(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 592 372 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.05.2013 Bulletin 2013/20

(51) Int Cl.:
F25D 29/00 *(2006.01)* ***F25D 17/06*** *(2006.01)*

(21) Application number: **12191517.7**

(22) Date of filing: **07.11.2012**

(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: **08.11.2011 KR 20110115911**

(71) Applicants:
- **Samsung Electronics Co., Ltd**
  Gyeonggi-do 443-742 (KR)
- **Korea University Research and Business Foundation**
  Seongbuk-gu
  Seoul 136-713 (KR)

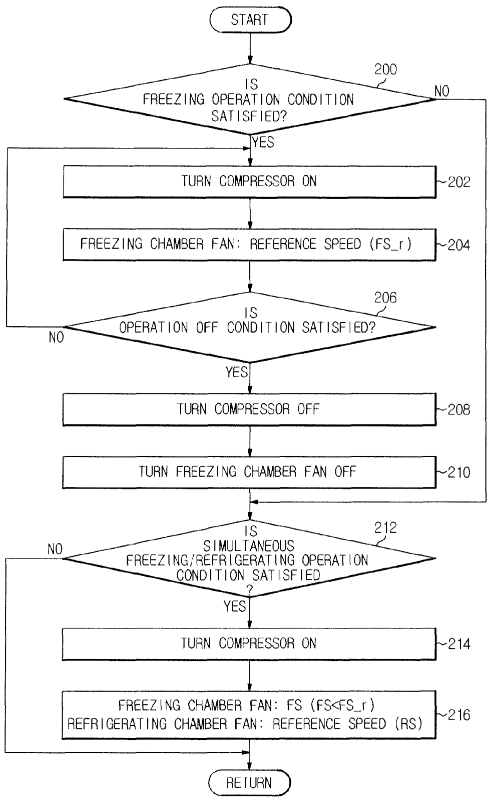
(72) Inventors:
- **Yoon, Won Jae**
  Seoul (KR)
- **Kim, Yong Chan**
  Seoul (KR)
- **Kim, Yong Han**
  Chungnam (KR)
- **Seo, Kook Jeong**
  Gyeonggi-do (KR)

(74) Representative: **Grünecker, Kinkeldey, Stockmair & Schwanhäusser**
Leopoldstrasse 4
80802 München (DE)

(54) Refrigerator using non-azeotropic refrigerant mixture and control method thereof

(57) A refrigerator using a non-azeotropic refrigerant mixture (NARM) and a control method thereof. The refrigerator reduces the rotational speed of a freezing chamber fan or stopping the freezing chamber fan for a designated time, and/or increasing the rotational speed of a compressor in a simultaneous freezing/refrigerating operation mode of an NARM cycle as compared to a freezing operation mode, and may thus decrease evaporation latent heat of a refrigerant consumed by a freezing chamber evaporator and relatively increase evaporation latent heat of the refrigerant usable in a refrigerating chamber evaporator without increase in a charging amount of the refrigerant, thereby preventing over-charging due to increase in the charging amount of the refrigerant and reducing cycling loss.

FIG. 6



EP 2 592 372 A2

Description

BACKGROUND

1. Field

[0001] Embodiments of the present disclosure relate to a refrigerator using a non-azeotropic refrigerant mixture (NARM) and a control method thereof.

2. Description of the Related Art

[0002] Non-azeotropic refrigerant mixtures (NARMs) are refrigerants, the temperature of which is changed during a phase change process differently from pure refrigerants generally used in refrigerators.

[0003] Efficiency of a refrigerator may be improved by applying such a non-azeotropic refrigerant to a refrigerant cycle.

[0004] If the non-azeotropic refrigerant is used, a refrigerant temperature at a point where evaporation is started becomes lower than the mean evaporation temperature. By applying such a fact to operation of a freezing chamber, the mean evaporation temperature may be raised as compared to a pure refrigerant, and thus a compression ratio may be reduced. For this reason, a refrigerator using an NARM cycle is configured such that the refrigerant first passes through a freezing chamber evaporator and then passes through a refrigerating chamber evaporator differently from a general refrigerator.

[0005] Therefore, a refrigerant charging amount may be increased compared to that of a conventional refrigerant cycle and a refrigerating chamber evaporator may be installed at a position further upstream than a freezing chamber evaporator.

[0006] In the conventional refrigerant cycle, the refrigerating chamber evaporator first uses evaporation latent heat of a refrigerant and then the freezing chamber evaporator uses remaining latent heat during simultaneous freezing/refrigerating operation. Here, although evaporation latent heat of the refrigerant usable in the freezing chamber evaporator is sufficient, freezing chamber heat load is supplemented in an independent freezing operation mode and thus operation of the cycle is not hindered.

[0007] However, in case of such a serial NARM cycle, the freezing chamber evaporator is installed at a position further upstream than the refrigerating chamber evaporator and thus the refrigerating chamber evaporator uses evaporation latent heat remaining after use in the freezing chamber evaporator. Since cooling operation of the refrigerating chamber needs to be finished in the simultaneous freezing/refrigerating operation mode (because there is no independent refrigerating operation mode in the conventional refrigerant cycle), evaporation latent heat remaining after use in the freezing chamber evaporator needs to be sufficient to perform the cooling operation of the refrigerating chamber.

[0008] For this reason, the charging amount of the refrigerant in the NARM cycle is increased. Increase in the charging amount of the refrigerant causes overcharge of the refrigerant during independent freezing operation, thus producing side effects, such as lowering of system efficiency. Because over-charging of the refrigerant at an amount more than a proper level causes increase of input of the compressor and rise of an evaporation temperature due to increase in the operating pressure of the cycle.

[0009] Further, increase in the charging amount of the refrigerant serves to increase loss generated by ON/OFF operation of the refrigerator. Such loss is referred to as cycling loss, and is generated in a refrigerator system in which the ON/OFF operation of the refrigerator is continuously performed. However, the cycling loss tends to increase together with increase in the charging amount of the refrigerant. The cycling loss may be divided into migration loss generated due to transfer of a high-pressure refrigerant distributed at a high-pressure side to a low-pressure side when a compressor is turned off, and redistribution loss to reach again a stable cycle operation state by transferring a part of the refrigerant located at the low-pressure side to the high-pressure side when the compressor is turned on, and both losses increase also together with increase in the charging amount of the refrigerant.

SUMMARY

[0010] Therefore, it is an aspect of the present disclosure to provide a refrigerator using a non-azeotropic refrigerant mixture (NARM) which increases evaporation latent heat usable in a refrigerating chamber evaporator during simultaneous freezing/refrigerating operation without increase in the charging amount of a refrigerant in a NARM cycle, and a control method of the refrigerator.

[0011] Additional aspects of the disclosure will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

[0012] In accordance with an aspect of the present disclosure, a refrigerator includes a freezing chamber and a refrigerating chamber, a compressor to compress a refrigerant, a condenser to cool the refrigerant discharged from the compressor, a refrigerating chamber evaporator to cool the refrigerating chamber, a freezing chamber evaporator provided between the condenser and the refrigerating chamber evaporator at a position further upstream than the refrigerating chamber evaporator and to cool the freezing chamber, a freezing chamber fan blowing cool air having undergone heat exchange in the freezing chamber evaporator, and a controller to control operation of the compressor and the freezing chamber fan, wherein the controller changes the rotational speed of at least one of the freezing chamber fan and the compressor so as to increase the amount of the refrigerant introduced into the refrigerating chamber evaporator in a simultaneous freezing/refrigerating operation mode.

[0013] The controller may lower the rotational speed of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode as compared to a freezing operation mode.

[0014] The controller may temporarily lower the rotational speed of the freezing chamber fan to 0 in the simultaneous freezing/refrigerating operation mode.

[0015] The controller may increase the rotational speed of the compressor in the simultaneous freezing/refrigerating operation mode as compared to a freezing operation mode.

[0016] The controller may lower the rotational speed of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode as compared to a freezing operation mode or temporarily stop the operation of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode, and may increase the rotational speed of the compressor in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

[0017] In accordance with another aspect of the present disclosure, a control method of a refrigerator in which a freezing chamber evaporator is provided at a position further upstream than the refrigerating chamber evaporator includes determining whether or not the refrigerator is in a simultaneous freezing/refrigerating operation mode, and changing the rotational speed of at least one of a freezing chamber fan and a compressor so as to increase the amount of a refrigerant introduced into the refrigerating chamber evaporator, upon determining that the refrigerator is in the simultaneous freezing/refrigerating operation mode.

[0018] The change of the rotational speed of at least one of the freezing chamber fan and the compressor may include lowering the rotational speed of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode as compared to a freezing operation mode.

[0019] The change of the rotational speed of at least one of the freezing chamber fan and the compressor may include temporarily lowering the rotational speed of the freezing chamber fan to 0 in the simultaneous freezing/refrigerating operation mode.

[0020] The change of the rotational speed of at least one of the freezing chamber fan and the compressor may include increasing the rotational speed of the compressor in the simultaneous freezing/refrigerating operation mode as compared to a freezing operation mode.

[0021] The change of the rotational speed of at least one of the freezing chamber fan and the compressor may include lowering the rotational speed of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode as compared to a freezing operation mode or temporarily stopping the operation of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode, increasing the rotational speed of the compressor in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a longitudinal-sectional view of a refrigerator in accordance with an embodiment of the present disclosure;

FIG. 2 is a circuit diagram illustrating a non-azeotropic refrigerant mixture (NARM) cycle of the refrigerator in accordance with an embodiment of the present disclosure;

FIG. 3 is a control block diagram of the refrigerator in accordance with an embodiment of the present disclosure;

FIG. 4 is a timing diagram illustrating rotational speed change of a freezing chamber fan in a freezing operation mode and a simultaneous freezing/refrigerating operation mode of the refrigerator in accordance with an embodiment of the present disclosure;

FIG. 5 is a timing diagram illustrating rotational speed change of a compressor in the freezing operation mode and the simultaneous freezing/refrigerating operation mode of the refrigerator in accordance with an embodiment of the present disclosure;

FIG. 6 is a flowchart illustrating a control method of a refrigerator in accordance with an embodiment of the present disclosure; and

FIG. 7 is a flowchart illustrating a control method of a refrigerator in accordance with another embodiment of the present disclosure.

DETAILED DESCRIPTION

[0023] Reference will now be made in detail to embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like components throughout.

[0024] FIG. 1 is a longitudinal-sectional view of a refrigerator in accordance with an embodiment of the present disclosure.

[0025] As shown in FIG. 1, the refrigerator in accordance with an embodiment of the present disclosure includes a freezing chamber 12 located above a diaphragm 11 forming a part of a main body 10 and provided with the opened front surface, a freezing chamber door 13 opening or closing the opened front surface of the freezing chamber 12, a refrigerating chamber 14 located under the diaphragm 11 and provided with the opened front surface, a refrigerating chamber door 15 opening or closing the opened front surface of the refrigerating chamber 14, and a compressor 16 provided at a rear portion of the lower portion of the main body 10.

[0026] A freezing chamber heat exchange device 30 and 31 and a refrigerating chamber heat exchange device 40 and 41 performing heat exchange are provided between the rear surface portions of the freezing chamber 12 and the refrigerating chamber 14 and the main body 10, respectively.

[0027] A freezing chamber temperature sensor 17 and a refrigerating chamber temperature sensor 18 are provided at designated portions of the walls of the freezing chamber 12 and the refrigerating chamber 14.

[0028] Shelves 19 and baskets 20 to store food are provided within the freezing chamber 12 and the refrigerating chamber 14.

[0029] A machinery chamber which is a separate space is provided at the rear portion of the lower portion of the main body 10, and the compressor 16 and the condenser 50 are provided within the machinery chamber..

[0030] The freezing chamber heat exchange device 30 and 31 includes a freezing chamber evaporator 30 to cool air in the freezing chamber 12 through heat exchange, and a freezing chamber fan 31 installed above the freezing chamber evaporator 30 and circulating cool air having passed through the freezing chamber evaporator 30 to the inside of the freezing chamber 12.

[0031] A suction hole 32 through which air in the freezing chamber 12 is sucked by driving of the freezing chamber fan 31 is formed below the freezing chamber evaporator 30, and a plurality of discharge holes 33 to uniformly discharge cool air blown by the freezing chamber fan 31 to the inside of the freezing chamber 12 is formed on the rear surface of the freezing chamber 12.

[0032] Similar to the freezing chamber heat exchange device 30 and 31, the refrigerating chamber heat exchange device 40 and 41 includes a refrigerating chamber evaporator 40 to cool air in the refrigerating chamber 14 through heat exchange, and a refrigerating chamber fan 41 installed above the refrigerating chamber evaporator 40 and circulating cool air having passed through the refrigerating chamber evaporator 40 to the inside of the refrigerating chamber 14.

[0033] A suction channel 42 to suck air in the refrigerating chamber 14 by driving of the refrigerating chamber fan 41 is provided below the refrigerating chamber evaporator 40, and a plurality of discharge holes 43 to uniformly discharge cool air blown by the refrigerating chamber fan 41 to the inside of the refrigerating chamber 14 is formed on the rear surface of the refrigerating chamber 14.

[0034] FIG. 2 is a view illustrating a non-azeotropic refrigerant mixture (NARM) cycle of the refrigerator in accordance with an embodiment of the present disclosure.

[0035] As shown in FIG. 2, the refrigerator having the NARM cycle includes the compressor 16, a condenser 50, a capillary tube 60, the freezing chamber evaporator 30 and the refrigerating chamber evaporator 40, and these components are sequentially connected to refrigerant flow channels represented by solid lines.

[0036] The capillary tube 60 is an example of an expansion device which decompresses and expands a refrigerant discharged from the condenser 50.

[0037] A condenser fan 51 which sucks air at the outside of the refrigerator into the condenser 50 and then discharges the air to the outside of the refrigerator so as to rapidly perform heat exchange with air at the outside of the refrigerator is provided around the condenser 50.

[0038] A freezing chamber fan 31 which sucks air at the inside of the freezing chamber 12 into the freezing chamber evaporator 30 and then discharges the air to the inside of the freezing chamber 12 so as to rapidly perform heat exchange with air at the inside of the freezing chamber 12 is provided around the freezing chamber evaporator 30.

[0039] A refrigerating chamber fan 41 which sucks air at the inside of the refrigerating chamber 14 into the refrigerating chamber evaporator 40 and then discharges the air to the inside of the refrigerating chamber 14 so as to rapidly perform heat exchange with air at the inside of the refrigerating chamber 14 is provided around the refrigerating chamber evaporator 40.

[0040] Further, a 3-way valve 70, i.e., a flow channel switch valve to selectively change the respective refrigerant flow channels, is provided at an intersection of a refrigerant pipe connecting the freezing chamber evaporator 30 and the refrigerating chamber evaporator 40 and a refrigerant pipe connecting the freezing chamber evaporator and the inlet side of the compressor 16.

[0041] The NARM cycle having the above-described configuration is performed by circulating a non-azeotropic refrigerant mixture (NARM) along the components shown by arrows represented by dotted lines.

[0042] The temperature of the NARM is changed during a phase change process differently from pure refrigerants generally used in refrigerators. That is, the temperature of the NARM is raised as the NARM is evaporated.

[0043] In general, efficiency of a refrigerator cycle increases as a compression ratio between a high-pressure side and a low-pressure side is reduced, and such a compression ratio is restricted by the refrigerant evaporation temperature of a freezing chamber evaporator. For example, if it is desired to keep the freezing chamber at a temperature of -20□, the evaporation temperature needs to be lower than such a temperature and thus the temperature of the inside of the freezing chamber acts as a critical point in decreasing the compression ratio.

[0044] If the NARM is used under this condition, the refrigerant temperature at a point where evaporation is started is lower than the mean evaporation temperature, and thus, by applying the NARM to operation of the freezing chamber, the mean evaporation temperature may be raised as compared to a pure refrigerant and a compression ratio may be reduced.

[0045] For this reason, the refrigerator using the NARM cycle is configured such that the refrigerant first passes through the freezing chamber evaporator 30 and then passes through the refrigerating chamber evaporator 40 differently from a general refrigerator.

[0046] Therefore, in the NARM cycle, the freezing chamber evaporator 30 is located at a position further upstream than the refrigerating chamber evaporator 40.

[0047] Now, the flow of the refrigerant in the NARM cycle will be described. The refrigerant discharged from the compressor 16 reaches the 3-way valve 70 via the condenser 50, the capillary tube 60 and the freezing chamber evaporator 30. The refrigerant pipe at the 3-way valve 70 is branched so that the refrigerant having passed through the freezing chamber evaporator 30 is introduced into the inlet side of the compressor 16 via the refrigerating chamber evaporator 40 or is introduced directly into the compressor 16 bypassing the refrigerating chamber evaporator 40 according to switching of the 3-way valve 70.

[0048] That is, according to switching of the 3-way valve 70, a freezing/refrigerating cycle in the order of the compressor 16, the condenser 50, the capillary tube 60, the freezing chamber evaporator 30, the refrigerating chamber evaporator 40 and then the compressor 16, and a freezing cycle in the order of the compressor 16, the condenser 50, the capillary tube 60, the freezing chamber evaporator 30 and then the compressor 16 are formed.

[0049] If it is desired to introduce the refrigerant having passed through the freezing chamber evaporator 30 into the refrigerating chamber evaporator 40, a refrigerant flow channel A of the 3-way valve 70 is opened and a refrigerant flow channel B is closed by turning the 3-way valve 70 on. Further, if it is desired to introduce the refrigerant having passed through the freezing chamber evaporator 30 into the compressor 16 bypassing the refrigerating chamber evaporator 40, the refrigerant flow channel A of the 3-way valve 70 is closed and the refrigerant flow channel B is opened by turning the 3-way valve 70 off.

[0050] In the simultaneous freezing/refrigerating operation mode, a refrigerant in a gas phase compressed into a high-temperature and high-pressure state by the compressor 16 of the refrigerator is introduced into the condenser 50. The condenser 50 converts the refrigerant from the gas phase to a liquid phase by emitting heat to the outside through heat exchange with air at the outside of the refrigerator introduced by the condenser fan 51. The refrigerant in the liquid phase having passed through the condenser 50 is decompressed via the capillary tube 60, and is then introduced sequentially into the freezing chamber evaporator 30 and the refrigerating chamber evaporator 40. The freezing chamber evaporator 30 converts the refrigerant from the liquid phase to the gas phase by absorbing heat at the inside of the freezing chamber through heat exchange with air at the inside of the refrigerator introduced by the freezing chamber fan 31. Cool air is generated by such phase conversion of the refrigerant, and the generated cool air is introduced into the freezing chamber by the freezing chamber fan 31 and lowers the temperature of the freezing chamber. Further, the refrigerating chamber evaporator 40 converts the refrigerant from the liquid phase to the gas phase by absorbing heat at the inside of the refrigerating chamber through heat exchange between with air at the inside of the refrigerator introduced by the refrigerating chamber fan 41. Cool air is generated by such phase conversion of the refrigerant, and the generated cool air is introduced into the refrigerating chamber by the refrigerating chamber fan 41 and lowers the temperature of the refrigerating chamber. The refrigerant having passed through the refrigerating chamber evaporator 40 is introduced into the inlet side of the compressor 16.

[0051] On the other hand, in the freezing operation mode, a refrigerant in a gas phase compressed into a high-temperature and high-pressure state by the compressor 16 of the refrigerator is introduced into the condenser 50. The condenser 50 converts the refrigerant from the gas phase to a liquid phase by emitting heat to the outside through heat exchange with air at the outside of the refrigerator introduced by the condenser fan 51. The refrigerant in the liquid phase having passed through the condenser 50 is decompressed via the capillary tube 60, and is then introduced into the freezing chamber evaporator 30. The freezing chamber evaporator 30 converts the refrigerant from the liquid phase to the gas phase by absorbing heat at the inside of the freezing chamber through heat exchange with air at the inside of the refrigerator introduced by the freezing chamber fan 31. Cool air is generated by such phase conversion of the refrigerant, and the generated cool air is introduced into the freezing chamber by the freezing chamber fan 31 and lowers the temperature of the freezing chamber. The refrigerant having passed through the freezing chamber evaporator 30 is introduced into the inlet side of the compressor 16.

[0052] The refrigerator having the above-described configuration includes an operation control device 100 which increases evaporation latent heat of the refrigerant usable in the refrigerating chamber evaporator 40 in the simultaneous freezing/refrigerating operation mode.

[0053] FIG. 3 is a control block diagram of the refrigerator in accordance with an embodiment of the present disclosure, FIG. 4 is a timing diagram illustrating rotational speed change of the freezing chamber fan in the freezing operation mode and the simultaneous freezing/refrigerating operation mode of the refrigerator in accordance with an embodiment of the present disclosure, and FIG. 5 is a timing diagram illustrating rotational speed change of the compressor in the freezing operation mode and the simultaneous freezing/refrigerating operation mode of the refrigerator in accordance with an embodiment of the present disclosure.

[0054] As shown in FIG. 3, the operation control device

100 includes a controller 110 which stores programs in the simultaneous freezing/refrigerating operation mode and the freezing operation mode and thus outputs control signals to the respective components to cool both the freezing chamber 12 and the refrigerating chamber 14 in the simultaneous freezing/refrigerating operation mode and to cool the freezing chamber 12 alone in the freezing operation mode.

[0055] Particularly, the controller 110 reduces evaporation latent heat of the refrigerant consumed by the freezing chamber evaporator 30 in the simultaneous freezing/refrigerating operation mode and thus relatively increases evaporation latent heat of the refrigerant consumed by the refrigerating chamber evaporator 40. For this purpose, the controller 110 changes the rotational speed of at least one of the freezing chamber fan 31 and/or the compressor 16 so as to increase evaporation latent heat of the refrigerant introduced into the refrigerating chamber evaporator 40.

[0056] As a control method of the freezing chamber fan 31, a method of reducing the rotational speed of the freezing chamber fan 31 in the simultaneous freezing/refrigerating operation mode or a method of stopping the freezing chamber fan 31 for a designated time in the simultaneous freezing/refrigerating operation mode may be used. These methods is to relatively increase evaporation latent heat usable in the refrigerating chamber evaporator 40 by relatively reducing evaporation latent heat consumed by the freezing chamber evaporator 30. Therethrough, cooling operation of the refrigerating chamber may be performed without increasing the amount of the refrigerant.

[0057] In addition to the control method of the freezing chamber fan 31, a control method of the rotational speed of an inverter compressor may be used. In such a method, the rotational speed of the compressor in the simultaneous freezing/refrigerating operation is increased as compared to the freezing operation, thereby exhibiting similar effects to the control method of the freezing chamber fan 31. If the rotational speed of the compressor 16 in the simultaneous freezing/refrigerating operation is increased, the mass flow rate of the refrigerant circulating in the cycle is increased at the same refrigerant charging amount and thus evaporation latent heat of the refrigerant of a relatively larger amount may be used in the refrigerating chamber evaporator 40.

[0058] The freezing chamber temperature sensor 17 to sense the temperature of the freezing chamber 12 and the refrigerating chamber temperature sensor 18 to sense the temperature of the refrigerating chamber 14 are electrically connected to the input side of the controller 110.

[0059] Further, the compressor 16, the freezing chamber fan 31, the refrigerating chamber fan 41 and the condenser fan 51 operated by control signals from the controller 110 are electrically connected to the output side of the controller 110.

[0060] The controller 110 includes a fan speed control circuit 111 increasing and decreasing the rotational speed of the freezing chamber fan 31 and a compressor speed control circuit 112 increasing and decreasing the rotational speed of the compressor 16.

[0061] The 3-way valve 70 operated by a control signal from the controller 110 is electrically connected to the output side of the controller 110.

[0062] The above-described controller 110 performs one of the freezing operation mode and the simultaneous freezing/refrigerating operation mode. The controller 110 opens or closes the respective refrigerant flow channels A and B through the 3-way valve 70 in the freezing operation mode or the simultaneous freezing/refrigerating operation mode, thereby forming a freezing cycle or a freezing/refrigerating cycle.

[0063] As shown in FIG. 4, the controller 110 rotates the freezing chamber fan 31 at a reference speed N1 in the freezing operation mode, and decreases the rotational speed of the freezing chamber fan 31 to a speed N2 which is lower than the reference speed N1 in the simultaneous freezing/refrigerating operation mode. Thereby, evaporation latent heat of the refrigerant consumed by the freezing chamber evaporator 30 in the simultaneous freezing/refrigerating mode may be reduced, and thus evaporation latent heat of the refrigerant usable in the refrigerant chamber evaporator 40 may be relatively increased.

[0064] Further, the controller 110 operates the freezing chamber fan 31 for a reference operation time in the freezing operation mode, and operates the freezing chamber fan 31 for a time shorter than the reference operation time in the freezing/refrigerating operation time. That is, the controller 110 forms a temporary stoppage section where the freezing chamber fan 31 is temporarily stopped in the simultaneous freezing/refrigerating operation mode.

[0065] As shown in FIG. 5, the controller 110 rotates the compressor 16 at a reference speed N1 in the freezing operation mode, and increases the rotational speed of the compressor 16 to a speed N2 which is higher than the reference speed N1 in the simultaneous freezing/refrigerating operation mode. Thereby, evaporation latent heat of the refrigerant usable in the refrigerant chamber evaporator 40 in the simultaneous freezing/refrigerating mode may be relatively increased.

[0066] FIG. 6 is a flowchart illustrating a control method of a refrigerator in accordance with an embodiment of the present disclosure.

[0067] With reference to FIG. 6, the controller 110 first senses the temperature of the freezing chamber 12, and determines whether or not a freezing operation condition is satisfied by comparing the sensed temperature with a predetermined temperature (Operation 200).

[0068] As a result of the determination of Operation 200, if it is determined that the freezing operation condition is satisfied, the controller 110 turns the compressor 16 on (Operation 202). At this time, the controller 110 changes the refrigerant flow channel through the 3-way valve 70 so that the refrigerant having passed through the freezing chamber evaporator 30 is introduced into the inlet side of the compressor 16.

[0069] After turning-on of the compressor 16, the controller 110 rotates the freezing chamber fan 31 at a predetermined speed, i.e., a reference speed FS_r (Operation 204).

[0070] After rotation of the freezing chamber fan 31, the controller 110 determines whether or not a freezing operation off condition is satisfied (Operation 206).

[0071] As a result of the determination of Operation 206, if it is determined that the freezing operation off condition is satisfied, the controller 110 turns the compressor 16 off (Operation 208) and turns the freezing chamber fan 31 off (Operation 210).

[0072] Thereafter, the controller 110 determines whether or not a simultaneous freezing/refrigerating operation condition is satisfied (Operation 212).

[0073] As a result of the determination of Operation 212, if it is determined that the simultaneous freezing/refrigerating operation condition is satisfied, the controller 110 turns the compressor 16 on (Operation 214). At this time, the controller 110 changes the refrigerant flow channel through the 3-way valve 70 so that the refrigerant having passed through the freezing chamber evaporator 30 is introduced into the inlet side of the compressor 16 via the refrigerating chamber evaporator 40.

[0074] After turning-on of the compressor 16, the controller 110 rotates the freezing chamber fan 31 at a speed FS (FS<FS_r) which is lower than the predetermined reference speed FS_r (Operation 216). At this time, the controller 110 operates the refrigerating chamber fan 41 at a reference speed RS.

[0075] On the other hand, as the result of the determination of Operation 200, if it is determined that the freezing operation condition is not satisfied, the controller 110 moves to Operation 212 and then performs subsequent Operations.

[0076] Further, as the result of the determination of Operation 212, if it is determined that the simultaneous freezing/refrigerating operation condition is not satisfied, the controller 110 returns to the predetermined routine.

[0077] FIG. 7 is a flowchart illustrating a control method of a refrigerator in accordance with another embodiment of the present disclosure.

[0078] With reference to FIG. 7, the controller 110 first senses the temperature of the freezing chamber 12, and determines whether or not a freezing operation condition is satisfied by comparing the sensed temperature with a predetermined temperature (Operation 300).

[0079] As a result of the determination of Operation 300, if it is determined that the freezing operation condition is satisfied, the controller 110 rotates the compressor 16 at a predetermined speed, i.e., a reference speed CS_r (Operation 302). At this time, the controller 110 changes the refrigerant flow channel through the 3-way valve 70 so that the refrigerant having passed through the freezing chamber evaporator 30 is introduced into the inlet side of the compressor 16.

[0080] After rotation of the compressor 16 at the predetermined reference speed CS_r, the controller 110 rotates the freezing chamber fan 31 at a predetermined speed, i.e., a reference speed FS_r (Operation 304).

[0081] After rotation of the freezing chamber fan 31 at the predetermined reference speed FS_r, the controller 110 determines whether or not a freezing operation off condition is satisfied (Operation 306).

[0082] As a result of the determination of Operation 306, if it is determined that the freezing operation off condition is satisfied, the controller 110 turns the compressor 16 off (Operation 308) and turns the freezing chamber fan 31 off (Operation 310).

[0083] Thereafter, the controller 110 determines whether or not a simultaneous freezing/refrigerating operation condition is satisfied (Operation 312).

[0084] As a result of the determination of Operation 312, if it is determined that the simultaneous freezing/refrigerating operation condition is satisfied, the controller 110 rotates the compressor 16 at a speed CS (CS>CS_r) which is higher than the predetermined reference speed CS_r (Operation 314). At this time, the controller 110 changes the refrigerant flow channel through the 3-way valve 70 so that the refrigerant having passed through the freezing chamber evaporator 30 is introduced into the inlet side of the compressor 16 via the refrigerating chamber evaporator 40.

[0085] After rotation of the compressor 16 at the speed CS, the controller 110 rotates the freezing chamber fan 31 at the predetermined reference speed FS_r or a speed FS (FS<FS_r) which is lower than the predetermined reference speed FS_r (Operation 316). At this time, the controller 110 operates the refrigerating chamber fan 41 at a reference speed RS.

[0086] On the other hand, as the result of the determination of Operation 300, if it is determined that the freezing operation condition is not satisfied, the controller 110 moves to Operation 312 and then performs subsequent Operations.

[0087] Further, as the result of the determination of Operation 312, if it is determined that the simultaneous freezing/refrigerating operation condition is not satisfied, the controller 110 returns to the predetermined routine.

[0088] In order to maximize effects of the NARM, the dryness and temperature of the refrigerant at the inlet of the evaporator need to be lowered, and for this purpose, sub-coolers may be mounted. The sub-coolers lower the dryness of the refrigerant at the inlet of the freezing chamber evaporator 30 (the outlet of the capillary tube) through heat exchange between the refrigerant pipe at the outlet of the condenser 50 and the refrigerant pipe at the outlet of the refrigerating chamber evaporator 40, and may thus lower the temperature of the refrigerant at the inlet of the freezing chamber evaporator 30. The number and positions of the sub-coolers may be varied according to characteristics of the cycle, and for example, two sub-coolers may be used.

[0089] A sub-cooler performing heat exchange between the low-pressure side refrigerant pipe between the freezing chamber evaporator 30 and the refrigerating chamber evaporator 40 and the refrigerant pipe of the condenser 50 is referred to as a low temperature heat exchanger (LTHX), and serves both to lower the temperature of the refrigerant at the inlet of the freezing chamber evaporator and to raise a refrigerating chamber evaporation temperature. Since operation of the refrigerating chamber 14 uses a part of evaporation latent heat of the refrigerant, the dryness of which is high, and the refrigerating chamber evaporation temperature of the NARM becomes higher than that of a pure refrigerant. This reduces a heat exchange temperature difference between the refrigerant and air, thus reducing thermodynamic irreversible loss. Since the irreversible loss is reduced in inverse proportion to the refrigerant chamber evaporation temperature, the LTHX may maximize reduction in the irreversible loss.

[0090] On the other hand, a sub-cooler performing heat exchange between the outlet of the evaporator and the refrigerant pipe of the condenser is referred to as a high temperature heat exchanger (HTHX). Such an HTHX serves to lower the temperature of the refrigerant at the inlet of the evaporator in the same manner as the LTHX.

[0091] As is apparent from the above description, a refrigerator in accordance with an embodiment of the present disclosure reduces the rotational speed of a freezing chamber fan or stopping the freezing chamber fan for a designated time, and/or increasing the rotational speed of a compressor in a simultaneous freezing/refrigerating operation mode of an NARM cycle as compared to a freezing operation mode, and may thus decrease evaporation latent heat of a refrigerant consumed by a freezing chamber evaporator and relatively increase evaporation latent heat of the refrigerant usable in a refrigerating chamber evaporator without increase in a charging amount of the refrigerant, thereby preventing over-charging due to increase in the charging amount of the refrigerant and reducing cycling loss.

[0092] Although a few embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents. For example, the technical features of the present disclosure may be applied to a direct cooling refrigerator such as a Kim-Chi refrigerator. In this case, the method of controlling the rotational speed of the compressor as describe above may be applied.

Claims

1. A refrigerator comprising:

   a freezing chamber and a refrigerating chamber;
   a compressor to compress a refrigerant;
   a refrigerating chamber evaporator to cool the refrigerating chamber;
   a freezing chamber evaporator provided at an upstream position as compared to a position of the refrigerating chamber evaporator, and to cool the freezing chamber;
   a freezing chamber fan to blow cool air having undergone heat exchange in the freezing chamber evaporator; and
   a controller to control operations of the compressor and the freezing chamber fan,
   wherein the refrigerator has a freezing operation mode and a simultaneous freezing/refrigerating operation mode, and
   wherein the controller changes a rotational speed of at least one of the freezing chamber fan and the compressor so as to increase evaporation latent heat of the refrigerant introduced into the refrigerating chamber evaporator in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

2. The refrigerator according to claim 1, wherein the controller lowers the rotational speed of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

3. The refrigerator according to claim 1, wherein the controller temporarily stops the rotational speed of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode.

4. The refrigerator according to claim 1, wherein the controller increases the rotational speed of the compressor in the simultaneous freezing/refrigerating operation mode as compared to a freezing operation mode.

5. The refrigerator according to claim 1, wherein the controller lowers the rotational speed of the freezing chamber fan or temporarily stops the operation of the freezing chamber fan while increasing the rotational speed of the compressor in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

6. A control method of a refrigerator in which a freezing chamber evaporator is provided at an upstream position as compared to a position of the refrigerating chamber evaporator, and having a freezing operation mode and a simultaneous freezing/refrigerating operation mode, comprising:

   determining whether or not the refrigerator operates in a simultaneous freezing/refrigerating

operation mode; and
changing a rotational speed of at least one of a freezing chamber fan and a compressor so as to increase evaporation latent heat of a refrigerant introduced into the refrigerating chamber evaporator, when the refrigerator operates in the simultaneous freezing/refrigerating operation mode.

7. The control method according to claim 6, wherein the changing of the rotational speed of at least one of the freezing chamber fan and the compressor includes lowering the rotational speed of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

8. The control method according to claim 6, wherein the changing of the rotational speed of at least one of the freezing chamber fan and the compressor includes temporarily stopping the rotational speed of the freezing chamber fan in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

9. The control method according to claim 6, wherein the changing of the rotational speed of at least one of the freezing chamber fan and the compressor includes increasing the rotational speed of the compressor in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

10. The control method according to claim 6, wherein the changing of the rotational speed of at least one of the freezing chamber fan and the compressor includes lowering the rotational speed of the freezing chamber fan or temporarily stopping the operation of the freezing chamber fan while increasing the rotational speed of the compressor in the simultaneous freezing/refrigerating operation mode as compared to the freezing operation mode.

11. The refrigerator according to claim 1, wherein the refrigerant is a non-azeotropic refrigerant mixture.

12. The control method according to claim 6, wherein the refrigerant is a non-azeotropic refrigerant mixture.

FIG. 1

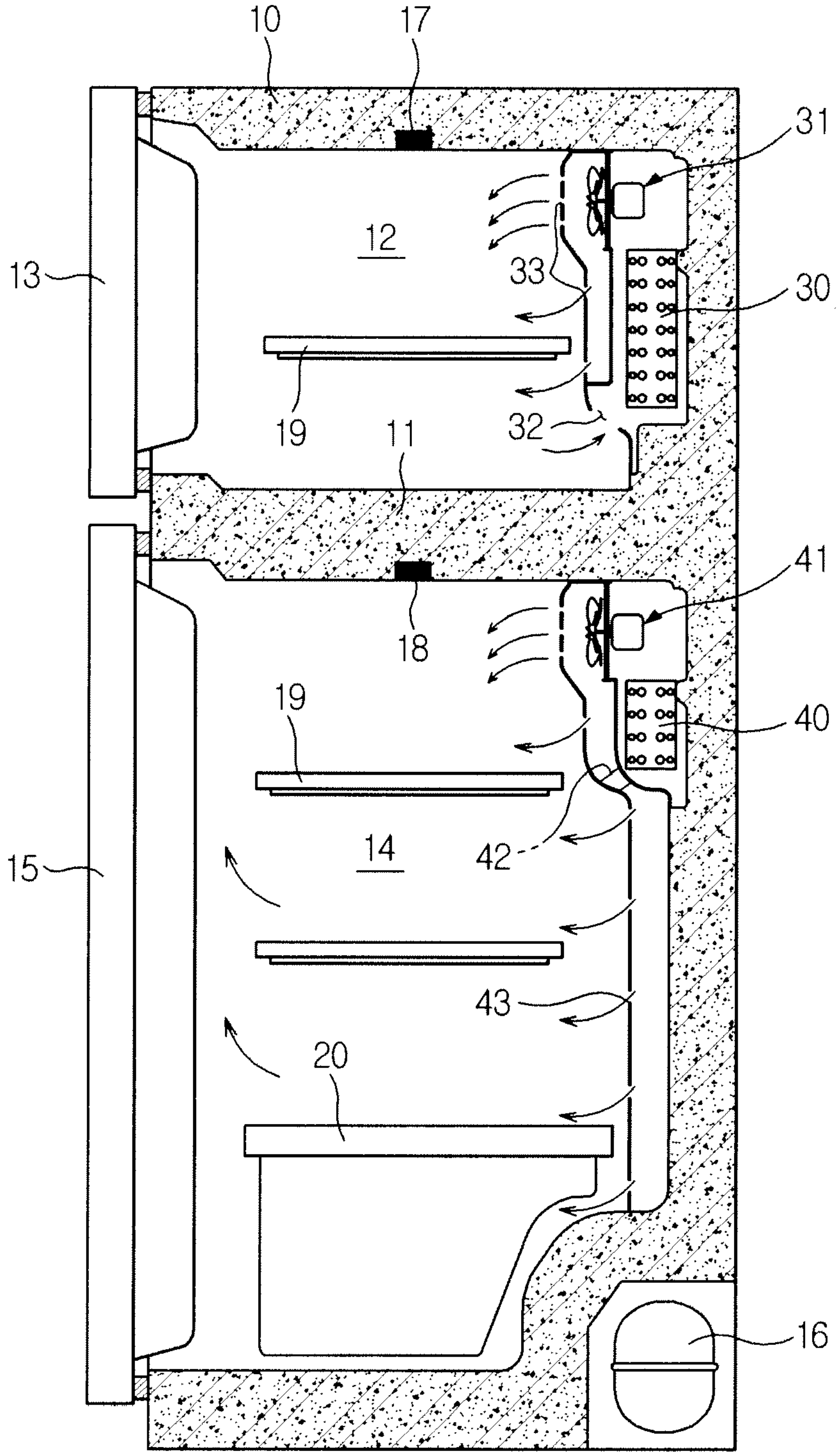


FIG. 2

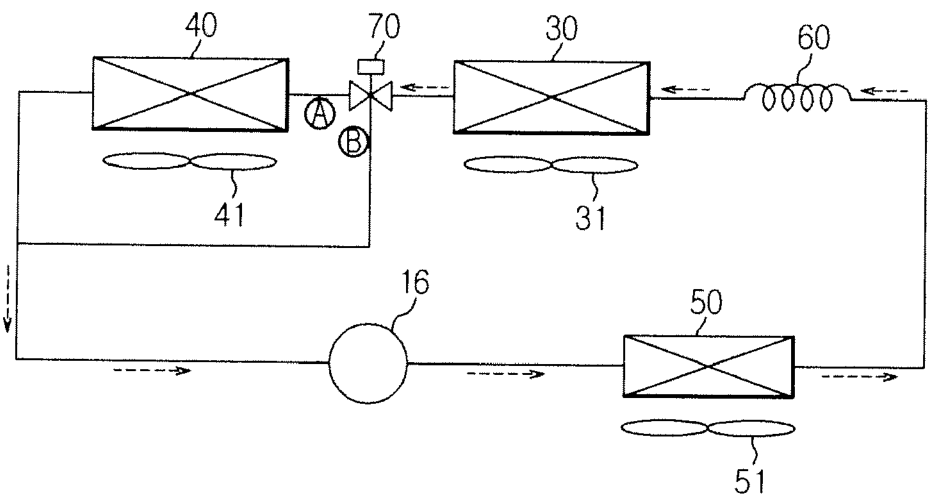


FIG. 3

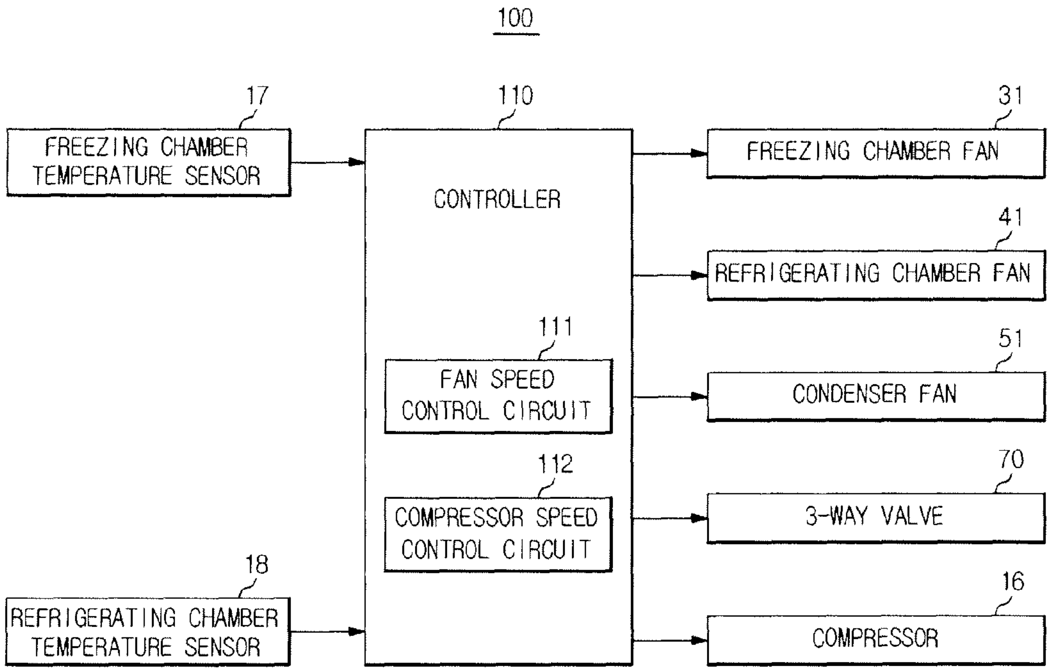

100
17
FREEZING CHAMBER TEMPERATURE SENSOR
18
REFRIGERATING CHAMBER TEMPERATURE SENSOR
110
CONTROLLER
111
FAN SPEED CONTROL CIRCUIT
112
COMPRESSOR SPEED CONTROL CIRCUIT
31
FREEZING CHAMBER FAN
41
REFRIGERATING CHAMBER FAN
51
CONDENSER FAN
70
3-WAY VALVE
16
COMPRESSOR

FIG. 4

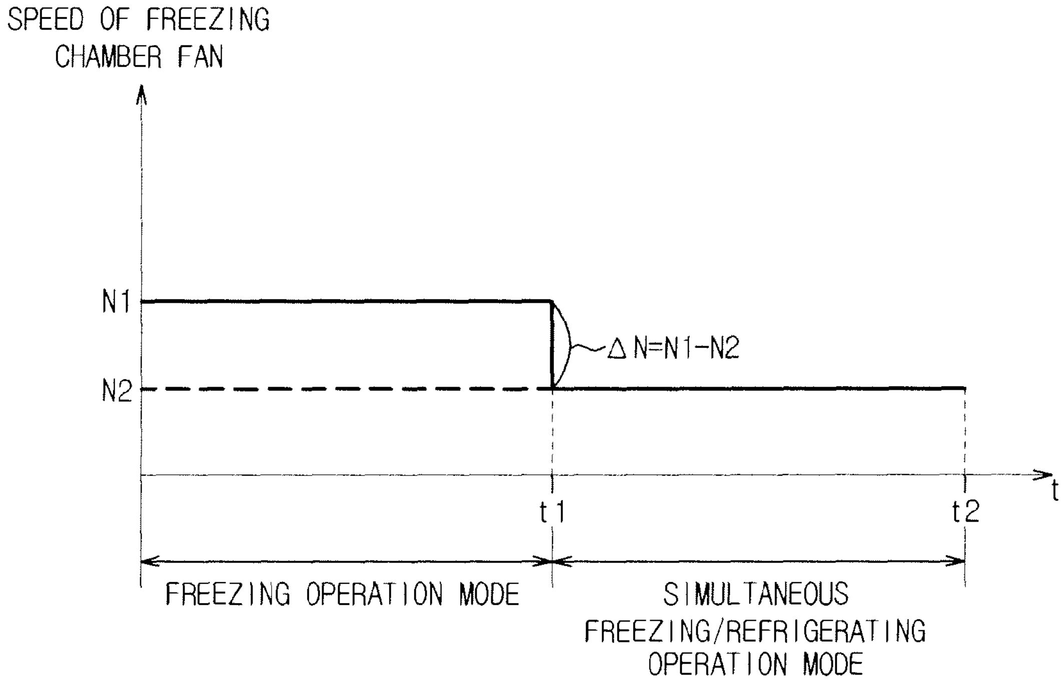

SPEED OF FREEZING
CHAMBER FAN
N1
N2
ΔN=N1-N2
t
t1
t2
FREEZING OPERATION MODE
SIMULTANEOUS
FREEZING/REFRIGERATING
OPERATION MODE

FIG. 5

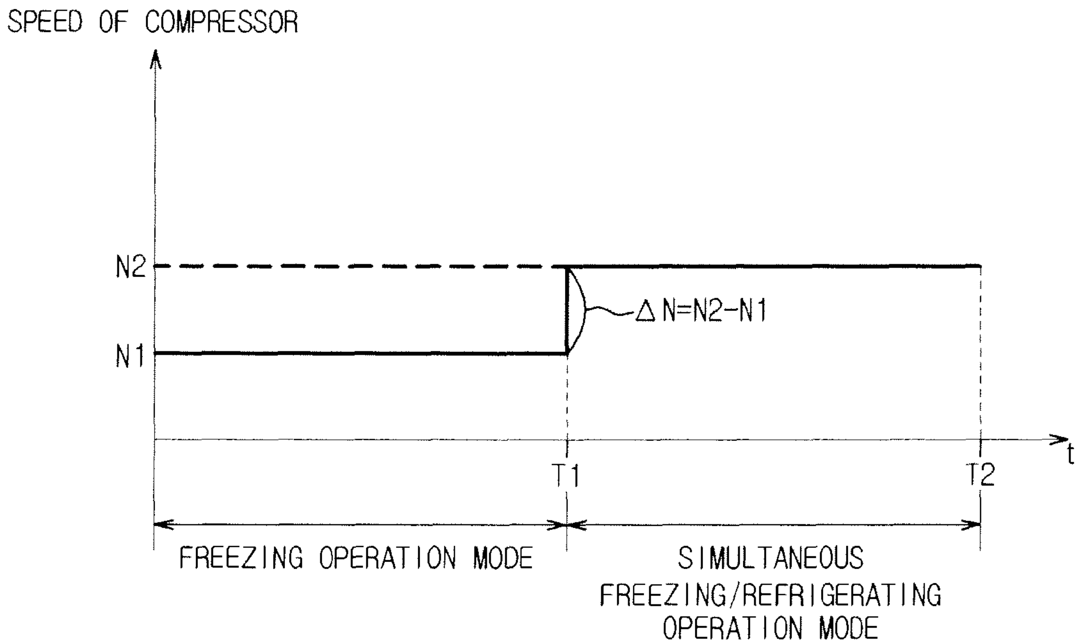

SPEED OF COMPRESSOR
N2
N1
ΔN=N2-N1
t
T1
T2
FREEZING OPERATION MODE
SIMULTANEOUS
FREEZING/REFRIGERATING
OPERATION MODE

FIG. 6

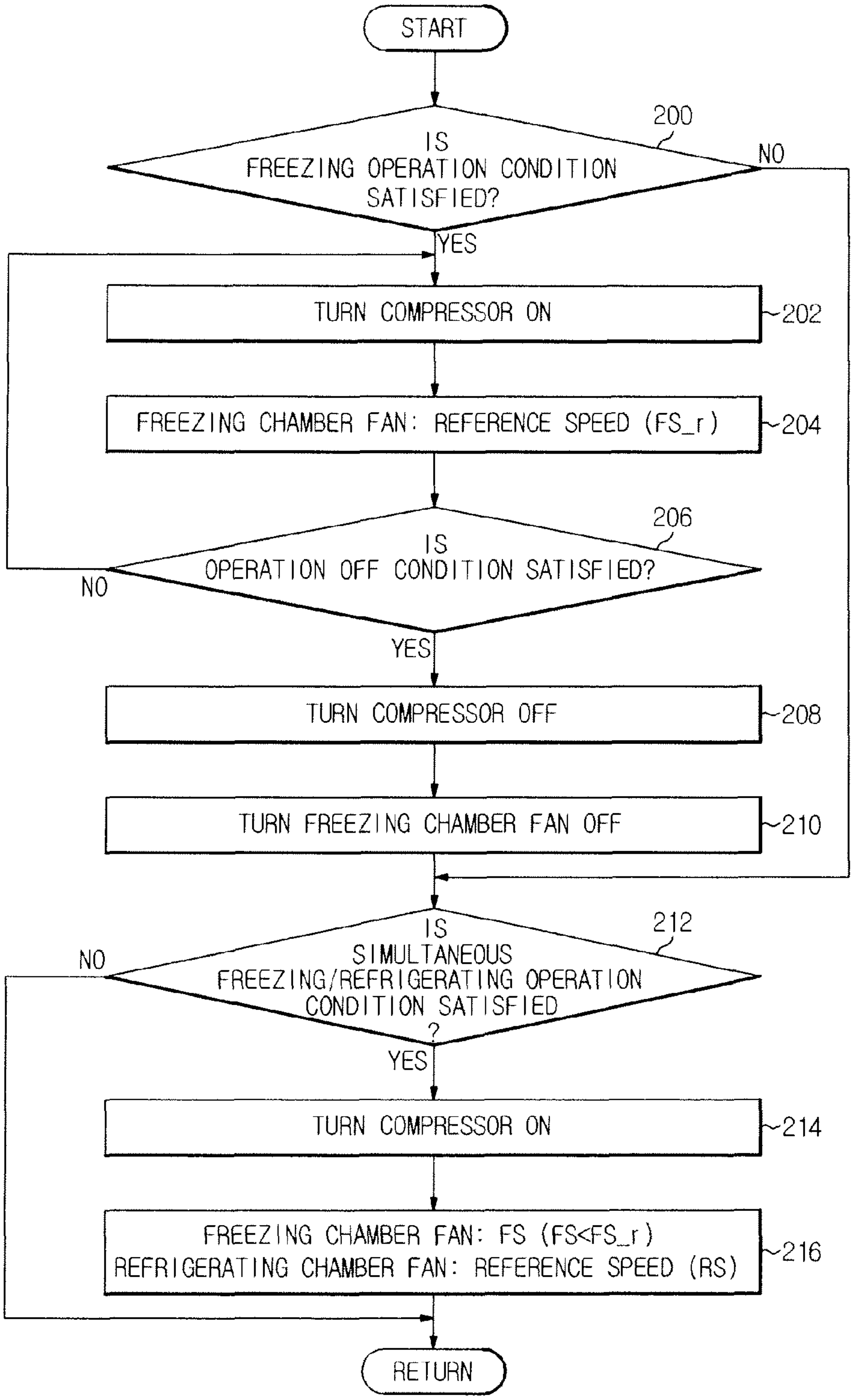
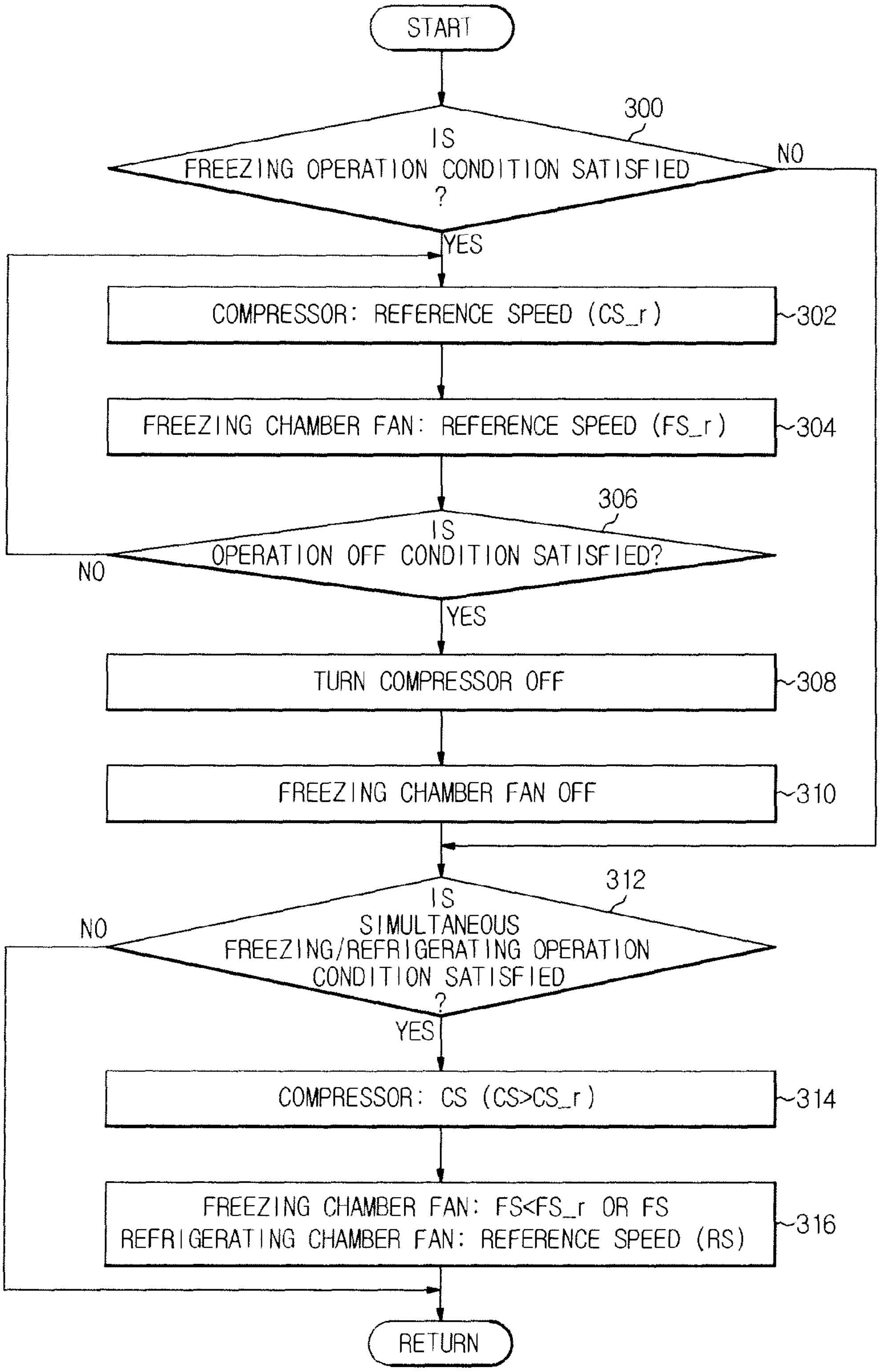

START
IS FREEZING OPERATION CONDITION SATISFIED?
200
NO
YES
TURN COMPRESSOR ON
202
FREEZING CHAMBER FAN: REFERENCE SPEED (FS_r)
204
IS OPERATION OFF CONDITION SATISFIED?
206
NO
YES
TURN COMPRESSOR OFF
208
TURN FREEZING CHAMBER FAN OFF
210
IS SIMULTANEOUS FREEZING/REFRIGERATING OPERATION CONDITION SATISFIED ?
212
NO
YES
TURN COMPRESSOR ON
214
FREEZING CHAMBER FAN: FS (FS<FS_r)
REFRIGERATING CHAMBER FAN: REFERENCE SPEED (RS)
216
RETURN

FIG. 7


START
IS FREEZING OPERATION CONDITION SATISFIED ?
300
NO
YES
COMPRESSOR: REFERENCE SPEED (CS_r)
302
FREEZING CHAMBER FAN: REFERENCE SPEED (FS_r)
304
IS OPERATION OFF CONDITION SATISFIED?
306
NO
YES
TURN COMPRESSOR OFF
308
FREEZING CHAMBER FAN OFF
310
IS SIMULTANEOUS FREEZING/REFRIGERATING OPERATION CONDITION SATISFIED ?
312
NO
YES
COMPRESSOR: CS (CS>CS_r)
314
FREEZING CHAMBER FAN: FS<FS_r OR FS
REFRIGERATING CHAMBER FAN: REFERENCE SPEED (RS)
316
RETURN