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(54) **DEFROSTING CONTROL METHOD FOR REFRIGERATOR**

(57) A defrosting control method for a refrigerator includes: measuring a temperature in a storage space, and determining whether the temperature of the storage space reaches a first preset temperature value during a temperature decreasing process; when the temperature of the storage space reaches the first preset temperature value during the temperature decreasing process, starting a defrosting program to perform defrosting once, wherein the defrosting program includes a first defrosting program, and the first defrosting program includes: turning off a low-temperature-level evaporation portion, and starting a first defrosting heating apparatus to heat an evaporator; measuring the temperature in the storage space, and determining whether a difference between the temperature of the storage space and the first preset temperature value is greater than a first preset difference; and when the difference between the temperature of the storage space and the first preset temperature value is greater than the first preset difference, stopping the first defrosting program, and turning on the low-temperature-level evaporation portion. Defrosting can be performed many times in a timely manner, which not only ensures that the refrigeration is not affected by excessive

frost, but also avoids the influence of excessive temperature rise caused by the defrosting on the nutritional preservation of food.

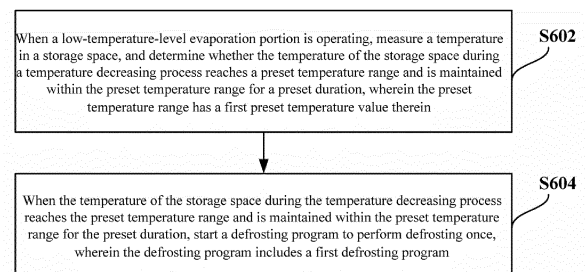


Fig. 6

Description

FIELD OF THE INVENTION

[0001] The present invention relates to the field of refrigeration storage, and in particular to a defrosting control method for a refrigerator.

BACKGROUND OF THE INVENTION

[0002] At present, the temperature of temperature-variable compartments of refrigerators on the market is mostly adjusted within a range of 8-18°C, and the overall designs thereof are relatively conventional. With the gradual improvement of people's living standards, such refrigerators with the temperature zone can no longer meet everyone's needs. It is necessary to design high-end refrigerators with a wider temperature range and more complete functions that can meet more needs of users. As for the preservation of food materials in a glassy state below -40°C, it is conducive to the maximum preservation of the nutritional value of food, and thus there is a demand for ultra-low temperature compartments (-40°C to -60°C) in the high-end user market to improve user satisfaction and keep a tight grip on user experience. For this reason, a conventional cascade compression refrigeration system usually consists of two separate refrigeration circulation loops, which are respectively called a high-temperature-level refrigeration circulation loop (referred to as a high temperature portion) and a low-temperature-level refrigeration circulation loop (referred to as a low temperature portion). A first refrigerant with a relatively higher evaporation temperature is used at the high temperature portion, and a second refrigerant with a relatively lower evaporation temperature is used at the low temperature portion. A condensing evaporator is adopted to condense the second refrigerant vapor discharged from a compressor in the low temperature portion by using the refrigerating capacity of the first refrigerant in the high temperature portion, thus achieving low temperature of -60°C or below.

BRIEF DESCRIPTION OF THE INVENTION

[0003] The inventor of the present invention found that the existence of a cryogenic compartment is a requirement for the preservation of high-end food materials. In this case, the impact of temperature fluctuations on the nutrition of the food materials is more obvious. For example, the food materials such as Boston lobster are best eaten at the first time after being transported by air. If they are stored in a refrigerator to ensure no loss of nutrition, a refrigerator with a cryogenic compartment is developed, because the temperature thereof is significantly lower than that of a conventional refrigerator and if the temperature fluctuates beyond a certain range, the preservation of nutrients will be affected. In other words, the inventor found that if an evaporator of the cryogenic com-

partment is not defrosted in time, it will lead to excessive frost formation and decrease in refrigeration efficiency, which will affect energy consumption and refrigeration depth. Failure to control the temperature fluctuation in time during the defrosting process will cause food nutrition damage. Based on this, the present invention proposes a defrosting control method for a refrigerator, which can not only ensure that the refrigeration is not affected by excessive frost during the defrosting of the cryogenic compartment, but also avoid the influence of excessive temperature rise caused by the defrosting on the nutritional preservation of food.

[0004] Specifically, the present invention provides a defrosting control method for a refrigerator; the refrigerator includes a refrigerator body, an evaporator, a low-temperature-level refrigeration circulation loop, and a first defrosting heating apparatus, where a storage space is formed inside the refrigerator body, the evaporator is configured to refrigerate the storage space, and the evaporator includes a low-temperature-level evaporation portion disposed in the low-temperature-level refrigeration circulation loop; the defrosting control method for the refrigerator includes:

when the low-temperature-level evaporation portion is operating, measuring a temperature in the storage space, and determining whether the temperature of the storage space during a temperature decreasing process reaches a preset temperature range and is maintained within the preset temperature range for a preset duration, where the preset temperature range has a first preset temperature value therein; and

when the temperature of the storage space during the temperature decreasing process reaches the preset temperature range and is maintained within the preset temperature range for the preset duration, starting a defrosting program to perform defrosting once, where the defrosting program includes a first defrosting program;

the first defrosting program includes: turning off the low-temperature-level evaporation portion, and starting the first defrosting heating apparatus to heat the evaporator; measuring the temperature in the storage space, and determining whether a difference between the temperature of the storage space and the first preset temperature value is greater than a first preset difference; and when the difference between the temperature of the storage space and the first preset temperature value is greater than the first preset difference, stopping the first defrosting program, and turning on the low-temperature-level evaporation portion.

[0005] Optionally, the refrigerator further includes a second defrosting heating apparatus; the defrosting program further includes a second defrosting program, and the defrosting control method for the refrigerator further

includes:

recording a working time of the low-temperature-level evaporation portion within a time period from the end of each defrosting to the beginning of the next defrosting;
determining whether a ratio between the next working time and the last working time is greater than or equal to a preset ratio, where the preset ratio is greater than 1; and
when the ratio between the next working time and the last working time is greater than or equal to the preset ratio, if the defrosting program is going into operation, starting the second defrosting program, otherwise starting the first defrosting program; wherein
the second defrosting program includes: turning off the low-temperature-level evaporation portion, and at least starting the second defrosting heating apparatus to heat the evaporator; measuring the temperature in the storage space, and determining whether the difference between the temperature of the storage space and the first preset temperature value is greater than a second preset difference; and when the difference between the temperature of the storage space and the first preset temperature value is greater than the second preset difference, stopping the second defrosting program, and turning on the low-temperature-level evaporation portion, where the second preset difference is greater than the first preset difference.

[0006] Optionally, the heating power of the second defrosting heating apparatus is greater than that of the first defrosting heating apparatus, and in the second defrosting program, only the second defrosting heating apparatus is started, or the first defrosting heating apparatus and the second defrosting heating apparatus are started at the same time to heat the evaporator; or the heating power of the second defrosting heating apparatus is smaller than or equal to that of the first defrosting heating apparatus, and in the second defrosting program, the first defrosting heating apparatus and the second defrosting heating apparatus are started at the same time to heat the evaporator.

[0007] Optionally, after a cryogenic mode is turned on to make the low-temperature-level evaporation portion work, and after the first defrosting program has been performed at least twice in succession, it is determined whether the ratio between the next working time and the last working time is greater than or equal to the preset ratio.

[0008] Optionally, the defrosting control method for the refrigerator further includes: when it is necessary to start the second defrosting program, determining whether the time interval between this time and that time when the second defrosting program was last started is less than or equal to a preset time interval; and if so, entering a

reminding program, and if not, executing the second defrosting program.

[0009] Optionally, when entering the reminding program, the second defrosting program is executed at the same time.

[0010] Optionally, the reminding program includes: sending out a reminder message; determining whether a feedback instruction is received; and if the feedback instruction is received, performing a corresponding operation according to the feedback instruction.

[0011] Optionally, if the feedback instruction is not received, the second defrosting program is performed when a follow-up defrosting program is going into operation.

[0012] Optionally, the refrigerator further includes a high-temperature-level refrigeration circulation loop, and the evaporator includes a high-temperature-level evaporation portion disposed in the high-temperature-level refrigeration circulation loop; and the feedback instruction includes switching a cryogenic mode that makes the low-temperature-level evaporation portion work to a conventional refrigeration mode that makes the high-temperature-level evaporation portion work.

[0013] Optionally, the corresponding operation performed according to the feedback instruction includes: starting the first defrosting heating apparatus and/or the second defrosting heating apparatus.

[0014] Optionally, the corresponding operation performed according to the feedback instruction further includes: when the temperature of the storage space rises to a second preset temperature value, and/or when the temperature of the evaporator rises to a third preset temperature value, stopping the first defrosting heating apparatus and/or the second defrosting heating apparatus, and controlling the high-temperature-level evaporation portion according to the temperature in the storage space to perform the conventional refrigeration mode.

[0015] Optionally, the corresponding operation performed according to the feedback instruction includes: starting the first defrosting heating apparatus and the second defrosting heating apparatus, stopping the second defrosting heating apparatus when the temperature of the storage space rises to a fourth preset temperature value, stopping the first defrosting heating apparatus when the temperature of the storage space rises to a fifth preset temperature value, and controlling the high-temperature-level evaporation portion according to the temperature in the storage space to perform the conventional refrigeration mode; and the fifth preset temperature value is higher than the fourth preset temperature value.

[0016] Optionally, during the conventional refrigeration mode, a corresponding conventional defrosting program can be performed.

[0017] According to the defrosting control method for a refrigerator provided by the present invention, a defrosting temperature change limiting value is set, so that defrosting can be performed many times in a timely manner, which not only ensures that the refrigeration is not

affected by excessive frost, but also avoids the influence of excessive temperature rise caused by the defrosting on the nutritional preservation of food, thus keeping the food stored in the refrigerator without nutrient loss as much as possible.

[0018] Further, according to the defrosting control method for a refrigerator provided by the present invention, because there are a plurality of heating wires, the defrosting program can be adjusted, so that the defrosting efficiency and effect are improved, and the defrosting can be more thorough.

[0019] Further, according to the defrosting control method for a refrigerator provided by the present invention, the reminding function switching and the control program of complete defrosting after the switching can timely remind a user to eat the food, so as to avoid the subsequent larger temperature fluctuation in the cryogenic compartment from affecting the nutrition and taste of the food. Of course, the defrosting control method for a refrigerator provided by the present invention can also well ensure the refrigeration efficiency and prevent the larger temperature fluctuation of the cryogenic compartment even after reminding, thus guaranteeing the nutrition and taste of the food.

[0020] Further, according to the defrosting control method for a refrigerator provided by the present invention, rapid switching between the cryogenic mode and the conventional refrigeration mode can be realized, and the evaporator can be easily defrosted and two temperature zones can be quickly switched by means of the heating apparatus.

[0021] The above and other objectives, advantages, and characteristics of the present invention will be better understood by those skilled in the art according to the following detailed description of specific embodiments of the present invention in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] In the following part, some specific embodiments of the present invention will be described in detail in an exemplary rather than limited manner with reference to the accompanying drawings. The same reference numerals in the accompanying drawings indicate the same or similar components or portions. Those skilled in the art should understand that these accompanying drawings are not necessarily drawn to scale. In figures:

FIG. 1 is a schematic diagram of a refrigerator according to one embodiment of the present invention; FIG. 2 is a schematic diagram of a cascade compression refrigeration system in a refrigerator according to one embodiment of the present invention; FIG. 3 is a schematic diagram of a partial structure of a refrigerator according to one embodiment of the present invention;

FIG. 4 is a schematic section diagram of a partial structure of a refrigerator according to one embodiment of the present invention;

FIG. 5 is a schematic diagram of a partial structure of a refrigerator according to one embodiment of the present invention;

FIG. 6 is a schematic flowchart of a defrosting control method for a refrigerator according to one embodiment of the present invention;

FIG. 7 is a schematic diagram showing a relationship between the working time P_{h1} of a first defrosting heating apparatus and the working time P_{DC} of a low-temperature-level evaporation portion as well as a temperature in a storage space in a defrosting control method for a refrigerator according to one embodiment of the present invention;

FIG. 8 is a schematic diagram showing a relationship between the time P_{h1+h2} of a first defrosting heating apparatus and a second defrosting heating apparatus working at the same time and the working time P_{DC} of a low-temperature-level evaporation portion as well as a temperature in a storage space in a defrosting control method for a refrigerator according to one embodiment of the present invention;

FIG. 9 is a schematic diagram showing a relationship between the time P_{h1+h2} of a first defrosting heating apparatus and a second defrosting heating apparatus working at the same time and the working time P_{DC} of a low-temperature-level evaporation portion as well as a temperature in a storage space in a defrosting control method for a refrigerator according to one embodiment of the present invention; and

FIG. 10 is a schematic diagram showing a relationship between the working time P_{h1} of a first defrosting heating apparatus, the time P_{h1+h2} of the first defrosting heating apparatus and a second defrosting heating apparatus working at the same time, the working time P_{DC} of a low-temperature-level evaporation portion, the working time P_C of a high-temperature-level evaporation portion, and a temperature in a storage space in a defrosting control method for a refrigerator according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0023] FIG. 1 is a schematic diagram of a refrigerator according to one embodiment of the present invention. As shown in FIG. 1, and with reference to FIG. 2 to FIG. 5, an embodiment of the present invention provides a refrigerator. The refrigerator may include a refrigerator body 20, an evaporator and a refrigeration system, where a plurality of storage compartments are also formed in the refrigerator body 20, including a first storage compartment 21, a second storage compartment 22 and a third storage compartment 23. An inner space of the second storage compartment 22 may be a storage space. The refrigeration system can be disposed in the refriger-

ator body 20, and the refrigeration system includes a high-temperature-level refrigeration circulation loop 30 and a low-temperature-level refrigeration circulation loop 40, and the refrigeration system can also be referred to as a cascade compression refrigeration system. The 'high temperature' and 'low temperature' in the 'high-temperature-level refrigeration circulation loop 30' and the 'low-temperature-level refrigeration circulation loop 40' are relative terms. Relatively speaking, the evaporation temperature of a refrigerant flowing through an interior of the high-temperature-level refrigeration circulation loop 30 is higher than that of a refrigerant flowing through an interior of the low-temperature-level refrigeration circulation loop 40. The evaporator is configured to refrigerate the storage space, and the evaporator includes a low-temperature-level evaporation portion disposed in the low-temperature-level refrigeration circulation loop, and a high-temperature-level evaporation portion disposed in the high-temperature-level refrigeration circulation loop.

[0024] Specifically, the high-temperature-level refrigeration circulation loop 30 is used to circulate a first refrigerant, and is internally provided with a control valve 33 as well as a first evaporator 35, the high-temperature-level evaporation portion 36 and an evaporation portion 37 which are used for heat absorption. The first evaporator 35 and the high-temperature-level evaporation portion 36 are used to promote the first refrigerant flowing therethrough to absorb heat, and are used to refrigerate the first storage compartment 21 and the second storage compartment 22, respectively. The high-temperature-level refrigeration circulation loop 30 further includes a high-temperature-level compressor 31 and a high-temperature-level condensing device 32. The low-temperature-level refrigeration circulation loop 40 is used to circulate a second refrigerant, and a condensing portion 42 and the low-temperature-level evaporation portion 44 are provided therein, where the low-temperature-level evaporation portion 44 is used to promote the second refrigerant flowing therethrough to absorb heat, and to refrigerate the second storage compartment 22. The low-temperature-level refrigeration circulation loop 40 further includes a low-temperature-level compressor 41. That is, the high-temperature-level refrigeration circulation loop 30 may include: the high-temperature-level compressor 31, the high-temperature-level condensing device 32, the control valve 33, the evaporation portion 37, the first evaporator 35, and the high-temperature-level evaporation portion 36. The low-temperature-level refrigeration circulation loop 40 may include: the low-temperature-level compressor 41, the condensing portion 42, and the low-temperature-level evaporation portion 44. The evaporation portion 37 is used to promote the first refrigerant flowing therethrough to absorb the heat of the second refrigerant flowing through the condensing portion 42 in the low-temperature-level refrigeration circulation loop 40. The first refrigerant and the second refrigerant may be the same refrigerant, such as R600a, or different re-

frigerants.

[0025] According to the refrigerator provided by the embodiment of the present invention, the first evaporator 35 and the high-temperature-level evaporation portion 36 are disposed in the high-temperature-level refrigeration circulation loop 30. The first evaporator 35 and the high-temperature-level evaporation portion 36 are used to refrigerate the first storage compartment 21 and the second storage compartment 22, respectively, and the low-temperature-level refrigeration circulation loop 40 is internally provided with the low-temperature-level evaporation portion 44 for refrigerating the second storage compartment 22. The energy utilization efficiency in the high-temperature-level refrigeration circulation loop 30 is improved, and the plurality of storage compartments of the refrigerator can be refrigerated at the same time, so that the refrigeration efficiency of the refrigerator is improved. Both the high-temperature-level evaporation portion 36 and the low-temperature-level evaporation portion 44 can refrigerate the second storage compartment 22, so that the single storage compartment of the refrigerator has a function of multiple temperature zones, that is, the second storage compartment 22 is enabled to achieve different refrigerating effects to meet different refrigerating demands; and the temperature zone range of the second storage compartment 22 can be expanded. That is to say, not only is the refrigerator enabled to have a cryogenic function, but also the energy-saving demands of daily refrigeration are met.

[0026] Further, an inlet of the control valve 33 may be communicated with an outlet of the high-temperature-level condensing device 32. The control valve 33 has a first outlet and a second outlet, an inlet of the first evaporator 35 is communicated with the first outlet, and an inlet of the high-temperature-level evaporation portion 36 is communicated with the second outlet. An outlet of the high-temperature-level evaporation portion 36 is communicated with the inlet of the first evaporator 35, and an inlet of the evaporation portion 37 is communicated with an outlet of the first evaporator 35. In other embodiments, the outlet of the high-temperature-level evaporation portion 36 is communicated with the inlet of the evaporation portion 37, and an outlet of the evaporation portion 37 is communicated with the inlet of the first evaporator 35. The control valve 33 can be a switching valve. The position arrangement of all the evaporators and the evaporation portion 37 in the high-temperature-level refrigeration circulation loop 30 can ensure the refrigeration efficiency of all the evaporators during normal temperature refrigeration, and improve the energy efficiency of the refrigerator, thus achieving an obvious energy saving effect. The control valve 33 has a third outlet, and the third outlet is communicated with the inlet of the evaporation portion 37. In order to improve the cryogenic efficiency, the evaporation portion 37 can be made to work alone, or the evaporation portion 37 and the first evaporator 35 can be made to work together while the high-temperature-level evaporation portion 36 is made not to work.

Further, the high-temperature-level refrigeration circulation loop 30 further includes a second evaporator 38, the second evaporator 38 is disposed between the third outlet and the evaporation portion 37, and the second evaporator 38 is used for refrigerating the third storage compartment 23. When the evaporation portion 37 is working, the third storage compartment 23 can also be refrigerated at the same time, so that the working efficiency of the high-temperature-level refrigeration circulation loop 30 is improved, and the energy saving effect is obvious. A first throttling device 341 is disposed between the inlet of the first evaporator 35 and the first outlet; a second throttling device 342 is disposed between the inlet of the high-temperature-level evaporation portion 36 and the second outlet; and a third throttling device 343 is disposed between the inlet of the second evaporator 38 and the third outlet.

[0027] In some embodiments of the present invention, the first storage compartment 21 and the second storage compartment 22 are disposed side by side along a lateral extension direction of the refrigerator, and the third storage compartment 23 is disposed at upper sides of the first storage compartment 21 and the second storage compartment 22. The first storage compartment 21 may be a freezing chamber, the second storage compartment 22 may be a multi-functional chamber with multiple temperature zones, and the third storage compartment 23 may be a refrigerating chamber. The arrangement can make the layout of the compartments more reasonable, and provide more convenience to access of corresponding articles.

[0028] In some embodiments of the present invention, as shown in FIG. 2, FIG. 3 and FIG. 4, the refrigerator further includes an air supply device 50 for promoting airflow to flow through the evaporators and enter the second storage compartment 22. Further, the high-temperature-level evaporation portion 36 includes a first refrigerating evaporation tube, the low-temperature-level evaporation portion 44 includes a second refrigerating evaporation tube, and the first refrigerating evaporation tube and the second refrigerating evaporation tube pass through a same fin group. The high-temperature-level evaporation portion 36 may be disposed at the upper side of the low-temperature-level evaporation portion 44. Further, a first refrigeration cabinet 24 for arranging the high-temperature-level evaporation portion 36 and the low-temperature-level evaporation portion 44 is also formed in the refrigerator body 20 at a corresponding position at a rear side of the second storage compartment 22. The first refrigeration cabinet 24 is communicated with the second storage compartment 22 by means of a first air supply structure so as to provide refrigerating airflow to the second storage compartment 22 through the first air supply structure.

[0029] As shown in FIG. 2 to FIG. 4, the evaporator provided with the high-temperature-level evaporation portion 36 and the low-temperature-level evaporation portion 44 can be a two-in-two-out dual-channel evaporator,

and has an up-down structure. When the refrigerator is set to operate normally, the high-temperature-level refrigeration circulation loop 30 operates, and the upper high-temperature-level evaporation portion 36 refrigerates. At this time, the evaporators share lower evaporator fins, so that the heat exchange area is large, and the heat exchange efficiency is high. When the refrigerator is set to operate in a cryogenic mode, the lower low-temperature-level evaporation portion 44 is connected, a cryogenic system works, and the lower evaporators are cooled and share upper evaporator fins at the same time, so that the heat exchange area is large, and the heat exchange efficiency is high. The structure of arranging the evaporators up and down can also make the heat exchange uniform. The utilization rate of the heat exchange area of the evaporators can be guaranteed, and the size of the dual-channel evaporator can be reduced; furthermore, the heat exchange is uniform, thus ensuring the uniform distribution of pipelines; and an air duct system and a refrigeration fan are matched for use, thus not only realizing both normal temperature refrigeration and cryogenic refrigeration, but also achieving the purpose of saving energy during conventional refrigeration.

[0030] In some embodiments of the present invention, as shown in FIG. 1 and FIG. 5, a second refrigeration cabinet for arranging the first evaporator 35 is also formed in the refrigerator body 20 at a corresponding position at a rear side of the first storage compartment 21. The second refrigeration cabinet is communicated with the first storage compartment 21 by means of a second air supply structure 52 so as to provide refrigerating airflow to the first storage compartment 21 through the second air supply structure 52. A third refrigeration cabinet for arranging the second evaporator 38 is also formed in the refrigerator body 20 at a corresponding position at a rear side of the third storage compartment 23. The third refrigeration cabinet is communicated with the third storage compartment 23 by means of a third air supply structure so as to provide refrigerating airflow to the third storage compartment 23 through the third air supply structure. The first air supply structure is disposed between the first refrigeration cabinet 24 and the second storage compartment 22. A rear side face of the first air supply structure is provided with an air inlet, and the air supply device 50 is disposed at the air inlet. A front side face of the first air supply structure is provided with a plurality of air supply outlets 54, and the first air supply structure 51 is internally provided with an air supply duct 55. An air return duct 56 may be provided on a lower side of the first air supply structure, so that the evaporators can supply air from the bottom and discharge air from the upper portion. Both the second air supply structure and the third air supply structure are similar to the first air supply structure 51.

[0031] As shown in FIG. 2, an outlet pipe of the high-temperature-level evaporation portion 36 is provided with a valve that only allows the refrigerant from the high-temperature-level evaporation portion 36 to flow out in one direction. The valve can be a one-way valve 39, and

the one-way valve 39 can prevent the reverse passage of the first refrigerant downstream of the one-way valve 39. When the low-temperature-level compressor 41 runs, the temperature of the low-temperature-level evaporation portion 44 is very low. Due to the short distance between the high-temperature-level evaporation portion 36 and the low-temperature-level evaporation portion 44, the pipeline temperature of the high-temperature-level evaporation portion 36 is also relatively low, even significantly lower than that of the other evaporators downstream of the high-temperature-level evaporation portion 36 in the high-temperature-level refrigeration circulation loop 30. The valve can prevent the first refrigerant in the other evaporators located downstream of the high-temperature-level evaporation portion 36 from flowing into the high-temperature-level evaporation portion 36 from a discharge outlet of the high-temperature-level evaporation portion 36, thereby avoiding the reverse flow of the first refrigerant in the high-temperature-level refrigeration circulation loop 30, ensuring the effective flux of the first refrigerant, and further improving the overall refrigeration efficiency.

[0032] Taking R600a as an example, when the refrigerant temperature is -50°C , the pressure is about 0.017 Mpa, the suction pressure of the compressor of R600a is about 0.06 Mpa, and the pressure on the side of the high-temperature-level evaporation portion 36 is lower than the suction pressure of the high-temperature-level compressor 31, which results in the high-temperature-level refrigeration circulation loop gradually accumulating in the high-temperature-level evaporation portion 36, and the refrigerant of the high-temperature-level refrigeration circulation loop being gradually reduced, thus causing poor refrigeration. Through the one-way valve 39, it is possible to prevent the refrigerant from reversely flowing to accumulate in the high-temperature-level evaporation portion 36 so as to avoid the poor refrigeration. The one-way valve 39 can solve the problem of refrigerant accumulation caused by low temperature without using a control program to adjust the operation of a valve body. Therefore, the structure is simple, and the operability is strong.

[0033] The high-temperature-level condensing device 32 may include a condenser and a moisture condensation-proof pipe. The low-temperature-level refrigeration circulation loop 40 further includes a low-temperature-level condensing device 45 and a low-temperature-level throttling device 43. An inlet of the high-temperature-level condensing device 32 is communicated with an outlet of the high-temperature-level compressor 31, the outlet of the evaporation portion 37 is communicated with the inlet of the first evaporator 35, and the outlet of the first evaporator 35 is communicated with an inlet of the high-temperature-level compressor 31. An outlet of the low-temperature-level compressor 41 is communicated with an inlet of the low-temperature-level condensing device 45, an outlet of the low-temperature-level condensing device 45 is communicated with an inlet of the condensing por-

tion 42, an outlet of the condensing portion 42 is communicated with the low-temperature-level throttling device 43, an outlet of the low-temperature-level throttling device 43 is communicated with an inlet of the low-temperature-level evaporation portion 44, and an outlet of the low-temperature-level evaporation portion 44 is communicated with an inlet of the low-temperature-level compressor 41.

[0034] In some alternative embodiments, the condensing portion 42 and the evaporation portion 37 may form a condensing evaporator. The condensing evaporator may be a double-tube heat exchanger. In some other alternative embodiments, the condensing portion 42 and the evaporation portion 37 can also be two copper pipes that are abutted against each other. The two copper pipes are abutted against each other. The contact portion between the two copper pipes can be fixed by soldering to enhance heat transfer. Exteriors of the two copper pipes can be wrapped with aluminum foils. In some other alternative embodiments, the condensing portion 42 and the evaporation portion 37 may share heat exchange fins. The evaporation portion 37 and the condensing portion 42 are disposed in the second refrigeration cabinet. Of course, the evaporation portion 37 and the condensing portion 42 can also be disposed at other positions of the refrigerator.

[0035] In some embodiments of the present invention, a storage compartment is also formed in the refrigerator body 20, and an inner space thereof can be a storage space. In some embodiments of the present invention, the refrigeration system may be a cascade compression refrigeration system having another structure including the high-temperature-level refrigeration circulation loop 30 and the low-temperature-level refrigeration circulation loop 40. For example, the evaporator includes only the low-temperature-level evaporation portion 44 disposed in the low-temperature-level refrigeration circulation loop 40.

[0036] As shown in FIG. 6, the embodiment of the present invention further provides a defrosting control method for a refrigerator. The refrigerator further includes a first defrosting heating apparatus, and the first defrosting heating apparatus may be an electric heating wire. The defrosting control method for the refrigerator at least includes the following step S602 to step S604:

[0037] In step S602, when the low-temperature-level evaporation portion 44 is operating, the temperature in the storage space is measured, and it is determined whether the temperature of the storage space during a temperature decreasing process reaches a preset temperature range and is maintained within the preset temperature range for a preset duration. The preset temperature range has a first preset temperature value therein. Keeping within the preset temperature range means that it fluctuates around the first preset temperature value, with a fluctuation range which generally does not exceed 2°C . When the first preset temperature value is -60°C , the preset temperature range can be -62°C to -58°C . The

first preset temperature value can be, for example, -80°C to -50°C , such as -60°C , and different cryogenic temperatures can be set according to different foods.

[0038] In step S604, when the temperature of the storage space during the temperature decreasing process reaches the preset temperature range and is maintained within the preset temperature range for the preset duration, a defrosting program is started to perform defrosting once. The defrosting program includes a first defrosting program. The first defrosting program includes: turning off the low-temperature-level evaporation portion 44, and starting the first defrosting heating apparatus to heat the evaporator; measuring the temperature in the storage space, and determining whether a difference between the temperature of the storage space and the first preset temperature value is greater than a first preset difference; and when the difference between the temperature of the storage space and the first preset temperature value is greater than the first preset difference, stopping the first defrosting program, and turning on the low-temperature-level evaporation portion 44. The first preset difference may be 3°C to 8°C , such as 5°C and 3°C . A defrosting temperature change limiting value is set, so that defrosting can be performed many times in a timely manner, which not only ensures that the refrigeration is not affected by excessive frost, but also avoids the influence of excessive temperature rise caused by the defrosting on the nutritional preservation of food, thus keeping the food stored in the refrigerator without nutrient loss as much as possible. Specifically, as shown in FIG. 7, according to the research on food preservation, when the temperature exceeds -50°C , it will affect the taste of food materials preserved by means of cryogenic fresh-keeping. Based on this, it is assumed that the temperature that a cryogenic compartment can reach during normal operation is -60°C , and when defrosting starts, the first defrosting heating apparatus works; and when the compartment temperature T_{df} rises by 5°C or more, the first defrosting heating apparatus stops working, and the refrigerator continues to perform refrigeration normally, for example, a cryogenic mode is normally carried out.

[0039] In some embodiments of the present invention, the refrigerator further includes a second defrosting heating apparatus, and the second defrosting heating apparatus may be an electric heating wire. The defrosting program further includes a second defrosting program, and the defrosting control method for the refrigerator further includes that:

the working time of the low-temperature-level evaporation portion 44 within a time period from the end of each defrosting to the beginning of the next defrosting is recorded. That is to say, the time for refrigerating the storage space in the low-temperature-level refrigeration circulation loop between the two defrosting operations is recorded. It is determined whether a ratio between the next working time and the last working time is greater than or equal to a preset ratio, where the preset ratio is greater than 1. Preferably, the preset ratio is 2, 2.5, 3, etc.

[0040] When the ratio between the next working time and the last working time is greater than or equal to the preset ratio, if the defrosting program is going into operation, the second defrosting program is started, otherwise the first defrosting program is started.

[0041] The second defrosting program includes: turning off the low-temperature-level evaporation portion 44, and at least starting the second defrosting heating apparatus to heat the evaporator; measuring the temperature in the storage space, and determining whether the difference between the temperature of the storage space and the first preset temperature value is greater than a second preset difference; and when the difference between the temperature of the storage space and the first preset temperature value is greater than the second preset difference, stopping the second defrosting program, and turning on the low-temperature-level evaporation portion 44, where the second preset difference is greater than the first preset difference. The second preset difference may be 8°C to 15°C , such as 10°C , 12°C , etc.

[0042] For example, in some embodiments, the heating power of the second defrosting heating apparatus is greater than that of the first defrosting heating apparatus, and in the second defrosting program, only the second defrosting heating apparatus is started, or the first defrosting heating apparatus and the second defrosting heating apparatus are started at the same time to heat the evaporator. In some other embodiments, the heating power of the second defrosting heating apparatus is smaller than or equal to that of the first defrosting heating apparatus, and in the second defrosting program, the first defrosting heating apparatus and the second defrosting heating apparatus are started at the same time to heat the evaporator.

[0043] Further, after a cryogenic mode is turned on to make the low-temperature-level evaporation portion 44 work, and after the first defrosting program has been performed at least twice in succession, it is determined whether the ratio between the next working time and the last working time is greater than or equal to the preset ratio. As shown in FIG. 8, in the storage space, that is, the cryogenic compartment, in a normal working cycle (except for the special conditions of not closing a door tightly or putting too many food materials), it starts from a third cycle of normal working of the cryogenic mode. If a startup time in the subsequent cycles is more than 2 times that of the previous cycles, the default is that the refrigeration time is prolonged due to incomplete defrosting, and a high-efficiency defrosting mode is turned on at this time. For example, the first defrosting heating apparatus and the second defrosting heating apparatus work at the same time, and when the compartment temperature T_{df} rises by 10°C or more, the defrosting is stopped, and the refrigerator continues to refrigerate normally.

[0044] In some embodiments of the present invention, the defrosting control method for the refrigerator further includes: when it is necessary to start the second defrost-

ing program, determining whether a time interval between this time and that time when the second defrosting program was last started is less than or equal to a preset time interval; and if so, entering a reminding program, and if not, executing the second defrosting program. The preset time interval may be 18 h to 30 h, such as 24 h. Further optionally, when the reminding program is issued, the second defrosting program is simultaneously executed.

[0045] The reminding program may include: sending out a reminder message; determining whether a feedback instruction is received, i.e., determining whether the feedback instruction is received after the second defrosting program is executed, or determining whether the feedback instruction is received within a preset time after sending out the reminder message while not executing the second defrosting program; and if the feedback instruction is received, performing a corresponding operation according to the feedback instruction. The reminder message can prompt a switching function of the cryogenic compartment on a refrigerator display screen to remind a user that the food in the cryogenic compartment is expired, so that the user is expected to switch back to the normal refrigeration cycle with one click, and start the conventional refrigeration and normal defrosting cycle. Of course, the reminder message can also be other information. Further optionally, if the feedback instruction is not received, the second defrosting program is performed when a follow-up defrosting program is going into operation.

[0046] In some further embodiments of the present invention, the refrigerator further includes the high-temperature-level refrigeration circulation loop 30, and the evaporator includes the high-temperature-level evaporation portion 36 disposed in the high-temperature-level refrigeration circulation loop 30. The feedback instruction includes switching a cryogenic mode that makes the low-temperature-level evaporation portion 44 work to a conventional refrigeration mode that makes the high-temperature-level evaporation portion 36 work. Further, in some embodiments, the corresponding operation performed according to the feedback instruction includes: starting the first defrosting heating apparatus and/or the second defrosting heating apparatus. Further, the corresponding operation performed according to the feedback instruction further includes: when the temperature of the storage space rises to a second preset temperature value, and/or when the temperature of the evaporator rises to a third preset temperature value, stopping the first defrosting heating apparatus and/or the second defrosting heating apparatus, and controlling the high-temperature-level evaporation portion 36 according to the temperature in the storage space to perform the conventional refrigeration mode. That is to say, when the temperature of the storage space rises to the second preset temperature value, and/or when the temperature of the evaporator rises to the third preset temperature value, if either or both of the first defrosting heating apparatus and the sec-

ond defrosting heating apparatus are in an 'ON' state, the heating apparatus in the 'ON' state will be turned off. For example, if only the first defrosting heating apparatus is turned on after the feedback instruction is received, the first defrosting heating apparatus will be turned off when the temperature of the storage space rises to the second preset temperature value, and/or when the temperature of the evaporator rises to the third preset temperature value. Correspondingly, if only the second defrosting heating apparatus is turned on, the second defrosting heating apparatus will be turned off when the temperature of the storage space rises to the second preset temperature value, and/or when the temperature of the evaporator rises to the third preset temperature value; and if the first defrosting heating apparatus and the second defrosting heating apparatus are turned on at the same time, the first defrosting heating apparatus and the second defrosting heating apparatus will be turned off when the temperature of the storage space rises to the second preset temperature, and/or when the temperature of the evaporator rises to the third preset temperature. Starting the first defrosting heating apparatus and/or the second defrosting heating apparatus can realize a rapid rise of the temperature of the cryogenic compartment switched back to a normal compartment without additional power consumption.

[0047] In some other embodiments of the present invention, the corresponding operation performed according to the feedback instruction includes: starting the first defrosting heating apparatus and the second defrosting heating apparatus, stopping the second defrosting heating apparatus when the temperature of the storage space rises to a fourth preset temperature value, stopping the first defrosting heating apparatus when the temperature of the storage space rises to a fifth preset temperature value, and controlling the high-temperature-level evaporation portion 36 according to the temperature in the storage space to perform the conventional refrigeration mode. The fifth preset temperature value is higher than the fourth preset temperature value. In the process of the conventional refrigeration mode, a corresponding conventional defrosting program can be performed.

[0048] In some alternative embodiments of the present invention, when it is determined that the time interval between this time and that time when the second defrosting program was last started is less than or equal to the preset time interval, the cryogenic mode that makes the low-temperature-level evaporation portion 44 work may be switched to the conventional refrigeration mode that makes the high-temperature-level evaporation portion 36 work after the second defrosting program has been executed, or be directly and automatically switched to the conventional refrigeration mode that makes the high-temperature-level evaporation portion 36 work.

[0049] In the embodiments of the present invention, as shown in FIG. 9 and FIG. 10, when the double heating wires are started more than once within 24 h, it means that even if the double heating wires are working, the

frost cannot be removed thoroughly. At this time, the refrigerator display screen indicates the switching function of the cryogenic compartment (reminding the user that the food in the cryogenic compartment is expired), and the user is expected to switch back to the normal refrigeration cycle with one click, and start the conventional refrigeration and the normal defrosting cycle. As shown in FIG. 10, if the user normally chooses to switch back, the first defrosting heating apparatus will start to accelerate the temperature rise in the storage space and play a role of defrosting at the same time. During the refrigeration at the normal compartment temperature, there is no problem in defrosting. If the user does not choose to switch back to the conventional refrigeration mode despite the reminder, as shown in FIG. 9, in order to ensure that the normal refrigeration is not affected, a control strategy of increasing the defrosting times or the high-efficiency defrosting mode can be used for defrosting to guarantee complete defrosting.

[0050] Hereto, those skilled in the art should realize that although a plurality of exemplary embodiments of the present invention have been shown and described in detail herein, without departing from the spirit and scope of the present invention, many other variations or modifications that conform to the principles of the present invention can still be directly determined or deduced from the contents disclosed in the present invention. Therefore, the scope of the present invention should be understood and recognized as covering all these other variations or modifications.

Claims

1. A defrosting control method for a refrigerator, wherein the refrigerator comprises a refrigerator body, an evaporator, a low-temperature-level refrigeration circulation loop, and a first defrosting heating apparatus, a storage space is formed inside the refrigerator body, the evaporator is configured to refrigerate the storage space, and the evaporator comprises a low-temperature-level evaporation portion disposed in the low-temperature-level refrigeration circulation loop, wherein the defrosting control method for the refrigerator comprises:

when the low-temperature-level evaporation portion is operating, measuring a temperature in the storage space, and determining whether the temperature of the storage space during a temperature decreasing process reaches a preset temperature range and is maintained within the preset temperature range for a preset duration, wherein the preset temperature range has a first preset temperature value therein; and when the temperature of the storage space during the temperature decreasing process reaches the preset temperature range and is main-

tained within the preset temperature range for the preset duration, starting a defrosting program to perform defrosting once, wherein the defrosting program comprises a first defrosting program;

the first defrosting program comprises: turning off the low-temperature-level evaporation portion, and starting the first defrosting heating apparatus to heat the evaporator; measuring the temperature in the storage space, and determining whether a difference between the temperature of the storage space and the first preset temperature value is greater than a first preset difference; and when the difference between the temperature of the storage space and the first preset temperature value is greater than the first preset difference, stopping the first defrosting program, and turning on the low-temperature-level evaporation portion.

2. The defrosting control method for the refrigerator according to claim 1, wherein the refrigerator further comprises a second defrosting heating apparatus; the defrosting program further comprises a second defrosting program, and the defrosting control method for the refrigerator further comprises:

recording a working time of the low-temperature-level evaporation portion within a time period from the end of each defrosting to the beginning of the next defrosting;

determining whether a ratio between the next working time and the last working time is greater than or equal to a preset ratio, the preset ratio being greater than 1; and

when the ratio between the next working time and the last working time is greater than or equal to the preset ratio, if the defrosting program is going into operation, starting the second defrosting program, otherwise starting the first defrosting program, wherein

the second defrosting program comprises: turning off the low-temperature-level evaporation portion, and at least starting the second defrosting heating apparatus to heat the evaporator; measuring the temperature in the storage space, and determining whether the difference between the temperature of the storage space and the first preset temperature value is greater than a second preset difference; and when the difference between the temperature of the storage space and the first preset temperature value is greater than the second preset difference, stopping the second defrosting program, and turning on the low-temperature-level evaporation portion, the second preset difference being greater than the first preset difference.

3. The defrosting control method for the refrigerator according to claim 2, wherein

the heating power of the second defrosting heating apparatus is greater than that of the first defrosting heating apparatus, and in the second defrosting program, only the second defrosting heating apparatus is started, or the first defrosting heating apparatus and the second defrosting heating apparatus are started at the same time to heat the evaporator; or
the heating power of the second defrosting heating apparatus is smaller than or equal to that of the first defrosting heating apparatus, and in the second defrosting program, the first defrosting heating apparatus and the second defrosting heating apparatus are started at the same time to heat the evaporator.

4. The defrosting control method for the refrigerator according to claim 2, wherein
after a cryogenic mode is turned on to make the low-temperature-level evaporation portion work, and after the first defrosting program has been performed at least twice in succession, it is determined whether the ratio between the next working time and the last working time is greater than or equal to the preset ratio.

5. The defrosting control method for the refrigerator according to claim 2, further comprising:

when it is necessary to start the second defrosting program, determining whether the time interval between this time and that time when the second defrosting program was last started is less than or equal to a preset time interval; and if so, entering a reminding program, and if not, executing the second defrosting program.

6. The defrosting control method for the refrigerator according to claim 5, wherein
when entering the reminding program, the second defrosting program is executed at the same time.

7. The defrosting control method for the refrigerator according to claim 5 or 6, wherein the reminding program comprises:

sending out a reminder message;
determining whether a feedback instruction is received; and
if the feedback instruction is received, performing a corresponding operation according to the feedback instruction.

8. The defrosting control method for the refrigerator according to claim 7, wherein

if the feedback instruction is not received, the second defrosting program is performed when a follow-up defrosting program is going into operation.

9. The defrosting control method for the refrigerator according to claim 7, wherein

the refrigerator further comprises a high-temperature-level refrigeration circulation loop, and the evaporator comprises a high-temperature-level evaporation portion disposed in the high-temperature-level refrigeration circulation loop; and the feedback instruction comprises switching a cryogenic mode that makes the low-temperature-level evaporation portion work to a conventional refrigeration mode that makes the high-temperature-level evaporation portion work.

10. The defrosting control method for the refrigerator according to claim 9, wherein
the corresponding operation performed according to the feedback instruction comprises: starting the first defrosting heating apparatus and/or the second defrosting heating apparatus.

11. The defrosting control method for the refrigerator according to claim 10, wherein
the corresponding operation performed according to the feedback instruction further comprises: when the temperature of the storage space rises to a second preset temperature value, and/or when the temperature of the evaporator rises to a third preset temperature value, stopping the first defrosting heating apparatus and/or the second defrosting heating apparatus, and controlling the high-temperature-level evaporation portion according to the temperature in the storage space to perform the conventional refrigeration mode.

12. The defrosting control method for the refrigerator according to claim 9, wherein
the corresponding operation performed according to the feedback instruction comprises: starting the first defrosting heating apparatus and the second defrosting heating apparatus, stopping the second defrosting heating apparatus when the temperature of the storage space rises to a fourth preset temperature value, stopping the first defrosting heating apparatus when the temperature of the storage space rises to a fifth preset temperature value, and controlling the high-temperature-level evaporation portion according to the temperature in the storage space to perform the conventional refrigeration mode; and the fifth preset temperature value is higher than the fourth preset temperature value.

13. The defrosting control method for the refrigerator according to claim 9, wherein during the conventional

refrigeration mode, a corresponding conventional defrosting program can be performed.

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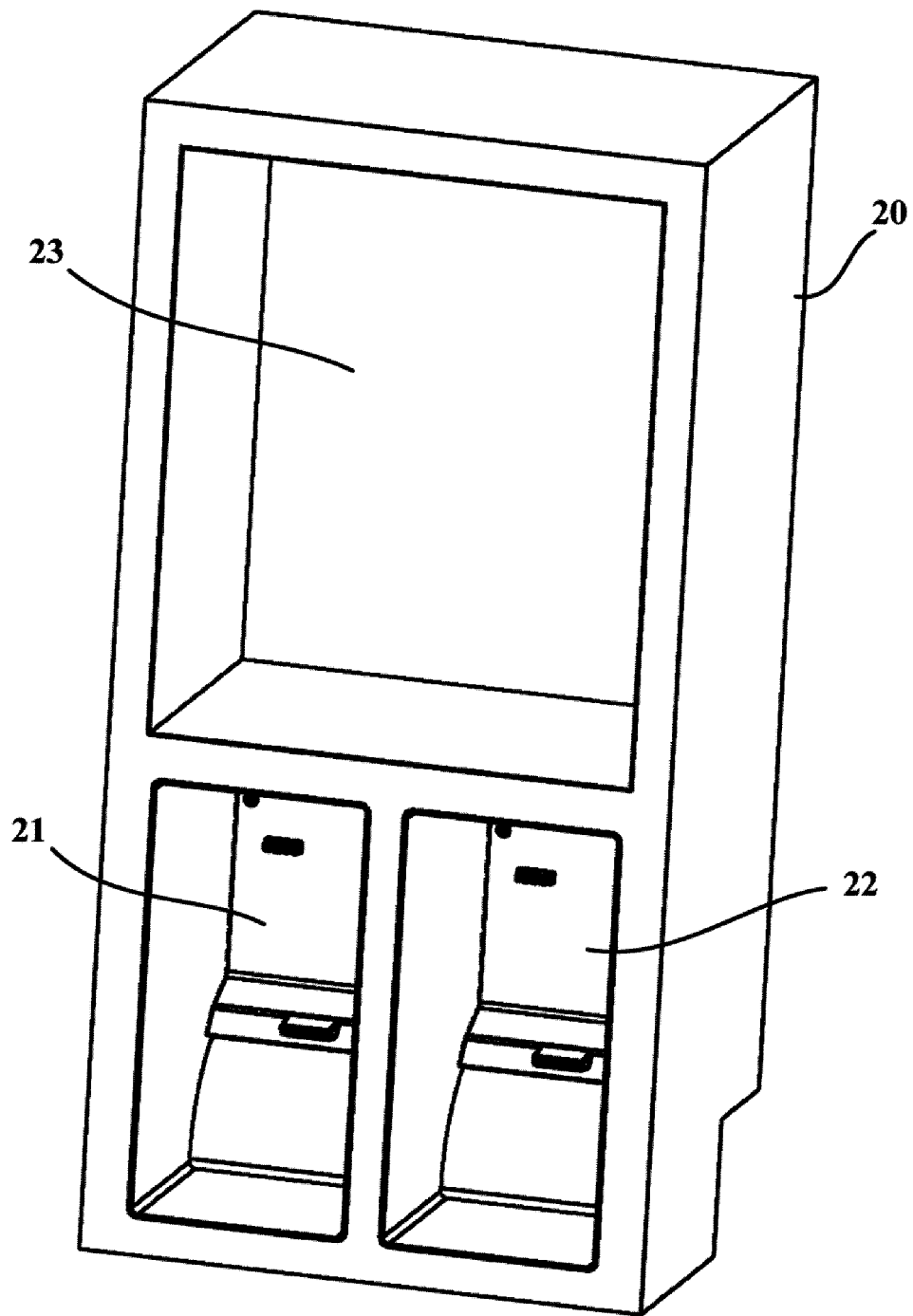


Fig. 1

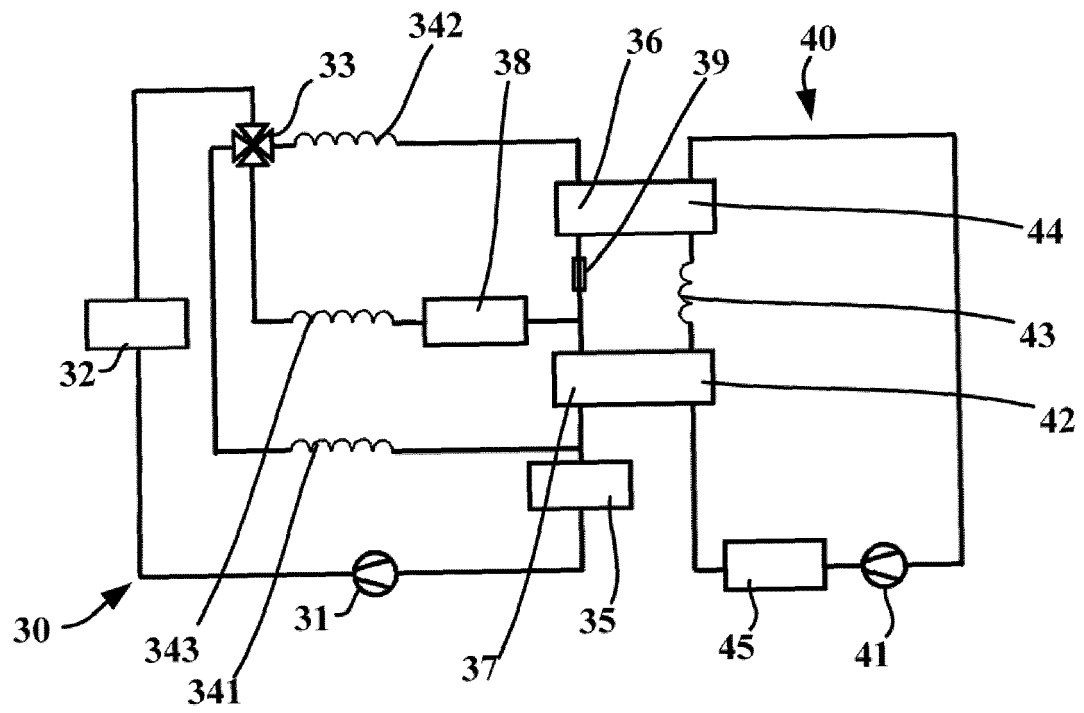


Fig. 2

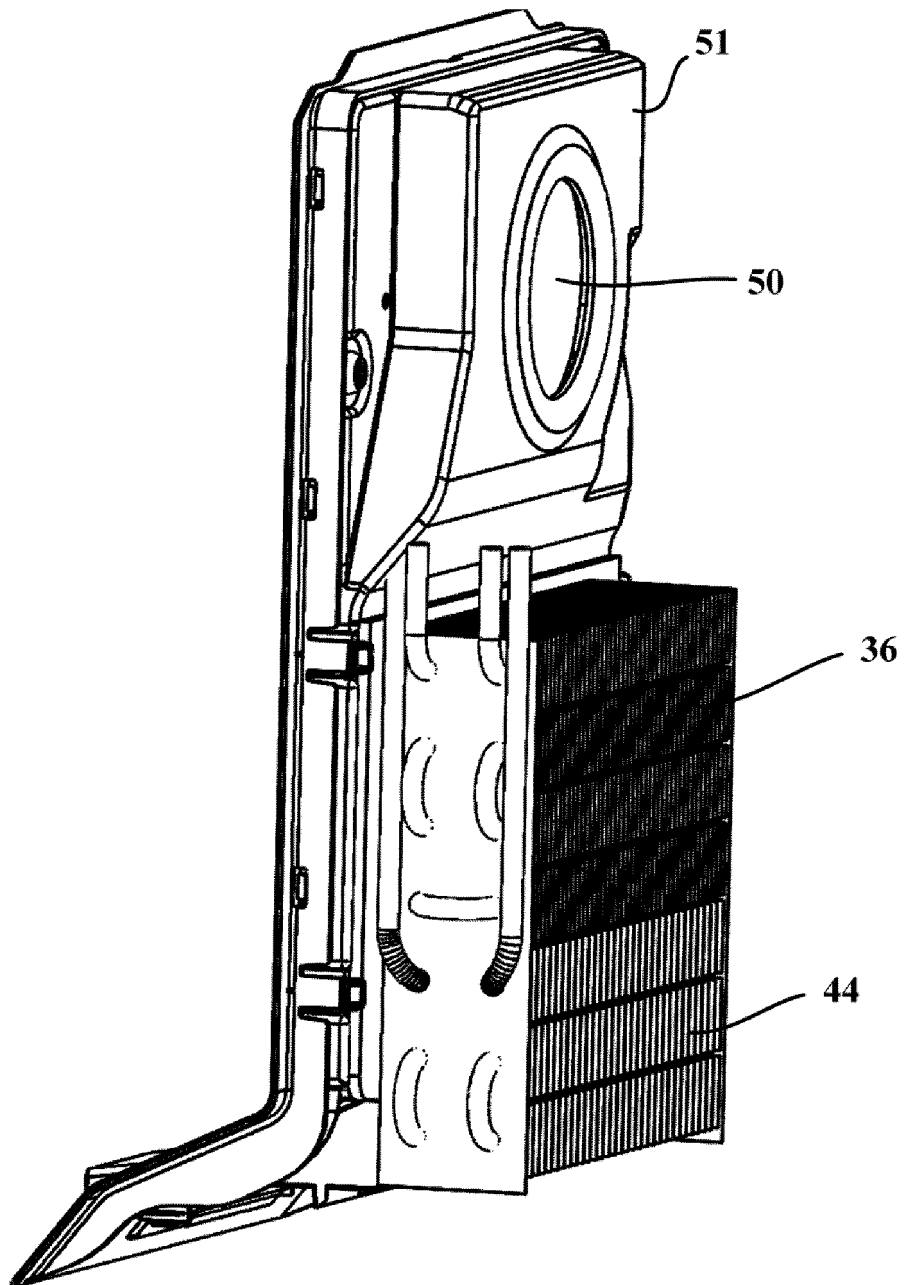


Fig. 3

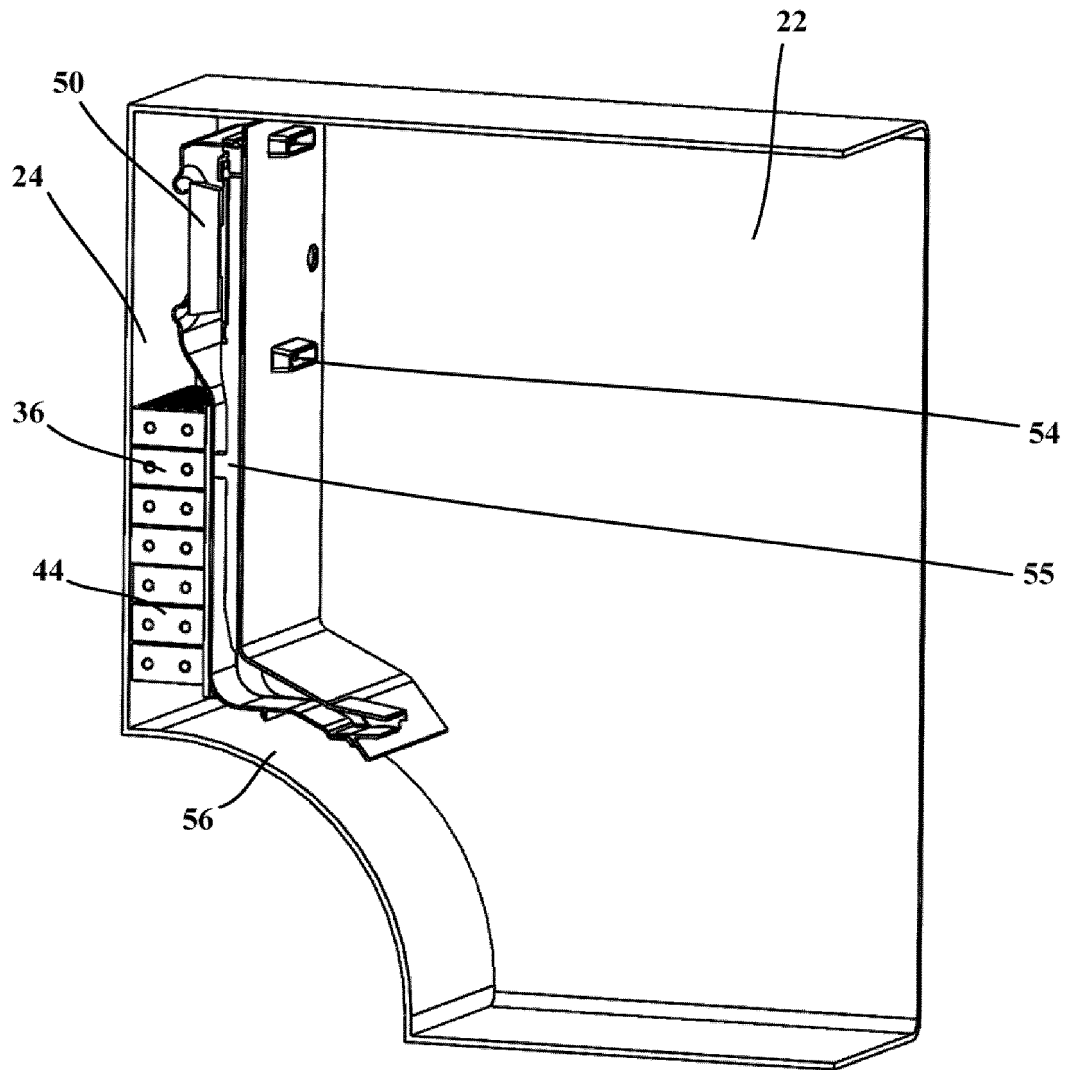


Fig. 4

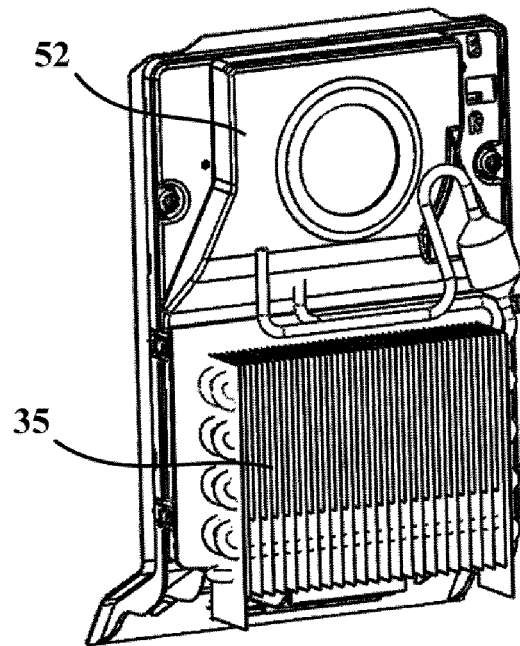


Fig. 5

When a low-temperature-level evaporation portion is operating, measure a temperature in a storage space, and determine whether the temperature of the storage space during a temperature decreasing process reaches a preset temperature range and is maintained within the preset temperature range for a preset duration, wherein the preset temperature range has a first preset temperature value therein

S602

When the temperature of the storage space during the temperature decreasing process reaches the preset temperature range and is maintained within the preset temperature range for the preset duration, start a defrosting program to perform defrosting once, wherein the defrosting program includes a first defrosting program

S604

Fig. 6

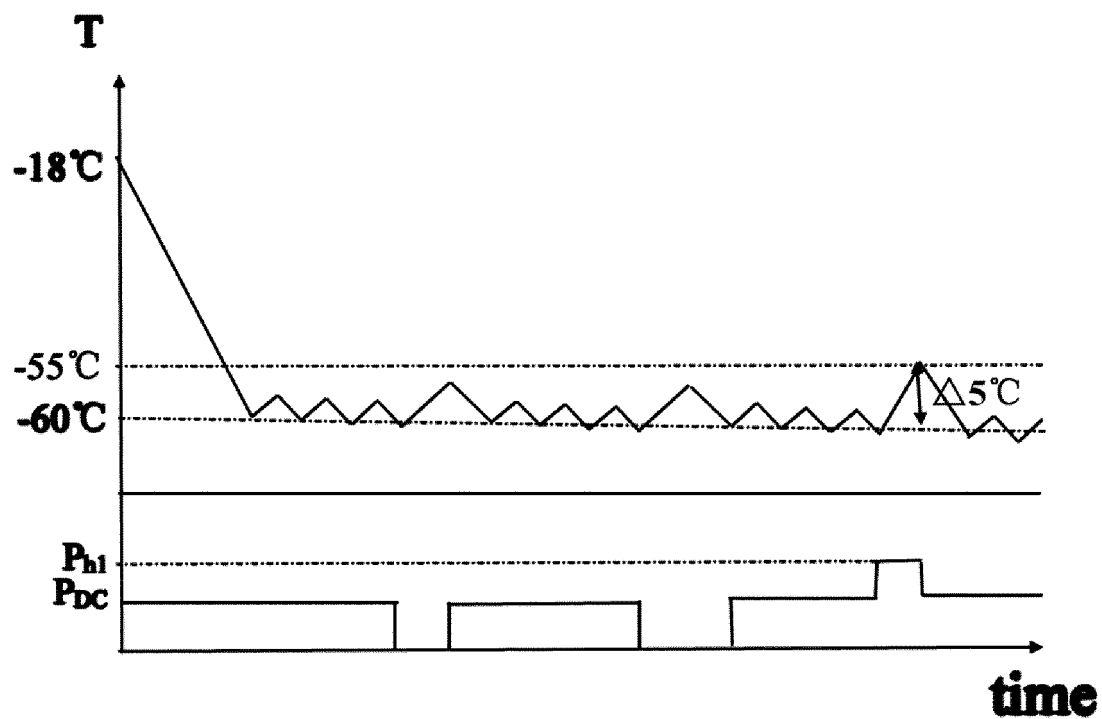


Fig. 7

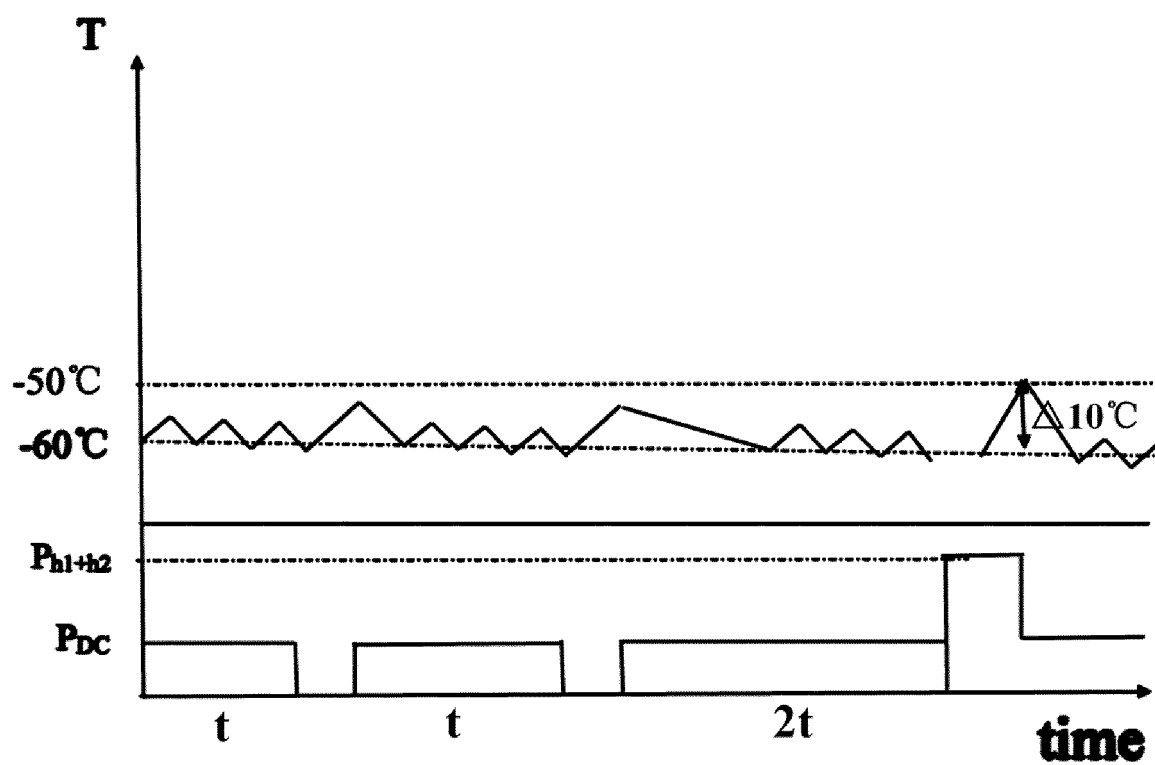


Fig. 8

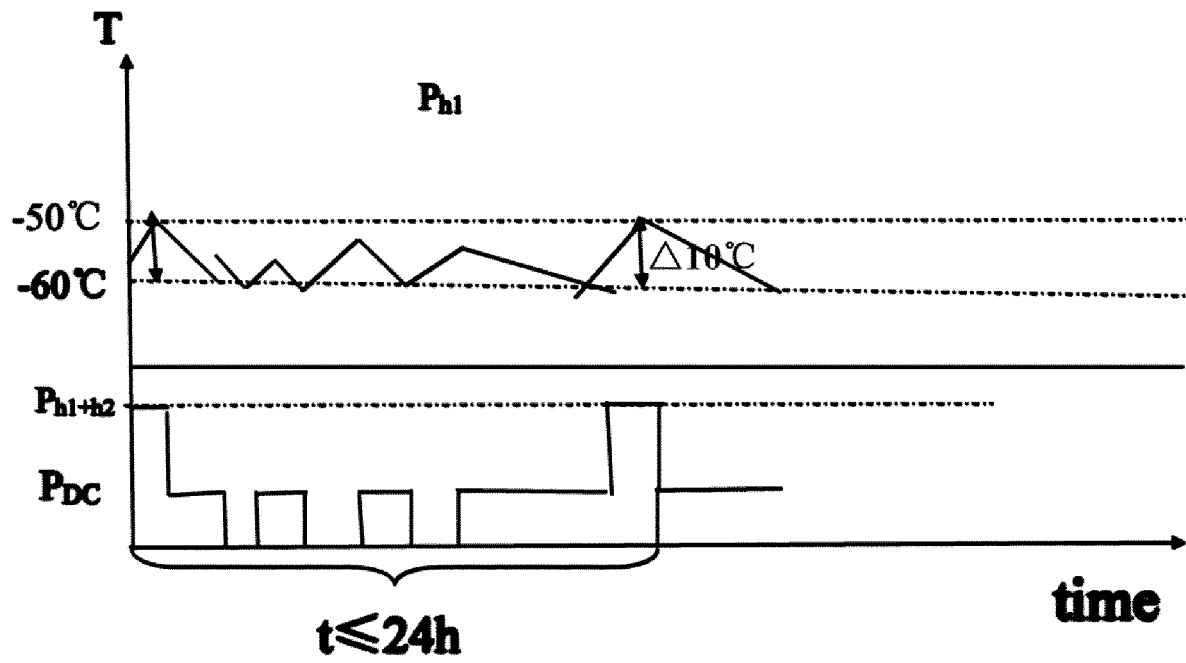


Fig. 9

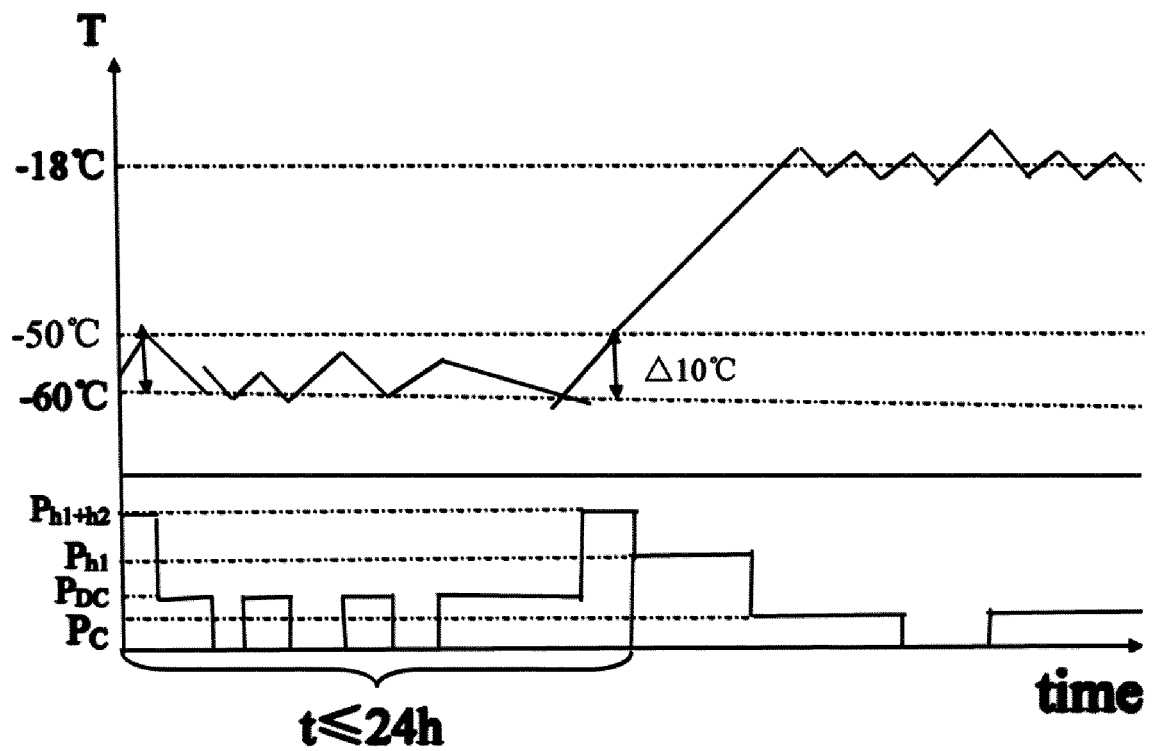


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/078168

A. CLASSIFICATION OF SUBJECT MATTER F25D 21/08(2006.01)i; F25D 29/00(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC	B. FIELDS SEARCHED																		
Minimum documentation searched (classification system followed by classification symbols) F25D	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNTXT, CNABS, CNKI, SIPOABS, DWPI: 冰箱, 化霜, 温度, 预设, 时间, 时长, 差值, 提醒, 报警, refrigerator, defrost, temperature, preset, time, duration, difference, reminder, alarm																			
C. DOCUMENTS CONSIDERED TO BE RELEVANT																			
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>CN 110207453 A (HEFEI MIDEA REFRIGERATOR CO., LTD. et al.) 06 September 2019 (2019-09-06) description, paragraphs [0045]-[0135], and figures 1-9</td> <td>1</td> </tr> <tr> <td>A</td> <td>CN 106766525 A (QINGDAO HAIER CO., LTD.) 31 May 2017 (2017-05-31) entire document</td> <td>1-13</td> </tr> <tr> <td>A</td> <td>CN 104949436 A (HEFEI MIDEA REFRIGERATOR CO., LTD. et al.) 30 September 2015 (2015-09-30) entire document</td> <td>1-13</td> </tr> <tr> <td>A</td> <td>CN 108151424 A (HEFEI MIDEA REFRIGERATOR CO., LTD. et al.) 12 June 2018 (2018-06-12) entire document</td> <td>1-13</td> </tr> <tr> <td>A</td> <td>JP 2015117850 A (TOSHIBA CORP. et al.) 25 June 2015 (2015-06-25) entire document</td> <td>1-13</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	CN 110207453 A (HEFEI MIDEA REFRIGERATOR CO., LTD. et al.) 06 September 2019 (2019-09-06) description, paragraphs [0045]-[0135], and figures 1-9	1	A	CN 106766525 A (QINGDAO HAIER CO., LTD.) 31 May 2017 (2017-05-31) entire document	1-13	A	CN 104949436 A (HEFEI MIDEA REFRIGERATOR CO., LTD. et al.) 30 September 2015 (2015-09-30) entire document	1-13	A	CN 108151424 A (HEFEI MIDEA REFRIGERATOR CO., LTD. et al.) 12 June 2018 (2018-06-12) entire document	1-13	A	JP 2015117850 A (TOSHIBA CORP. et al.) 25 June 2015 (2015-06-25) entire document	1-13	
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A	JP 2015117850 A (TOSHIBA CORP. et al.) 25 June 2015 (2015-06-25) entire document	1-13																	
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Date of the actual completion of the international search 18 May 2021	Date of mailing of the international search report 27 May 2021																		
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088 China Facsimile No. (86-10)62019451	Authorized officer Telephone No.																		

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2021/078168

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 110207453 A	06 September 2019	None	
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