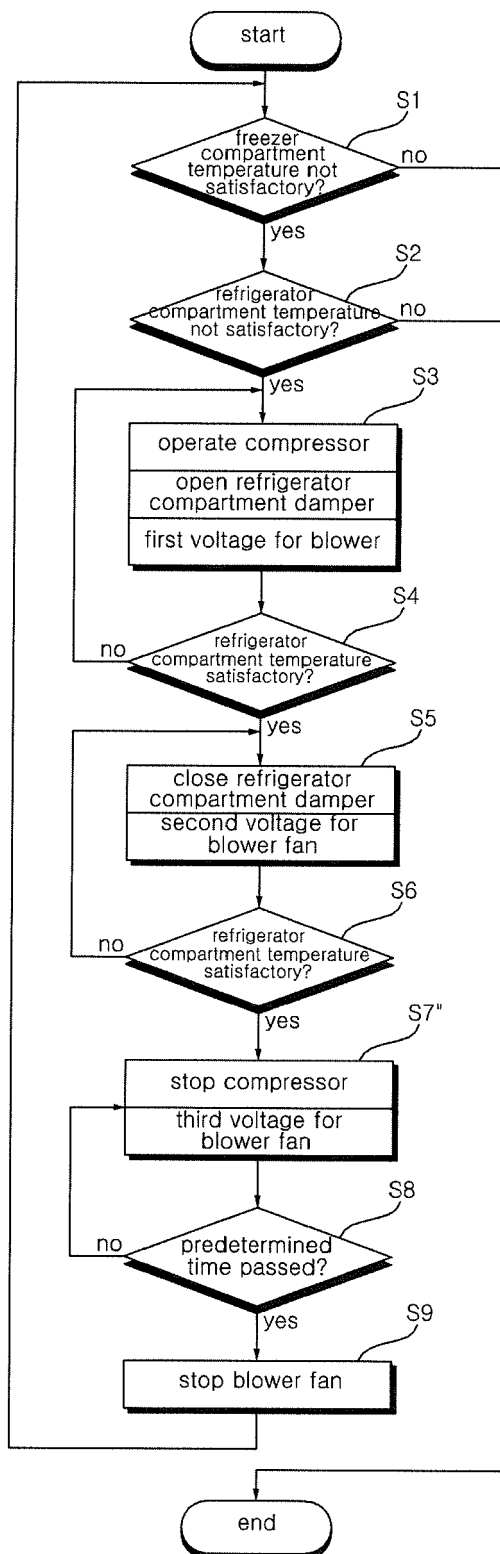


FIG. 12

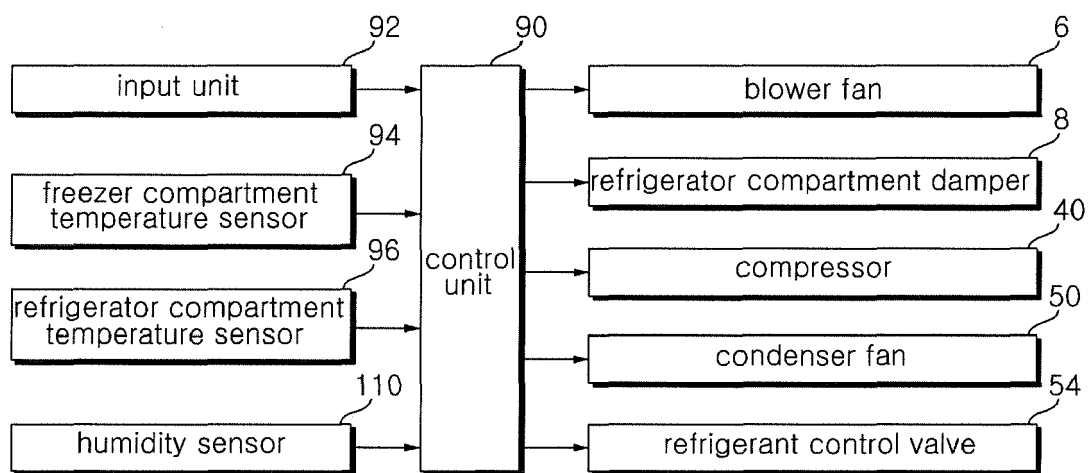


FIG. 13

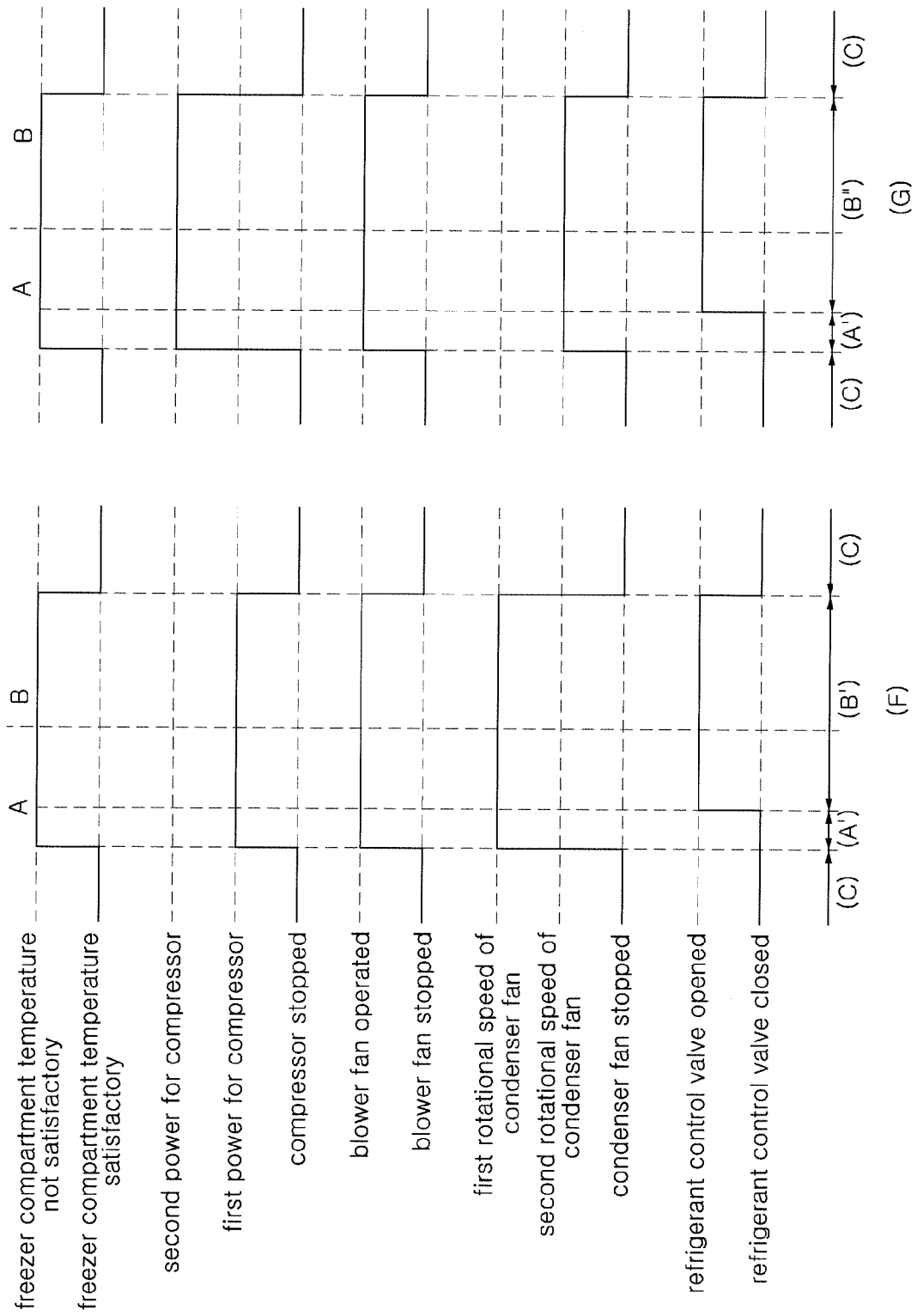


FIG. 14

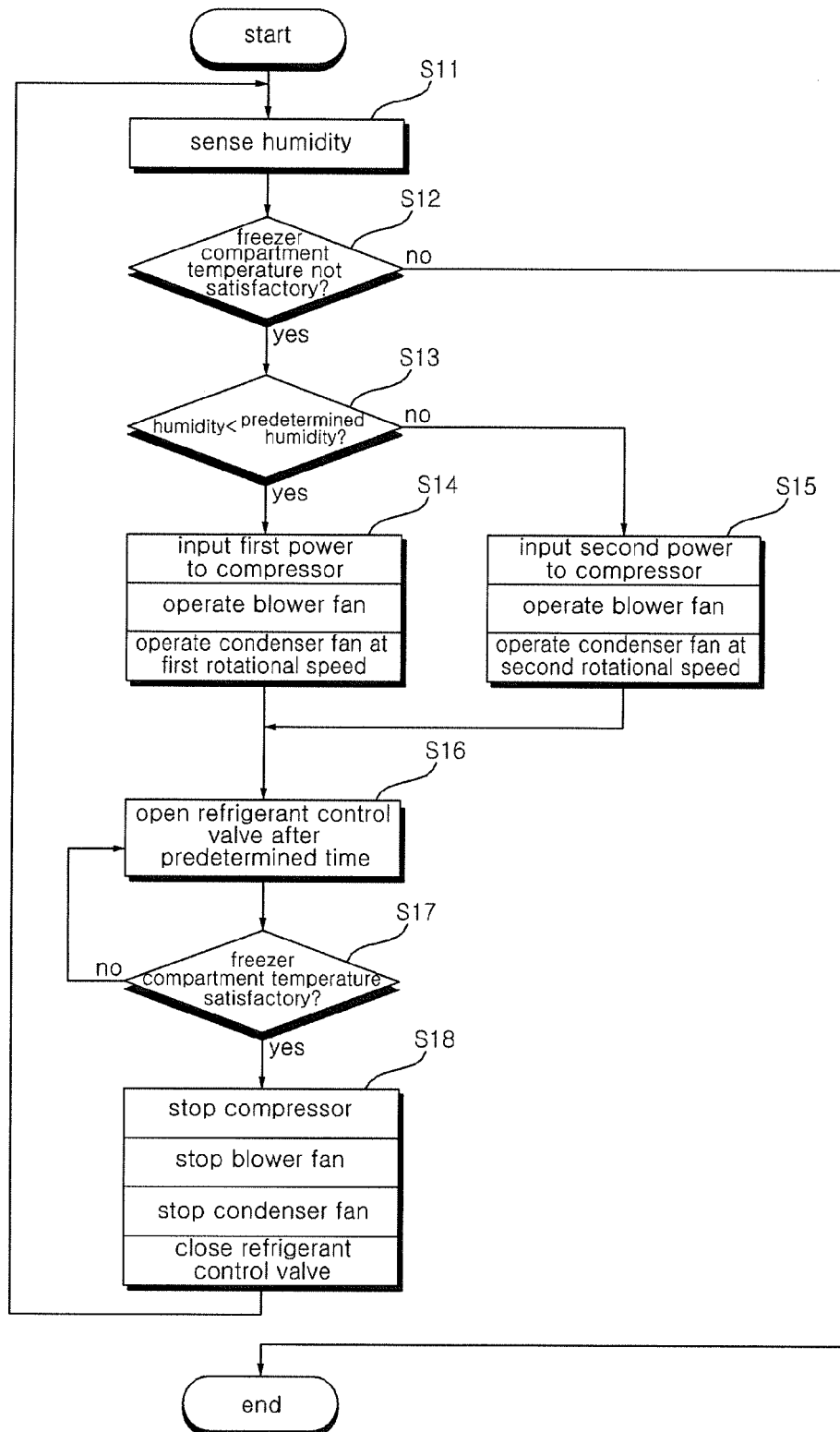


FIG. 15

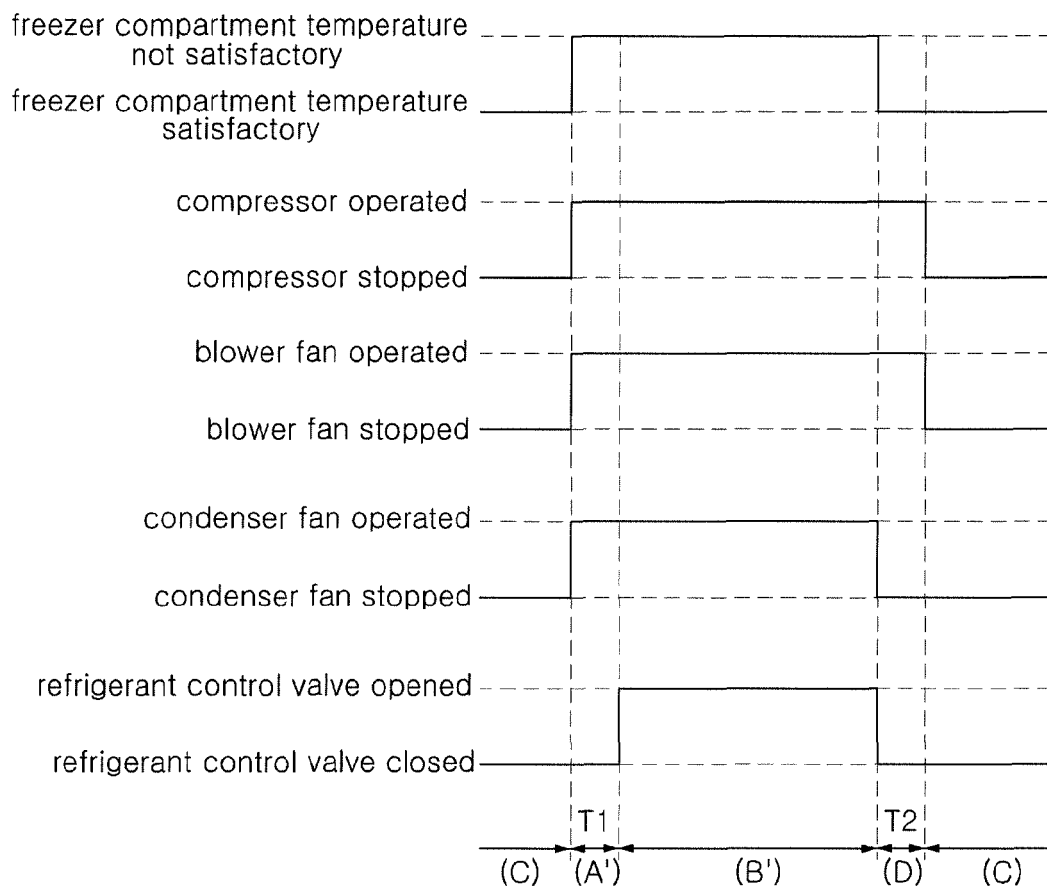


FIG. 16

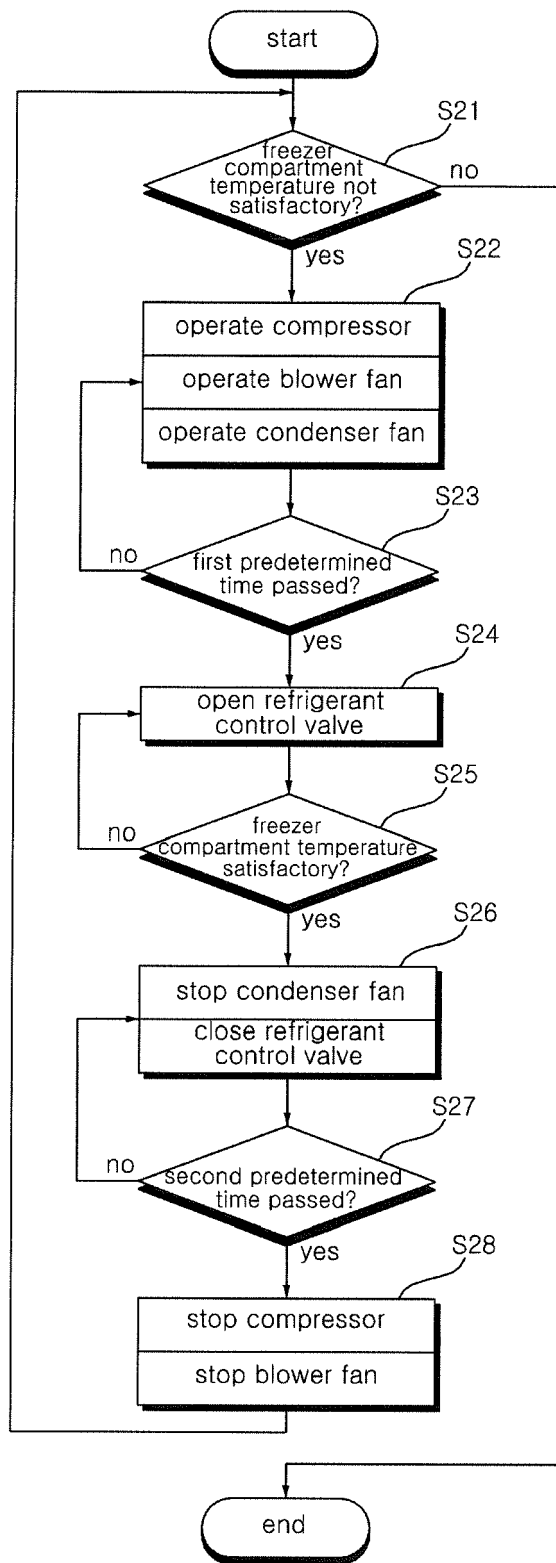


FIG. 17

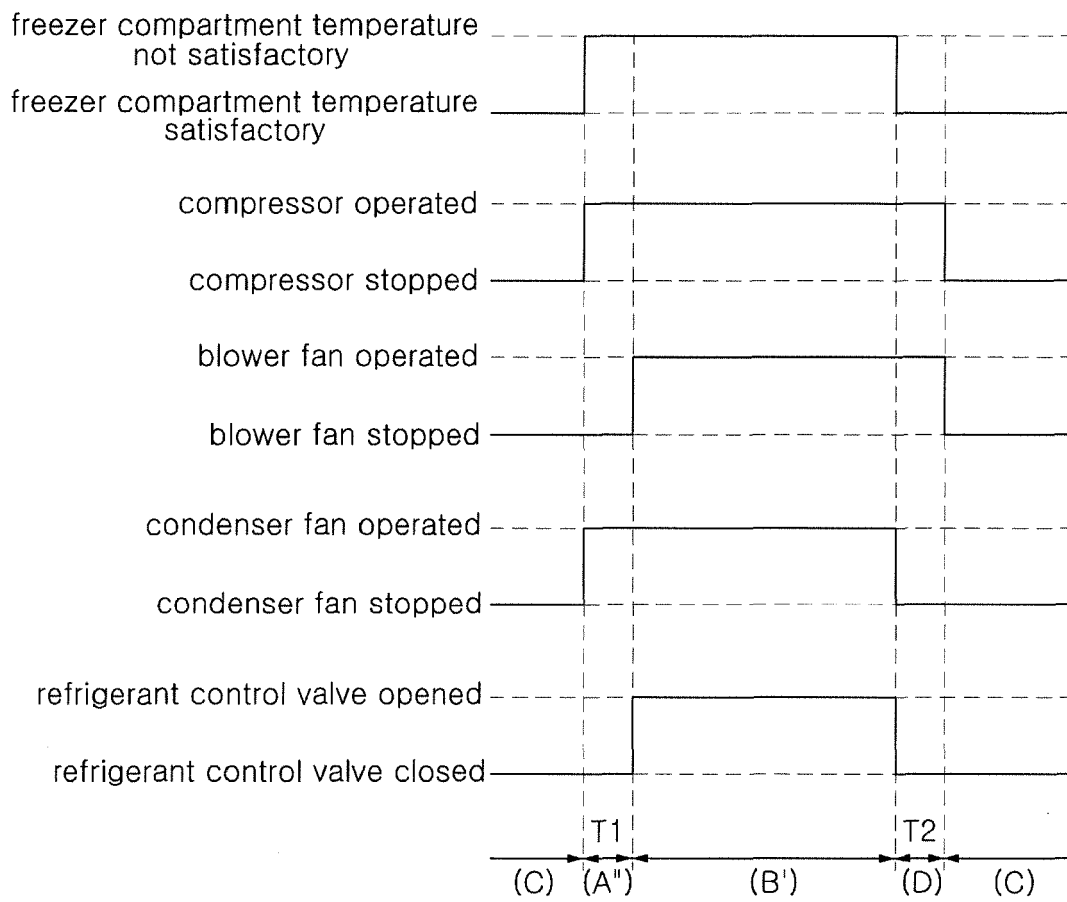


FIG. 18

