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[続葉有]

**(54) Title**: REFRIGERATOR

**(54) 発明の名称** : 冷蔵庫

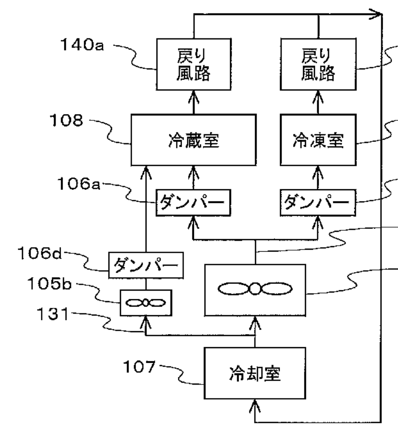


FIG. 1:
106a, 106b, 106d Damper
107 Cooling compartment
108 Refrigerator compartment
109 Freezer compartment
140a, 140b Return air passage

**(57) Abstract**: A refrigerator is provided with: storage compartments; a cooling compartment for generating cooling air for cooling the storage compartments; a primary air passage for connecting the cooling compartment and each of the storage compartments; a primary air blower for delivering cooling air from the cooling compartment to each of the storage compartments through the primary air passage; opening and closing devices each opening and closing the connection between the primary air passage and each of the storage compartments; a secondary air passage provided separately from the primary air passage and connecting the cooling compartment and some of the storage compartments; a secondary air blower for delivering cooling air from the cooling compartment to said some of the storage compartments through the secondary air passage; and a control unit for controlling the operation of the primary air blower, the opening and closing devices, and the secondary air blower.

(57) 要約: 冷蔵庫は、複数の貯蔵室と、複数の貯蔵室を冷却する冷却空気を生成する冷却室と、冷却室と複数の貯蔵室のそれぞれとを連通させるメイン風路と、冷却室から複数の貯蔵室のそれぞれにメイン風路を介して冷却空気を送風するメイン送風機と、メイン風路と複数の貯蔵室のそれぞれとの間を開閉する複数の開閉装置と、メイン風路とは別に設けられ、冷却室と複数の貯蔵室のうちの一部の貯蔵室とを連通させるサブ風路と、冷却室から一部の貯蔵室にサブ風路を介して冷却空気を送風するサブ送風機と、メイン送風機、複数の開閉装置及びサブ送風機の動作を制御する制御部と、を有する。

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# DESCRIPTION

## Title of Invention

REFRIGERATOR

## Technical Field

[0001]

The present invention relates to a refrigerator.

## Background Art

[0002]

Patent Literature 1 discloses a refrigerator configured to perform a first operation in which a fan is driven when a compressor is off, with a freezer compartment damper closed and a refrigerating compartment damper open; and a second operation in which the compressor and the fan are driven after the first operation, with the freezer compartment damper closed and the refrigerating compartment damper open. The refrigerator disclosed in Patent Literature 1 is configured to efficiently cool each of a plurality of storage compartments using a single fan and dampers provided for the respective storage compartments.

[0003]

Patent Literature 2 discloses a refrigerator that includes a cold-air-passage opening and closing device configured to open and close a cold air passage, and fans provided in the vicinity of openings at an edge of the cold air passage on the storage compartment side. In the refrigerator disclosed in Patent Literature 2, the fans are provided for respective storage compartments.

## Citation List

### Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2011-038716

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2006-300346

Summary of Invention

Technical Problem

[0005]

The volume of cooling air blown into a storage compartment of a refrigerator is determined by the point of intersection of a resistance curve determined by pressure loss caused by friction in an air passage and a P-Q characteristic curve representing fan performance. The pressure loss caused by friction is generally proportional to the square of the air volume. Therefore, a pressure loss $\Delta P$ [Pa] in the air passage, an air volume Q [$m^3/s$], and an air passage resistance value $\zeta$ [$kg/m^7$] have a relationship expressed by equation (1). The greater the air passage resistance value $\zeta$, the greater the pressure loss $\Delta P$.

$$\Delta P = \zeta Q^2 \quad \cdots (1)$$

[0006]

Fig. 9 shows resistance curves and a P-Q characteristic curve. In Fig. 9, a solid curve represents a P-Q characteristic curve of a fan, and a short-dashed curve and a dashed-dotted curve each represent an air passage resistance curve. As shown in Fig. 9, an increase in air passage resistance value $\zeta$ means an increase in pressure loss $\Delta P$, which means an increase in the slope of the resistance curve. Thus, the point of intersection of the resistance curve and the P-Q characteristic curve is moved to the low air volume side, and the air volume is reduced.

[0007]

Fig. 10 is a block diagram illustrating a schematic configuration of air passages in the refrigerator described in Patent Literature 1. When a plurality of storage compartments are cooled by a single fan as illustrated in Fig. 10, the total air volume is determined by the point of intersection of the P-Q characteristic curve of the fan and the resistance curve that takes into account the air passage resistance value $\zeta_{all}$ of all the air passages. When the air passage resistance values of return air passages extending from the respective storage compartments to a cooling chamber are expressed as $\zeta_1$, $\zeta_2$, ..., and $\zeta_n$, the air passage resistance value $\zeta_{all}$ of all the air passages can be calculated as in equation (2), as the return air passages are connected in parallel. Note that n represents the number of return air passages from the respective storage compartments. As in equation (2), the air passage resistance value $\zeta_{all}$ of all the air passages is smaller than each of the air passage resistance values $\zeta_1$, $\zeta_2$, ..., and $\zeta_n$ of the respective return air passages.

$$\frac{1}{\zeta_{all}} = \left( \frac{1}{\sqrt{\zeta_1}} + \frac{1}{\sqrt{\zeta_2}} + \cdots + \frac{1}{\sqrt{\zeta_n}} \right)^2 \quad \cdots (2)$$

[0008]

For example, assume that there are two storage compartments (a freezer compartment and a refrigerating compartment). Generally, the freezer compartment, which needs to be kept at a lower temperature than the refrigerating compartment, requires a larger volume of cooling air. Therefore, the air passage resistance value of the return air passage from the freezer compartment is designed to be smaller than the air passage resistance value of the return air passage from the refrigerating compartment. If the air passage resistance value $\zeta_1$ of the return air passage from the freezer compartment is 10 and the air passage resistance value $\zeta_2$ of the return air passage from the refrigerating compartment is 1000, the air passage resistance value $\zeta_{all}$ of these air passages is 8.26.

[0009]

Fig. 11 shows resistance curves, a P-Q characteristic curve, and a fan efficiency curve. As shown in Fig. 11, in the above-described case ($\zeta_{all}$ = 8.26), the fan can be operated at a high fan efficiency point, and hence a large volume of cooling air can be efficiently blown. The total volume of cooling air efficiently blown by the single fan is distributed to each storage compartment in accordance with the resistance ratio of the return air passages. For example, the volume of cooling air blown into the freezer compartment ($\zeta_1$ = 10) is 0.91(= $(8.26/10)^{0.5}$) times the total air volume.

[0010]

However, the volume of cooling air required for each storage compartment varies depending on the difference between the outside air temperature and the storage compartment temperature. This is because the amount of heat transferred from outside the refrigerator into the storage compartment varies depending on the difference between the outside air temperature and the storage compartment temperature. The temperature in the refrigerating compartment ranges from about 1 to 5 degrees C, and the temperature in the freezer compartment is about -18 degrees C. Therefore, the volume of cooling air needs to be regulated for each storage compartment. When the number of fans is one, the volume of cooling air blown into each storage compartment is regulated by controlling the opening degree of a damper in the middle of the corresponding air passage to regulate the air passage resistance ratio of the air passages. However, regulating the air volume using the damper increases the air passage resistance and hence decreases the total air volume. To maintain the total air volume, it is necessary to increase the rotation speed of the fan. This results in an increased input to the fan.

[0011]

Fig. 12 is a block diagram illustrating a schematic configuration of air passages in the refrigerator described in Patent Literature 2. As illustrated in Fig. 12, when each storage compartment is provided with a fan, the air volume ratio of the storage compartments can be regulated using the rotation speed of each fan. In this case, unlike the case of regulating the air volume ratio using the damper as described above, the air volume ratio can be regulated without changing the air passage resistance value. This allows efficient operation of the fans. On the other hand, the air passage resistance value of a return air passage from each storage compartment to the cooling chamber varies depending on the storage compartment. For example, as in the example described above, the air passage resistance value of the return air passage from the refrigerating compartment is greater than or equal to 100 times the air passage resistance value of the return air passage from the freezer compartment. This means that in the configuration illustrated in Fig. 12, the operating point of the fan for the refrigerating compartment is in a lower air volume region than the operating point of the fan for the freezer compartment. Therefore, particularly when a large volume of cooling air is blown into the refrigerating compartment having a large air passage resistance value, the operation suffers low fan efficiency.

[0012]

The present invention has been made to solve the problems described above. An object of the present invention is to provide a refrigerator that can efficiently operate fans and achieve energy saving.

Solution to Problem

[0013]

A refrigerator of an embodiment of the present invention includes a plurality of storage compartments; a cooling chamber configured to generate cooling air for cooling the plurality of storage compartments; a primary air passage configured to communicate between the cooling chamber and each of the plurality of storage compartments; a primary fan configured to blow the cooling air, through the primary air passage, from the cooling chamber to each of the plurality of storage compartments; a plurality of opening and closing devices configured to open and close between the primary air passage and each of the plurality of storage compartments; a secondary air passage provided separately from the primary air passage and configured to communicate between the cooling chamber and one of the plurality of storage compartments; a secondary fan configured to blow the cooling air, through the secondary air passage, from the cooling chamber to the one of the plurality of storage compartments; and a controller configured to control actions of the primary fan, the plurality of opening and closing devices, and the secondary fan.

Advantageous Effects of Invention

[0014]

In an embodiment of the present invention, by switching between an operation using only the primary fan and another operation using both the primary fan and the secondary fan, each of the fans can be driven at a high fan efficiency point. Thus, since the fans can operate efficiently, energy saving in the refrigerator can be achieved.

Brief Description of Drawings

[0015]

[Fig. 1] Fig. 1 is a block diagram illustrating a basic configuration of air passages in a refrigerator according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a cross-sectional view illustrating a schematic configuration of a refrigerator according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a block diagram illustrating a schematic configuration of air passages in the refrigerator illustrated in Fig. 2.

[Fig. 4] Fig. 4 is a block diagram illustrating a configuration of a controller in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 5] Fig. 5 is a flowchart illustrating a mode determining flow executed by the controller in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 6] Fig. 6 is a flowchart illustrating a rapid-cooling operation control flow executed by the controller in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 7] Fig. 7 is a flowchart illustrating a stable operation control flow executed by the controller in the refrigerator according to Embodiment 1 of the present invention.

[Fig. 8] Fig. 8 is a block diagram illustrating a schematic configuration of air passages in a refrigerator according to a modification of Embodiment 1 of the present invention.

[Fig. 9] Fig. 9 shows resistance curves and a P-Q characteristic curve.

[Fig. 10] Fig. 10 is a block diagram illustrating a schematic configuration of air passages in a refrigerator described in Patent Literature 1.

[Fig. 11] Fig. 11 shows resistance curves, a P-Q characteristic curve, and a fan efficiency curve.

[Fig. 12] Fig. 12 is a block diagram illustrating a schematic configuration of air passages in a refrigerator described in Patent Literature 2.

Description of Embodiments

[0016]

Embodiment 1

A refrigerator according to Embodiment 1 of the present invention will be described. First, a basic configuration of Embodiment 1 will be described. Fig. 1 is a block diagram illustrating a basic configuration of air passages in the refrigerator according to Embodiment 1. As illustrated in Fig. 1, the refrigerator according to Embodiment 1 includes a plurality of storage compartments (a refrigerating compartment 108 and a freezer compartment 109 in the present example), and a cooling chamber 107 configured to generate cooling air for cooling the refrigerating compartment 108 and the freezer compartment 109. The cooling chamber 107 communicates with each of the refrigerating compartment 108 and the freezer compartment 109 through a primary air passage 130. The primary air passage 130 is provided with a single primary fan 105a configured to blow cooling air, through the primary air passage 130, from the cooling chamber 107 to each of the refrigerating compartment 108 and the freezer compartment 109. On the downstream side of the primary fan 105a, the primary air passage 130 is provided with a plurality of dampers 106a and 106b (opening and closing devices) configured to open and close between the primary air passage 130 and the refrigerating compartment 108 and the freezer compartment 109, respectively. The primary fan 105a and the dampers 106a and 106b are configured to operate under control of a controller (not shown in Fig. 1).

[0017]

The cooling chamber 107 communicates with a part (the refrigerating compartment 108 in the present example) of the plurality of storage compartments through a secondary air passage 131 provided separately from the primary air passage 130. The secondary air passage 131 is provided with a secondary fan 105b configured to blow cooling air, through the secondary air passage 131, from the cooling chamber 107 to the refrigerating compartment 108. The secondary air passage 131 is also provided with a damper 106d (disposed downstream of the secondary fan 105b in the present example) configured to open and close between the secondary air passage 131 and the refrigerating compartment 108. The secondary fan 105b and the damper 106d are configured to operate under control of the controller (not shown in Fig. 1). The secondary air passage 131 may be provided with a backflow preventing mechanism (e.g., check valve) instead of the damper 106d. The backflow preventing mechanism is configured to allow the flow of air from the cooling chamber 107 toward the refrigerating compartment 108, and block the flow of air from the refrigerating compartment 108 toward the cooling chamber 107.

[0018]

The refrigerating compartment 108 and the freezer compartment 109 communicate through return air passages 140a and 140b, respectively, with the cooling chamber 107. The cooling air blown into the refrigerating compartment 108 is returned through the return air passage 140a to the cooling chamber 107, whereas the cooling air blown into the freezer compartment 109 is returned through the return air passage 140b to the cooling chamber 107.

[0019]

As described below, the controller of the refrigerator according to Embodiment 1 is capable of executing at least two operation modes. In a first operation mode, the controller opens the dampers 106a and 106b, closes the damper 106d, drives the primary fan 105a, and stops the secondary fan 105b. Thus, cooling air is blown into the refrigerating compartment 108 and the freezer compartment 109 by the primary fan 105a. On the other hand, in a second operation mode, the controller opens the dampers 106b and 106d, closes the damper 106a, and drives the primary fan 105a and the secondary fan 105b. Thus, cooling air is blown into the freezer compartment 109 by the primary fan 105a, and blown into the refrigerating compartment 108 by the secondary fan 105b.

[0020]

A refrigerator according to Embodiment 1 will now be specifically described. Fig. 2 is a cross-sectional view illustrating a schematic configuration of the refrigerator according to Embodiment 1. Embodiment 1 illustrates a configuration in which a secondary air passage is provided between a cooling chamber and a refrigerating compartment, and is provided with a secondary fan for the refrigerating compartment. In the following drawings including Fig. 2, the dimensional relationships among, and the shapes of, components may differ from actual ones.

[0021]

As illustrated in Fig. 2, the refrigerator includes a heat insulating housing 101 open at the front thereof and having a storage space formed therein. The heat insulating housing 101 includes an outer box made of steel, an inner box made of resin, and an insulating material charged in the space between the outer box and the inner box. The storage space formed in the heat insulating housing 101 is divided into a plurality of storage compartments by one or more partitions formed of an insulating material. As the plurality of storage compartments, the refrigerator of the present example includes a refrigerating compartment 8 at the top, a freezer compartment 9 in the middle, and a vegetable compartment 10 at the bottom. The refrigerating compartment 8 has, for example, a swinging door 8a at the front opening. The freezer compartment 9 and the vegetable compartment 10 have, for example, drawer-type doors 9a and 10a, respectively, at the front opening.

[0022]

The refrigerator further includes a cooling chamber 7 configured to generate cooling air for cooling each storage compartment, and a machine chamber 11 disposed outside all the storage compartments and the cooling chamber 7.

[0023]

The machine chamber 11 contains a compressor 1 with a variable rotation speed, a condenser 2, and a pressure reducing device 3. The cooling chamber 7 contains an evaporator 4 (cooler). The compressor 1, the condenser 2, the pressure reducing device 3, and the evaporator 4 are sequentially connected through a refrigerant pipe to form a refrigeration cycle. In the cooling chamber 7, cooling air is generated by exchanging heat with a refrigerant in the evaporator 4. The cooling chamber 7 communicates with each of the storage compartments through an air passage (described below).

[0024]

Fig. 3 is a block diagram illustrating a schematic configuration of air passages in the refrigerator illustrated in Fig. 2. As illustrated in Fig. 3, the cooling chamber 7 communicates with each of the storage compartments (the refrigerating compartment 8, the freezer compartment 9, and the vegetable compartment 10) through a primary air passage 30 (primary air blowing passage). The primary air passage 30 is provided with a single primary fan 5a configured to blow cooling air, through the primary air passage 30, from the cooling chamber 7 to each of the refrigerating compartment 8, the freezer compartment 9, and the vegetable compartment 10. On the downstream side of the primary fan 5a, the primary air passage 30 is provided with a damper 6a (an opening and closing device) configured to open and close between the primary air passage 30 and the refrigerating compartment 8, a damper 6b (an opening and closing device) configured to open and close between the primary air passage 30 and the freezer compartment 9, and a damper 6c (an opening and closing device) configured to open and close between the primary air passage 30 and the vegetable compartment 10. The dampers 6a, 6b, and 6c each have a plate-like member that can open and close and is capable of closing the air passage. The dampers 6a, 6b, and 6c are each capable of fully closing and fully opening the air passage. The dampers 6a, 6b, and 6c may each be capable of regulating the opening degree of the air passage. The primary fan 5a and the dampers 6a, 6b, and 6c are configured to operate under control of a controller 50 (see Fig. 4).

[0025]

The cooling chamber 7 and the refrigerating compartment 8 communicate with each other through a secondary air passage 31 (secondary air blowing passage) provided separately from the primary air passage 30. The secondary air passage 31 is provided with a secondary fan 5b (fan for the refrigerating compartment) configured to blow cooling air, through the secondary air passage 31, from the cooling chamber 7 to the refrigerating compartment 8. The secondary fan 5b is a fan smaller in size than the primary fan 5a. For example, blades of the secondary fan 5b are smaller than blades of the primary fan 5a. In the secondary air passage 31, the secondary fan 5b is disposed away from the cooling chamber 7 and closer to the refrigerating compartment 8 (see Fig. 2). For example, a distance along the air passage between the secondary fan 5b and the cooling chamber 7 (e.g., the evaporator 4) is longer than a distance along the air passage between the secondary fan 5b and the refrigerating compartment 8 (e.g., an air outlet through which cooling air from the secondary air passage 31 is blown out into the refrigerating compartment 8). At the same time, a distance along the air passage between the secondary fan 5b and the cooling chamber 7 is longer than a distance along the air passage between the primary fan 5a and the cooling chamber 7. Thus, the secondary fan 5b is disposed in a higher temperature environment than the primary fan 5a.

[0026]

The secondary air passage 31 is also provided with a damper 6d configured to open and close between the secondary air passage 31 and the refrigerating compartment 8. The damper 6d may be disposed downstream of the secondary fan 5b as illustrated in Fig. 3, or may be disposed upstream of the secondary fan 5b as illustrated in Fig. 2. The damper 6d is provided to block the flow of air from the refrigerating compartment 8 toward the secondary air passage 31. The secondary fan 5b and the damper 6d are configured to operate under control of the controller 50 (see Fig. 4).

[0027]

The refrigerating compartment 8, the freezer compartment 9, and the vegetable compartment 10 communicate through return air passages 40a, 40b, and 40c, respectively, with the cooling chamber 7. The cooling air blown into the refrigerating compartment 8 is returned through the return air passage 40a to the cooling chamber 7, the cooling air blown into the freezer compartment 9 is returned through the return air passage 40b to the cooling chamber 7, and the cooling air blown into the vegetable compartment 10 is returned through the return air passage 40c to the cooling chamber 7.

[0028]

With reference to Fig. 2, the flow of refrigerant in the refrigeration cycle according to Embodiment 1 will be described. A high-temperature high-pressure gas refrigerant discharged from the compressor 1 flows through the condenser 2 (air heat exchanger) or a copper pipe disposed along the outer wall of the refrigerator. The refrigerant in the condenser 2 or copper pipe dissipates heat to the outside air therearound and is condensed. The condensed high-pressure liquid refrigerant is reduced in pressure by the pressure reducing device 3 and turns into a low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant flows into the evaporator 4 in the cooling chamber 7. After flowing into the evaporator 4, the refrigerant removes heat from air in the cooling chamber 7 and turns into a low-pressure gas refrigerant. The air in the cooling chamber 7 from which heat has been removed by the refrigerant is cooled and turns into cooling air. The low-pressure gas refrigerant flowing out of the evaporator 4 is suctioned into the compressor 1 and compressed again.

[0029]

With reference to Figs. 2 and 3, a general flow of cooling air in Embodiment 1 will be described. The cooling air cooled in the cooling chamber 7 is conveyed by a fan (the primary fan 5a or the secondary fan 5b), passes through the air passage connected to each storage compartment, and is blown into the storage compartment. The interior of each storage compartment is cooled by the cooling air that has been blown into the storage compartment. The volume of cooling air is regulated, for example, by varying the rotation speed of the fan. The temperature in each storage compartment is thus regulated. After cooling each storage compartment, the cooling air is returned through the corresponding return air passage to the cooling chamber 7, where it is cooled again.

[0030]

With reference to Fig. 2, sensors in Embodiment 1 will be described. Each storage compartment includes a sensor that detects a temperature therein. A temperature sensor 21 that detects the inside temperature of the refrigerating compartment 8 is disposed in the refrigerating compartment 8, a temperature sensor 22 that detects the inside temperature of the freezer compartment 9 is disposed in the freezer compartment 9, and a temperature sensor 23 that detects the inside temperature of the vegetable compartment 10 is disposed in the vegetable compartment 10. A temperature sensor 24 that detects a refrigerant evaporating temperature is disposed in a refrigerant outlet pipe from the evaporator 4. A temperature sensor 25 that detects the temperature of air (primary-side air) suctioned by the primary fan 5a is disposed between the cooling chamber 7 and the primary fan 5a (i.e., disposed downstream of the evaporator 4 and upstream of the primary fan 5a in the air flow). These temperature sensors 21 to 25 are each configured to output a detection signal to the controller 50. The locations of the temperature sensors 21, 22, and 23 are not limited to those shown in Fig. 2. The temperature sensors 21, 22, and 23 may each be disposed at any location at which the temperature in the corresponding storage compartment can be represented. The temperature sensor 24 may be disposed at any location around the evaporator 4 as long as the refrigerant evaporating temperature can be represented. The temperature sensor 24 may be omitted, and a refrigerant saturation temperature determined from a detection value of a pressure sensor disposed around the evaporator 4 may be treated as the refrigerant evaporating temperature. The temperature sensor 25 may be disposed at any location at which the temperature of air between the cooling chamber 7 and the primary fan 5a can be represented.

[0031]

A door open/close sensor 26 that detects the opening and closing of the door 8a is disposed at an open end of the refrigerating compartment 8. A door open/close sensor 27 that detects the opening and closing of the door 9a is disposed at an open end of the freezer compartment 9. A door open/close sensor 28 that detects the opening and closing of the door 10a is disposed at an open end of the vegetable compartment 10. These door open/close sensors 26, 27, and 28 are each configured to output a detection signal to the controller 50.

[0032]

Fig. 4 is a block diagram illustrating a configuration of the controller 50 according to Embodiment 1. For example, the controller 50 has a microcomputer including a CPU, a storage unit, an input/output unit, and a timer. As illustrated in Fig. 4, the controller 50 is connected to the temperature sensors 21 to 25, the door open/close sensors 26 to 28, the compressor 1, the primary fan 5a, the secondary fan 5b, and the dampers 6a, 6b, 6c, and 6d. The controller 50 controls the rotation speeds of the primary fan 5a and the secondary fan 5b on the basis of detection signals from the temperature sensors 21 to 25. The controller 50 determines the operation mode on the basis of detection signals from the temperature sensors 21 to 25 and the door open/close sensors 26 to 28. Then, on the basis of the determination, the controller 50 controls not only the rotation speeds of the primary fan 5a and the secondary fan 5b, but also the opening and closing of the dampers 6a, 6b, 6c, and 6d.

[0033]

The refrigerator according to Embodiment 1 can execute at least two operation modes under control of the controller 50. A first operation mode is a rapid-cooling operation mode. The rapid-cooling operation mode is an operation mode executed, for example, immediately after opening and closing of a refrigerator door, or immediately after the refrigerator is powered on. The rapid-cooling operation mode involves increasing the cooling capacity to decrease the temperature inside the refrigerator. A second operation mode is a stable operation mode. The stable operation mode is an operation mode executed when a predetermined period of time elapses after the start of the rapid-cooling operation mode and the temperature in each storage compartment reaches the vicinity of a set temperature. The stable operation mode involves regulating the rotation speed of the compressor and the rotation speed of the fan to maintain the temperature in each storage compartment at the set temperature.

[0034]

A mode determining flow for determining which of the rapid-cooling operation mode and the stable operation mode is to be executed will now be described. Fig. 5 is a flowchart illustrating a mode determining flow executed by the controller 50. The mode determining flow is started immediately after power-on and executed repeatedly at predetermined time intervals.

[0035]

As illustrated in Fig. 5, in step S101 of the mode determining flow, it is determined whether the refrigerator has just been powered on (step S101). This determination is made, for example, by determining whether the value of a timer that counts the time elapsed from power-on is less than or equal to a predetermined value. If it is determined that the refrigerator has just been powered on, the process proceeds to a rapid-cooling operation control flow. Otherwise, the process proceeds to step S102.

[0036]

In step S102, it is determined whether a door (e.g., one of the doors 8a, 9a, and 10a) has just been opened and closed. This determination is made by determining whether the value of a timer that counts the time elapsed after one of detection signals from the door open/close sensors 26, 27, and 28 has changed from "open" to "closed" is less than or equal to a predetermined value. If it is determined that the door has just been opened and closed, the process proceeds to step S103. Otherwise, the process proceeds to step S104.

[0037]

In step S103, it is determined whether an inside temperature TR of each storage compartment is higher than a set temperature TR_set (TR > TR_set). For example, if the inside temperature TR of at least one of the storage compartments is determined to be higher than the set temperature TR_set, the process proceeds to the rapid-cooling operation control flow. Otherwise, the process proceeds to step S104.

[0038]

In step S104, it is determined whether a defrosting operation has just been completed. This determination is made, for example, by determining whether the value of a timer that counts the time elapsed from completion of a defrosting operation is less than or equal to a predetermined value. If it is determined that the defrosting operation has just been completed, the process proceeds to the rapid-cooling operation control flow. Otherwise, the process proceeds to a stable operation control flow, as the inside temperature TR of every storage compartment is determined to be around the corresponding set temperature TR_set.

[0039]

The rapid-cooling operation control flow will now be described. The rapid-cooling operation control flow involves cooling all the storage compartments using a single fan (primary fan 5a), thereby allowing the fan to operate at a high fan efficiency point. Fig. 6 is a flowchart illustrating a rapid-cooling operation control flow executed by the controller 50. As illustrated in Fig. 6, in the rapid-cooling operation control flow, the dampers 6a, 6b, and 6c on the side of the primary fan 5a are opened (step S201), and the damper 6d on the side of a fan for each storage compartment (i.e., the secondary fan 5b for the refrigerating compartment 8 in the present example) is closed (step S202). Closing the damper 6d prevents backflow of cooling air from the refrigerating compartment 8 to the cooling chamber 7. The primary fan 5a is driven, and the secondary fan 5b is stopped.

[0040]

Next, the rotation speed of the primary fan 5a is changed (step S203). The rotation speed of the primary fan 5a is controlled, for example, such that a difference between the suction temperature of the primary fan 5a detected by the temperature sensor 25 and the refrigerant evaporating temperature detected by the temperature sensor 24 becomes closer to a certain value (e.g., 5K). Since this control allows effective use of the evaporator 4 (cooler), energy saving can be achieved.

[0041]

The rotation speed of the compressor 1 may be changed (step S204). The rotation speed of the compressor 1 is controlled, for example, such that a difference between a set temperature of a storage compartment with the lowest temperature in the refrigerator (i.e., the freezer compartment 9 in the present example) and the refrigerant evaporating temperature detected by the temperature sensor 24 becomes closer to a certain value (e.g., 5K). Since this control allows the compressor 1 to operate at a minimum rotation speed required, it is possible to achieve energy saving.

[0042]

After the operation described above, if the inside temperatures of the storage compartments (the refrigerating compartment 8 and the vegetable compartment 10 in the present example), other than that of the storage compartment having the lowest set temperature and requiring cooling air the most (i.e., the freezer compartment 9 in the present example), fall below their set temperatures (YES in step S205), the dampers 6a and 6c on the side of the primary fan 5a corresponding to the storage compartments are closed (step

S206). For example, if the inside temperature of the refrigerating compartment 8 falls below the set temperature, the damper 6a is closed to prevent excessive cooling of the refrigerating compartment 8.

[0043]

After repeating the process from step S203 to step S206 (step S207), if the dampers 6a and 6c for the storage compartments, other than the storage compartment having the lowest set temperature and requiring cooling air the most (the freezer compartment 9 in the present example), are both closed (YES in step S207), the rapid-cooling operation control flow is terminated and the process proceeds to the mode determining flow.

[0044]

Since the freezer compartment 9 having the lowest set temperature requires a large amount of cooling air, the air passage resistance value of the return air passage 40b is set at a small value. Therefore, by blowing cooling air into the freezer compartment 9 and the other storage compartments at the same time, the single primary fan 5a can be used at a high fan efficiency point.

[0045]

The stable operation control flow will now be described. Fig. 7 is a flowchart illustrating a stable operation control flow executed by the controller 50. The stable operation control flow involves using a plurality of fans (the primary fan 5a and the secondary fan 5b) to blow a minimum volume of cooling air required, thereby achieving efficient operation. In the present example, the refrigerating compartment 8 is cooled by using the secondary fan 5b for the refrigerating compartment, and the freezer compartment 9 is cooled by using the primary fan 5a. Thus, as illustrated in Fig. 7, the damper 6b for the freezer compartment 9 on the side of the primary fan 5a and the damper 6d on the side of the fan for each storage compartment (i.e., the secondary fan 5b for the refrigerating compartment 8 in the present example) are opened, and the damper 6a for the refrigerating compartment 8 on the side of the primary fan 5a is closed (steps S301, S302, and S303). Also, the primary fan 5a and the secondary fan 5b are driven.

[0046]

The rotation speed of the primary fan 5a may be controlled, for example, such that a difference between the suction temperature of the primary fan 5a detected by the temperature sensor 25 and the refrigerant evaporating temperature detected by the temperature sensor 24 becomes closer to a certain value (e.g., 5K) (step S304). Since this control allows effective use of the evaporator 4 (cooler), energy saving can be achieved.

[0047]

The rotation speed of the compressor 1 may be controlled, for example, such that a difference between a set temperature of a storage compartment with the lowest temperature in the refrigerator (i.e., the freezer compartment 9 in the present example) and the refrigerant evaporating temperature detected by the temperature sensor 24 becomes closer to a certain value (e.g., 5K) (step S305). Since this control allows the compressor 1 to operate at a minimum rotation speed required, it is possible to achieve energy saving.

[0048]

The rotation speed of the secondary fan 5b may be controlled such that the inside temperature of a storage compartment to be cooled (i.e., the inside temperature of the refrigerating compartment 8 detected by the temperature sensor 21 in the present example) becomes closer to the set temperature of the storage compartment to be cooled (i.e., the set temperature of the refrigerating compartment 8 in the present example) (step S306). Since this control allows effective use of the evaporator 4 (cooler), energy saving can be achieved.

[0049]

The inside temperature of a storage compartment (the vegetable compartment 10 in the present example) provided with no fan (secondary fan) for the storage compartment, other than the freezer compartment 9, is regulated by opening and closing the damper 6c on the side of the primary fan 5a such that the inside temperature becomes closer to a set temperature. That is, if the inside temperature of the vegetable compartment 10 is lower than the set temperature (YES in step S307), the damper 6c on the side of the primary fan 5a corresponding to the vegetable compartment 10 is closed (step S308). This prevents excessive cooling of the vegetable compartment 10. On the other hand, if the inside temperature of the vegetable compartment 10 is higher than the set temperature (YES in step S309), the damper 6c is opened (step S310). Thus, cooling air can be blown into the vegetable compartment 10 using the primary fan 5a.

[0050]

After completion of the process described above, the stable operation control flow is terminated and the process proceeds to the mode determining flow.

[0051]

As described above, in the rapid-cooling operation control flow that is executed when a large volume of cooling air is required, only one fan (primary fan 5a) is driven. On the other hand, in the stable operation control flow that is executed when a relatively small volume of cooling air is required, a plurality of fans (the primary fan 5a and the secondary fan 5b) are driven. Therefore, in Embodiment 1, the total volume of air in the case of driving only one (primary fan 5a) of the plurality of fans is greater than the total volume of air in the case of driving the plurality of fans (the primary fan 5a and the secondary fan 5b).

[0052]

Embodiment 1 illustrates a configuration in which there is no secondary fan specifically provided for the vegetable compartment 10. This is because since an air passage resistance value $\zeta 3$ of the return air passage 40c from the vegetable compartment 10 is greater than an air passage resistance value $\zeta 1$ of the return air passage 40b from the freezer compartment 9 and an air passage resistance value $\zeta 2$ of the return air passage 40a from the refrigerating compartment 8 ($\zeta 3 > \zeta 2 > \zeta 1$), opening and closing the damper 6c for the vegetable compartment 10 has less impact on the volume of air in the freezer compartment 9. Therefore, in the stable operation control flow described above, the inside temperature of the vegetable compartment 10 is regulated by opening and closing the damper 6c. However, the present invention is not limited to this. A secondary fan for the vegetable compartment 10 may be provided, and the inside temperature of the vegetable compartment 10 may be regulated by controlling the rotation speed of the secondary fan, in a flow similar to that of regulating the inside temperature of the refrigerating compartment 8.

[0053]

Fig. 8 is a block diagram illustrating a schematic configuration of air passages in a refrigerator according to a modification. Unlike the configuration in Fig. 3, the cooling chamber 7 and the vegetable compartment 10 in the present modification communicate with each other through a secondary air passage 32 provided separately from the primary air passage 30. The secondary air passage 32 is provided with a secondary fan 5c (a fan for the vegetable compartment) configured to blow cooling air, through the secondary air passage 32, from the cooling chamber 7 to the vegetable compartment 10. The secondary air passage 32 is also provided with a damper 6e configured to open and close between the secondary air passage 32 and the vegetable compartment 10. The damper 6e is provided to block the flow of air from the vegetable compartment 10 toward the secondary air passage 31.

[0054]

As described above, in Embodiment 1, when all the storage compartments require a large amount of air as in the case of rapid cooling, air is blown using the single primary fan 5a. Since this allows the fan to be driven at a high fan efficiency point, it is possible to efficiently cool each storage compartment while reducing the input to the fan. It is thus possible to provide an energy-saving refrigerator capable of effectively maintaining food quality.

[0055]

During stable operation, the volume of cooling air required for each storage compartment can be individually regulated using the rotation speed of the secondary fan for the storage compartment. It is thus possible to minimize the input to the fan and maintain the temperature of each storage compartment at a constant level. Therefore, it is possible to provide an energy-saving refrigerator capable of effectively maintaining food quality.

[0056]

The volume of cooling air required for the refrigerating compartment 8 is about 1/15 the volume of cooling air required for the freezer compartment 9. Therefore, the secondary fan 5b used in Embodiment 1 is a small fan smaller in size than the primary fan 5a (e.g., a fan with blades smaller in size than those of the primary fan 5a, or a fan with a smaller output than the primary fan 5a). Adopting a small fan can contribute to reduced cost.

[0057]

In Embodiment 1, the secondary fan 5b for the refrigerating compartment 8 is disposed farther from the cooling chamber 7 (e.g., evaporator 4) than the primary fan 5a is. The secondary fan 5b can thus be driven in a higher temperature environment than the primary fan 5a. Driving the secondary fan 5b in a relatively high temperature environment can lower the viscosity at the bearing of the secondary fan 5b, and thus can reduce axial loss. Therefore, the secondary fan 5b can be driven efficiently.

[0058]

As described above, the refrigerator according to Embodiment 1 includes a plurality of storage compartments (e.g., the refrigerating compartment 8, the freezer compartment 9, and the vegetable compartment 10); the cooling chamber 7 configured to generate cooling air for cooling the plurality of storage compartments; the primary air passage 30 configured to communicate between the cooling chamber 7 and each of the plurality of storage compartments; the primary fan 5a configured to blow the cooling air, through the primary air passage 30, from the cooling chamber 7 to each of the plurality of storage compartments; a plurality of opening and closing devices (e.g., the dampers 6a, 6b, and 6c) configured to open and close between the primary air passage 30 and each of the plurality of storage compartments; the secondary air passage 31 provided separately from the primary air passage 30 and configured to communicate between the cooling chamber 7 and a part (e.g., the refrigerating compartment 8) of the plurality of storage compartments; the secondary fan 5b configured to blow the cooling air, through the secondary air passage 31, from the cooling chamber 7 to the part of the plurality of storage compartments; and the controller 50 configured to control actions of the primary fan 5a, the plurality of opening and closing devices, and the secondary fan 5b.

[0059]

In the refrigerator according to Embodiment 1, the controller 50 is capable of executing a first operation mode (rapid-cooling operation mode) in which the plurality of opening and closing devices are opened, the primary fan 5a is driven, the secondary fan 5b is stopped, and cooling air is blown into each of the plurality of storage compartments using the primary fan 5a; and a second operation mode (stable operation mode) in which a part (e.g., the damper 6a) of the plurality of opening and closing devices, the part being configured to open and close between the primary air passage 30 and the part of the plurality of storage compartments, is closed, others (e.g., the dampers 6b and 6c) of the plurality of opening and closing devices, the others being configured to open and close between the primary air passage 30 and others (e.g., the freezer compartment 9 and the vegetable compartment 10) of the plurality of storage compartments, are opened, the primary fan 5a and the secondary fan 5b are driven, and cooling air is blown into the others of the plurality of storage compartments using the primary fan 5a and into the part of the plurality of storage compartments using the secondary fan 5b.

[0060]

In the refrigerator according to Embodiment 1, an air volume of the primary fan 5a in the first operation mode is greater than a total air volume of the primary fan 5a and the secondary fan 5b in the second operation mode.

[0061]

In the refrigerator according to Embodiment 1, in the second operation mode, the controller 50 controls a rotation speed of the secondary fan 5b based on a temperature in the part of the plurality of storage compartments.

[0062]

In the refrigerator according to Embodiment 1, in the second operation mode, the controller 50 controls a rotation speed of the primary fan 5a based on a temperature of air suctioned by the primary fan 5a.

[0063]

In the refrigerator according to Embodiment 1, in the first operation mode, the controller 50 controls a rotation speed of the primary fan 5a based on a temperature of air suctioned by the primary fan 5a.

[0064]

The refrigerator according to Embodiment 1 further includes a refrigeration cycle for generating cooling air in the cooling chamber 7. In the refrigerator, the controller 50 controls a rotation speed of the compressor 1 in the refrigeration cycle such that a refrigerant evaporating temperature in the refrigeration cycle becomes closer to a target evaporating temperature.

[0065]

In the refrigerator according to Embodiment 1, the secondary fan 5b is smaller in size than the primary fan 5a.

[0066]

In the refrigerator according to Embodiment 1, the secondary fan 5b is disposed in a higher temperature environment than the primary fan 5a.

[0067]

In the refrigerator according to Embodiment 1, a distance (e.g., a distance along an air passage) between the secondary fan 5b and the cooling chamber 7 is longer than a distance (e.g., a distance along an air passage) between the primary fan 5a and the cooling chamber 7.

[0068]

Embodiment 1 and the modification described above can be carried out in combination with each other.

Reference Signs List

[0069]

1: compressor, 2: condenser, 3: pressure reducing device, 4: evaporator, 5a, 105a: primary fan, 5b, 5c, 105b: secondary fan, 6a, 6b, 6c, 6d, 6e, 106a, 106b, 106d: damper, 7, 107: cooling chamber, 8, 108: refrigerating compartment, 8a, 9a, 10a: door, 9, 109: freezer compartment, 10: vegetable compartment, 11: machine chamber, 21, 22, 23, 24, 25: temperature sensor, 26, 27, 28: door open/close sensor, 30, 130: primary air passage, 31, 32, 131: secondary air passage, 40a, 40b, 40c, 140a, 140b: return air passage, 50: controller, 101: heat insulating housing

CLAIMS

[Claim 1]

A refrigerator comprising:

a plurality of storage compartments;

a cooling chamber configured to generate cooling air for cooling the plurality of storage compartments;

a primary air passage configured to communicate between the cooling chamber and each of the plurality of storage compartments;

a primary fan configured to blow the cooling air, through the primary air passage, from the cooling chamber to each of the plurality of storage compartments;

a plurality of opening and closing devices configured to open and close between the primary air passage and each of the plurality of storage compartments;

a secondary air passage provided separately from the primary air passage and configured to communicate between the cooling chamber and one of the plurality of storage compartments;

a secondary fan configured to blow the cooling air, through the secondary air passage, from the cooling chamber to the one of the plurality of storage compartments; and

a controller configured to control actions of the primary fan, the plurality of opening and closing devices, and the secondary fan.

[Claim 2]

The refrigerator of claim 1, wherein the controller executes

a first operation mode in which the plurality of opening and closing devices are opened, the primary fan is driven, the secondary fan is stopped, and cooling air is blown into each of the plurality of storage compartments using the primary fan; and

a second operation mode in which one of the plurality of opening and closing devices, the one of the plurality of opening and closing devices being configured to open and close between the primary air passage and the one of the plurality of storage compartments, is closed, an other one of the plurality of opening and closing devices, the other one of the plurality of opening and closing devices being configured to open and close between the primary air passage and an other one of the plurality of storage compartments, are opened, the primary fan and the secondary fan are driven, and cooling air is blown into the other one of the plurality of storage compartments using the primary fan and into the one of the plurality of storage compartments using the secondary fan.

[Claim 3]

The refrigerator of claim 2, wherein an air volume of the primary fan in the first operation mode is greater than a total air volume of the primary fan and the secondary fan in the second operation mode.

[Claim 4]

The refrigerator of claim 2 or 3, wherein in the second operation mode, the controller controls a rotation speed of the secondary fan based on a temperature in the one of the plurality of storage compartments.

[Claim 5]

The refrigerator of any one of claims 2 to 4, wherein in the second operation mode, the controller controls a rotation speed of the primary fan based on a temperature of air suctioned by the primary fan.

[Claim 6]

The refrigerator of any one of claims 2 to 5, wherein in the first operation mode, the controller controls a rotation speed of the primary fan based on a temperature of air suctioned by the primary fan.

[Claim 7]

The refrigerator of any one of claims 1 to 6, further comprising a refrigeration cycle for generating cooling air in the cooling chamber,

wherein the controller controls a rotation speed of a compressor in the refrigeration cycle such that a refrigerant evaporating temperature in the refrigeration cycle becomes closer to a target evaporating temperature.

[Claim 8]

The refrigerator of any one of claims 1 to 7, wherein the secondary fan is smaller in size than the primary fan.

[Claim 9]

The refrigerator of any one of claims 1 to 8, wherein the secondary fan is disposed in a higher temperature environment than the primary fan.

[Claim 10]

The refrigerator of claim 9, wherein a distance between the secondary fan and the cooling chamber is longer than a distance between the primary fan and the cooling chamber.

FIG. 1

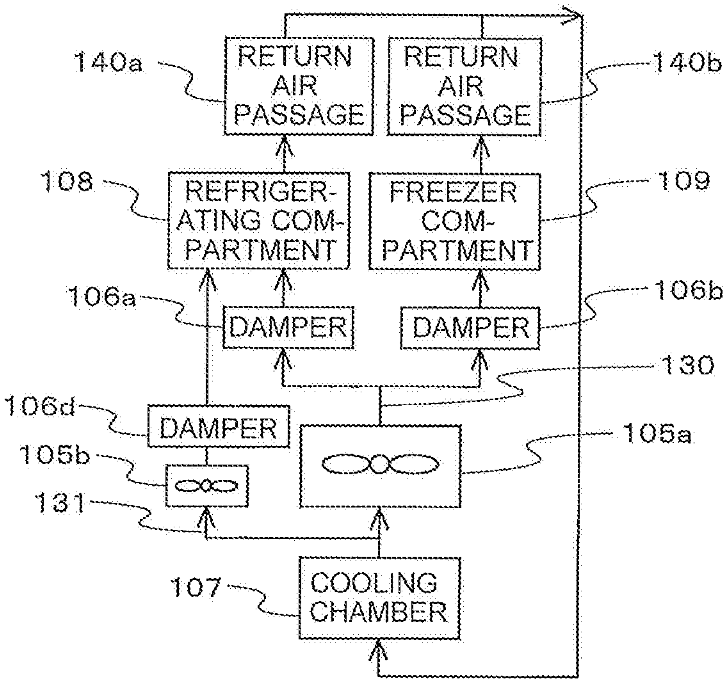

140a
RETURN AIR PASSAGE
RETURN AIR PASSAGE
140b
108
REFRIGERATING COMPARTMENT
FREEZER COMPARTMENT
109
106a
DAMPER
DAMPER
106b
130
106d
DAMPER
105b
105a
131
107
COOLING CHAMBER

FIG. 2

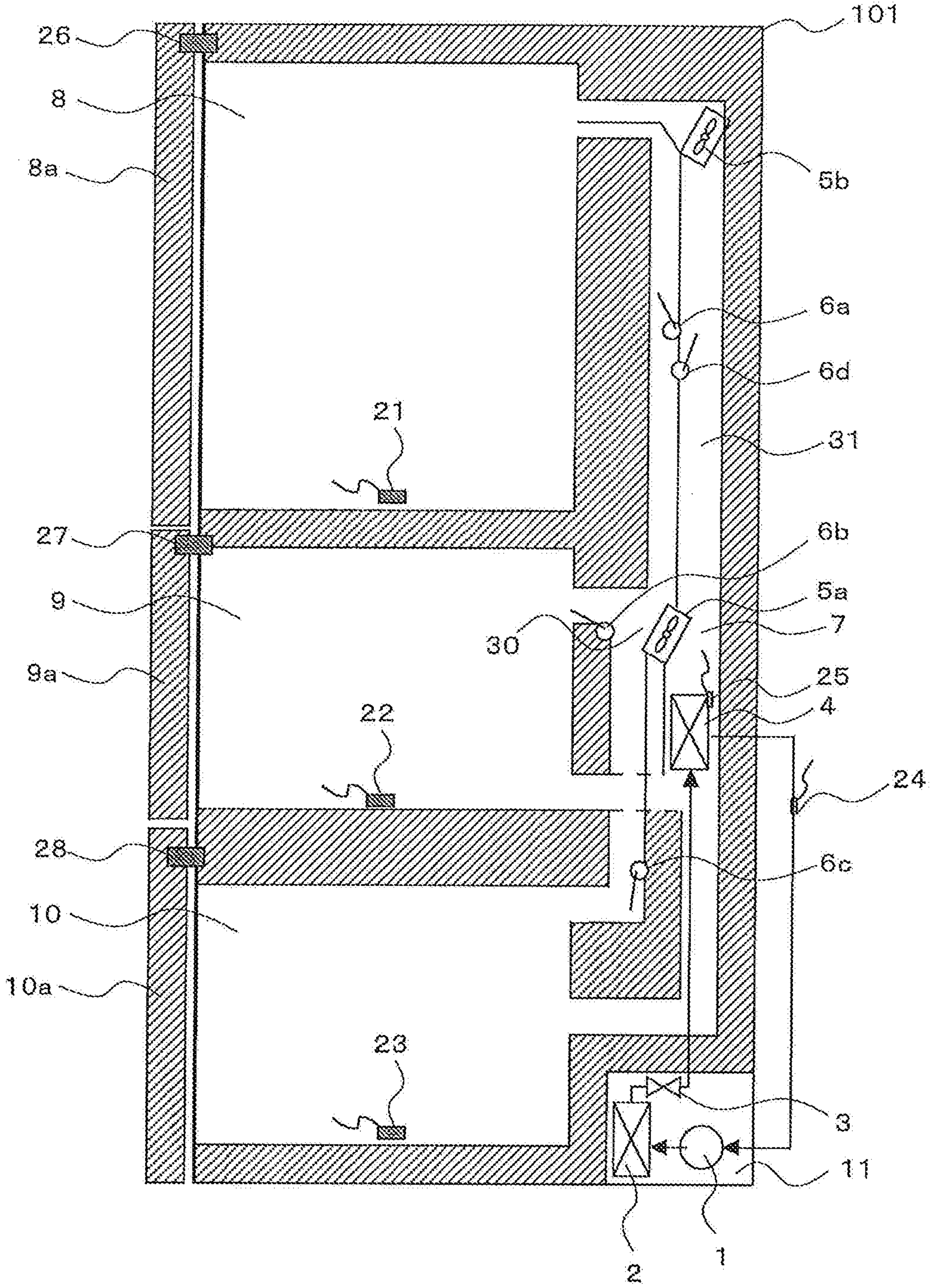

26
101
8
8a
5b
6a
6d
21
31
27
6b
5a
9
30
7
9a
25
4
22
24
28
6c
10
10a
23
3
11
2
1

FIG. 3

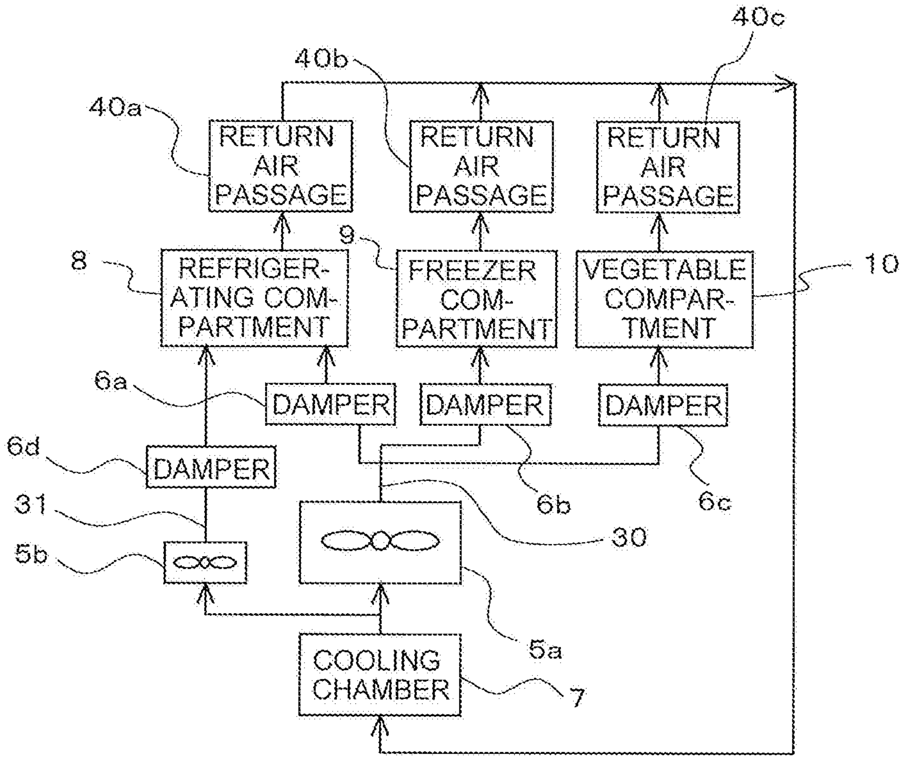

40c
40b
40a
RETURN AIR PASSAGE
RETURN AIR PASSAGE
RETURN AIR PASSAGE
9
8
REFRIGER-ATING COM-PARTMENT
FREEZER COM-PARTMENT
VEGETABLE COMPAR-TMENT
10
6a
DAMPER
DAMPER
DAMPER
6d
DAMPER
6b
6c
31
30
5b
5a
COOLING CHAMBER
7

FIG. 4

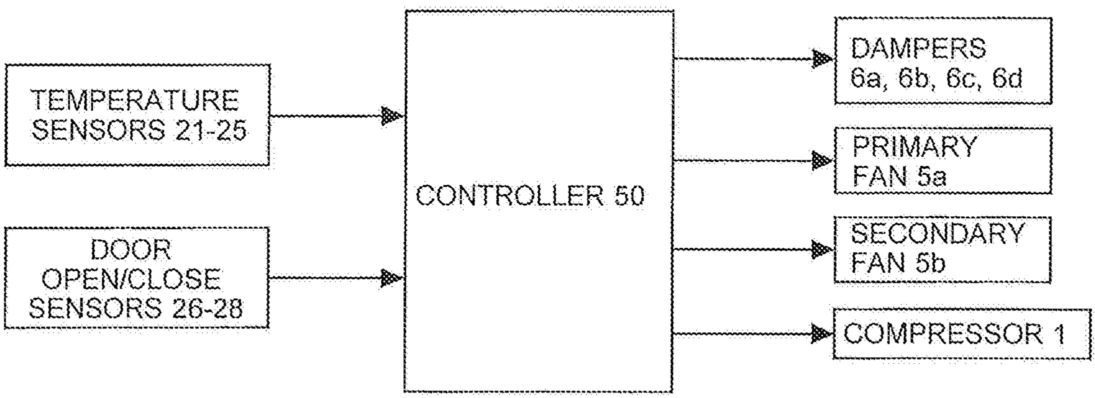

TEMPERATURE SENSORS 21-25
DOOR OPEN/CLOSE SENSORS 26-28
CONTROLLER 50
DAMPERS 6a, 6b, 6c, 6d
PRIMARY FAN 5a
SECONDARY FAN 5b
COMPRESSOR 1

FIG. 5

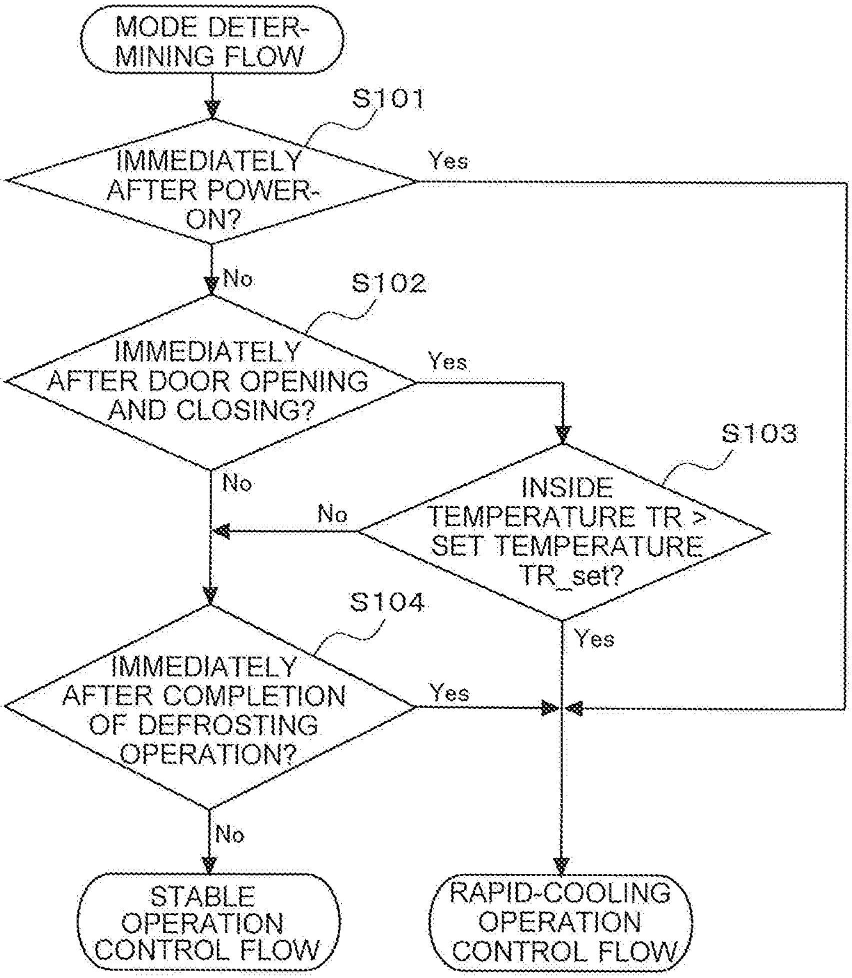

MODE DETER-MINING FLOW
S101
IMMEDIATELY AFTER POWER-ON?
Yes
No
S102
IMMEDIATELY AFTER DOOR OPENING AND CLOSING?
Yes
No
S103
INSIDE TEMPERATURE TR > SET TEMPERATURE TR_set?
No
Yes
S104
IMMEDIATELY AFTER COMPLETION OF DEFROSTING OPERATION?
Yes
No
STABLE OPERATION CONTROL FLOW
RAPID-COOLING OPERATION CONTROL FLOW

FIG. 6

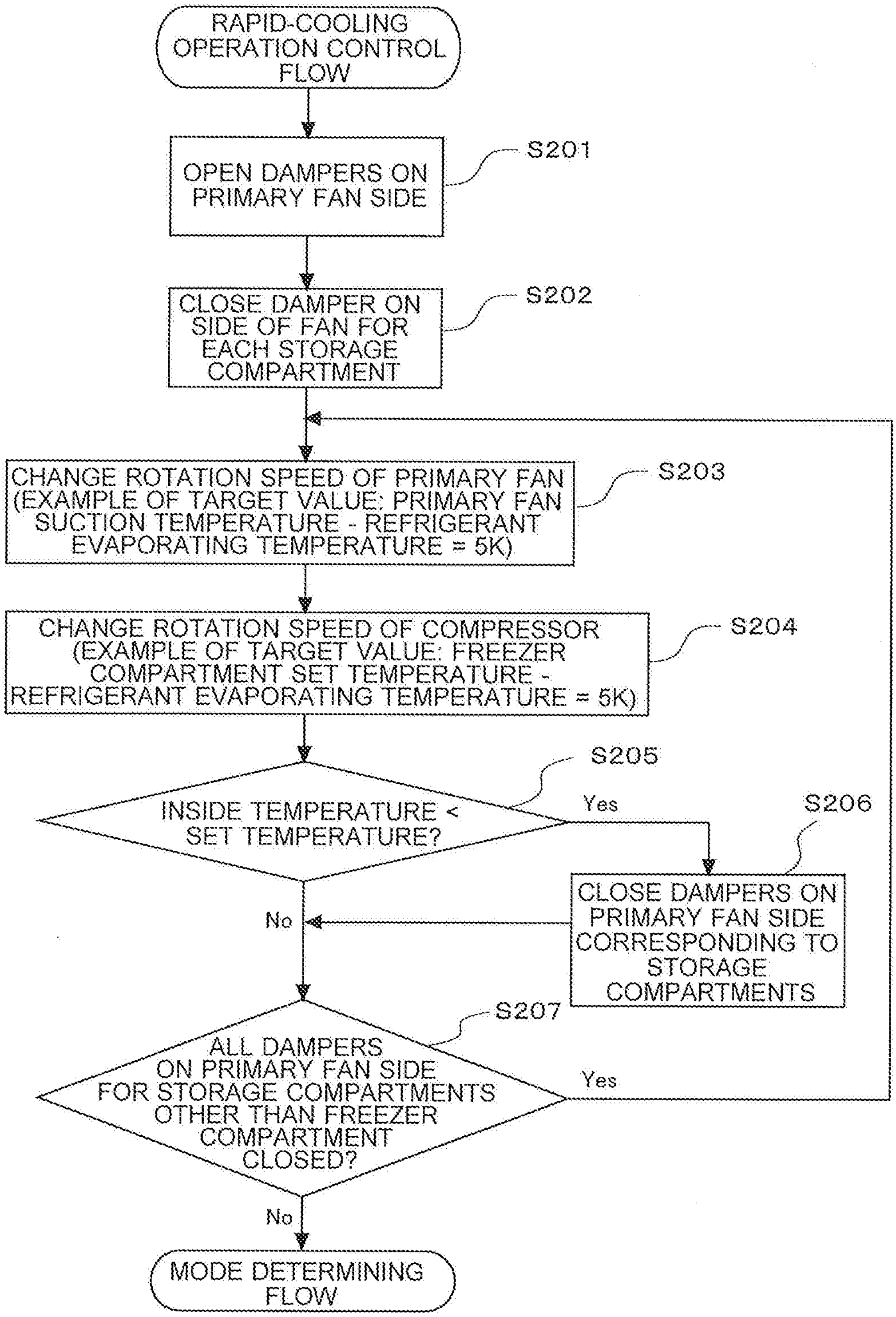
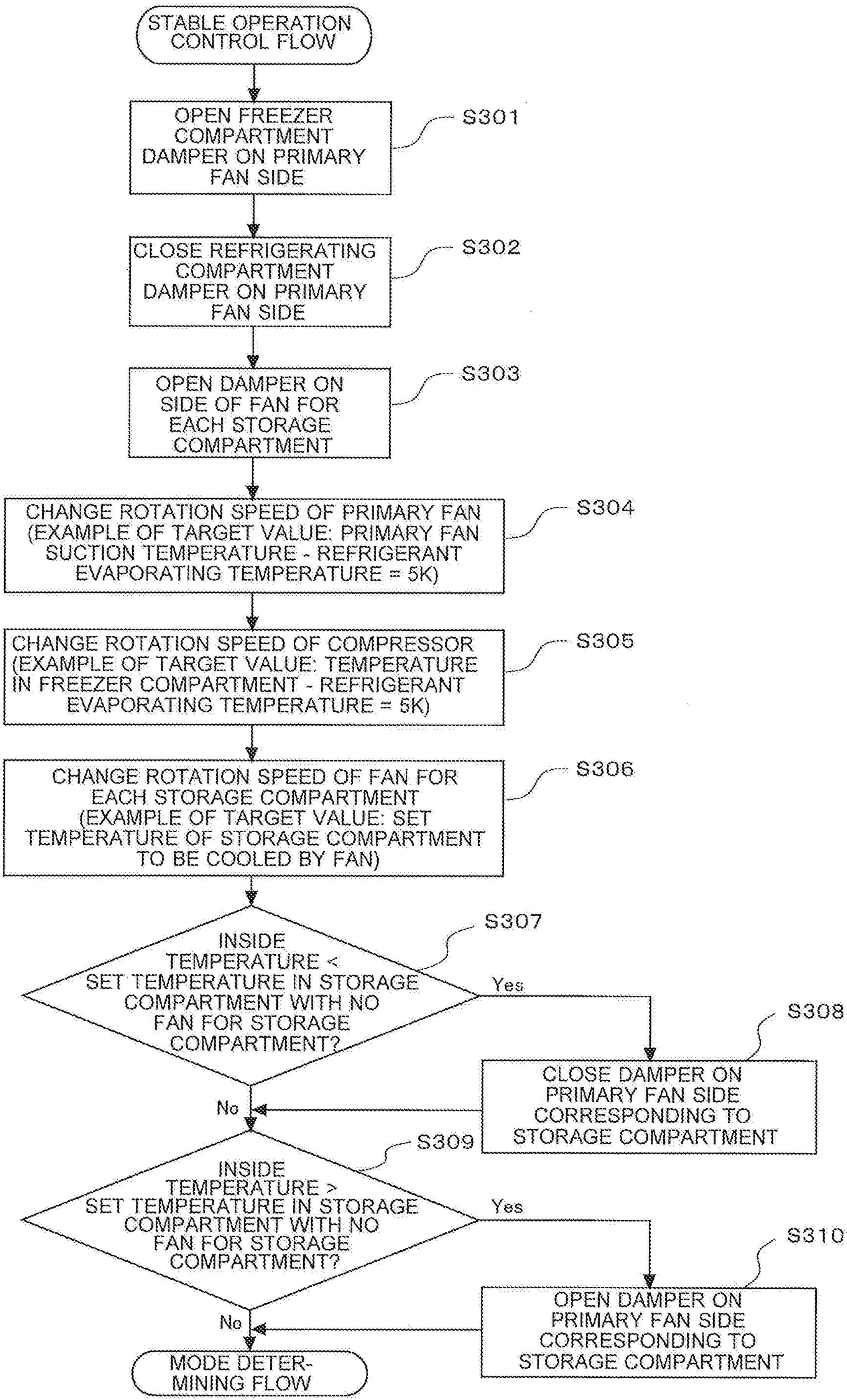

RAPID-COOLING OPERATION CONTROL FLOW
OPEN DAMPERS ON PRIMARY FAN SIDE
S201
CLOSE DAMPER ON SIDE OF FAN FOR EACH STORAGE COMPARTMENT
S202
CHANGE ROTATION SPEED OF PRIMARY FAN (EXAMPLE OF TARGET VALUE: PRIMARY FAN SUCTION TEMPERATURE - REFRIGERANT EVAPORATING TEMPERATURE = 5K)
S203
CHANGE ROTATION SPEED OF COMPRESSOR (EXAMPLE OF TARGET VALUE: FREEZER COMPARTMENT SET TEMPERATURE - REFRIGERANT EVAPORATING TEMPERATURE = 5K)
S204
INSIDE TEMPERATURE < SET TEMPERATURE?
S205
Yes
S206
CLOSE DAMPERS ON PRIMARY FAN SIDE CORRESPONDING TO STORAGE COMPARTMENTS
No
ALL DAMPERS ON PRIMARY FAN SIDE FOR STORAGE COMPARTMENTS OTHER THAN FREEZER COMPARTMENT CLOSED?
S207
Yes
No
MODE DETERMINING FLOW

FIG. 7



STABLE OPERATION CONTROL FLOW
OPEN FREEZER COMPARTMENT DAMPER ON PRIMARY FAN SIDE
S301
CLOSE REFRIGERATING COMPARTMENT DAMPER ON PRIMARY FAN SIDE
S302
OPEN DAMPER ON SIDE OF FAN FOR EACH STORAGE COMPARTMENT
S303
CHANGE ROTATION SPEED OF PRIMARY FAN (EXAMPLE OF TARGET VALUE: PRIMARY FAN SUCTION TEMPERATURE - REFRIGERANT EVAPORATING TEMPERATURE = 5K)
S304
CHANGE ROTATION SPEED OF COMPRESSOR (EXAMPLE OF TARGET VALUE: TEMPERATURE IN FREEZER COMPARTMENT - REFRIGERANT EVAPORATING TEMPERATURE = 5K)
S305
CHANGE ROTATION SPEED OF FAN FOR EACH STORAGE COMPARTMENT (EXAMPLE OF TARGET VALUE: SET TEMPERATURE OF STORAGE COMPARTMENT TO BE COOLED BY FAN)
S306
INSIDE TEMPERATURE < SET TEMPERATURE IN STORAGE COMPARTMENT WITH NO FAN FOR STORAGE COMPARTMENT?
S307
Yes
CLOSE DAMPER ON PRIMARY FAN SIDE CORRESPONDING TO STORAGE COMPARTMENT
S308
No
INSIDE TEMPERATURE > SET TEMPERATURE IN STORAGE COMPARTMENT WITH NO FAN FOR STORAGE COMPARTMENT?
S309
Yes
OPEN DAMPER ON PRIMARY FAN SIDE CORRESPONDING TO STORAGE COMPARTMENT
S310
No
MODE DETER-MINING FLOW

FIG. 8

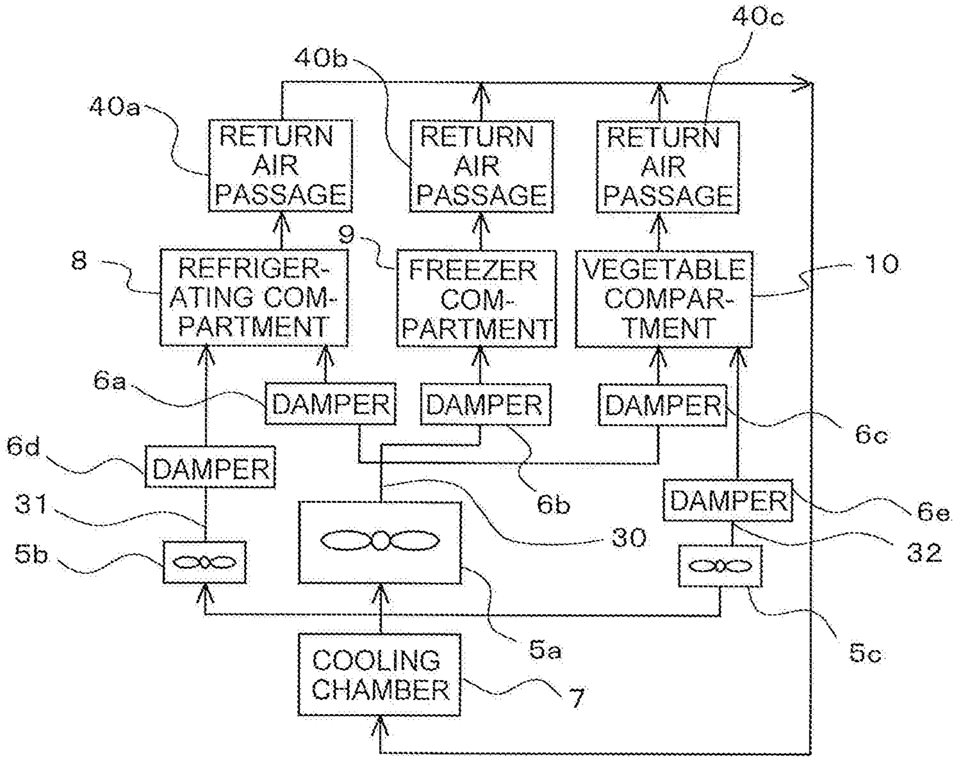

40c
40b
40a
RETURN AIR PASSAGE
RETURN AIR PASSAGE
RETURN AIR PASSAGE
8
9
REFRIGER-ATING COM-PARTMENT
FREEZER COM-PARTMENT
VEGETABLE COMPAR-TMENT
10
6a
DAMPER
DAMPER
DAMPER
6c
6d
DAMPER
6b
31
DAMPER
6e
30
5b
32
5a
5c
COOLING CHAMBER
7

FIG. 9

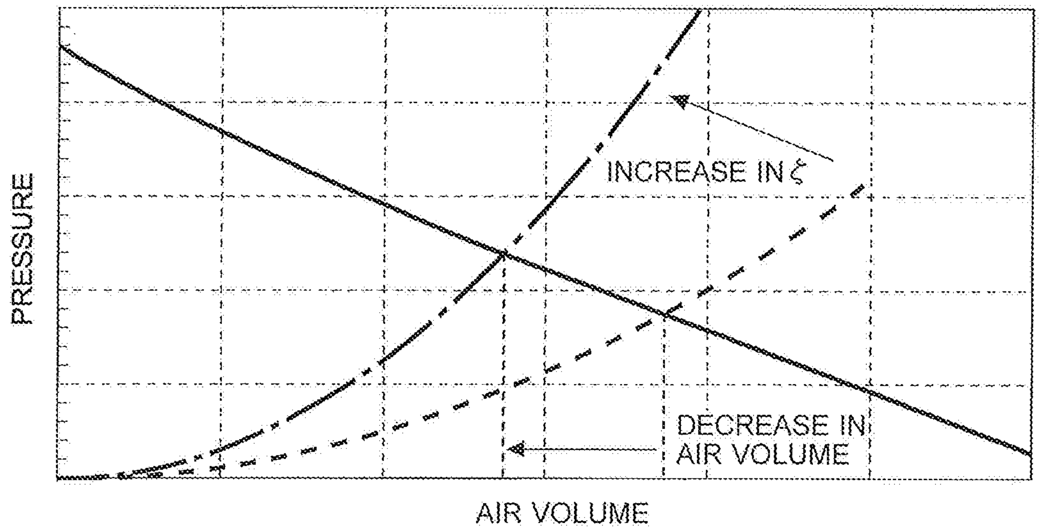

PRESSURE
INCREASE IN ζ
DECREASE IN AIR VOLUME
AIR VOLUME

FIG. 10

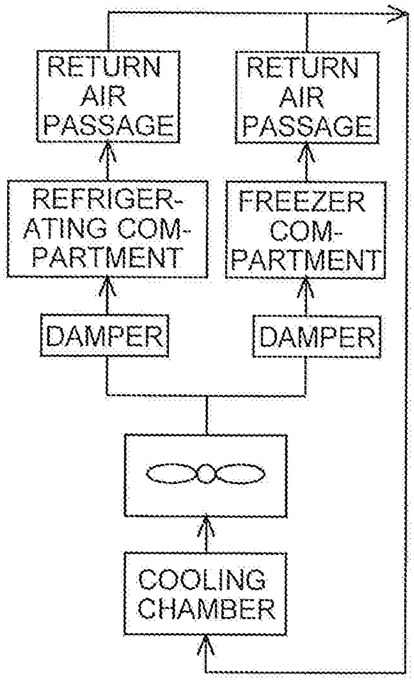

RETURN AIR PASSAGE
RETURN AIR PASSAGE
REFRIGERATING COMPARTMENT
FREEZER COMPARTMENT
DAMPER
DAMPER
COOLING CHAMBER

FIG. 11

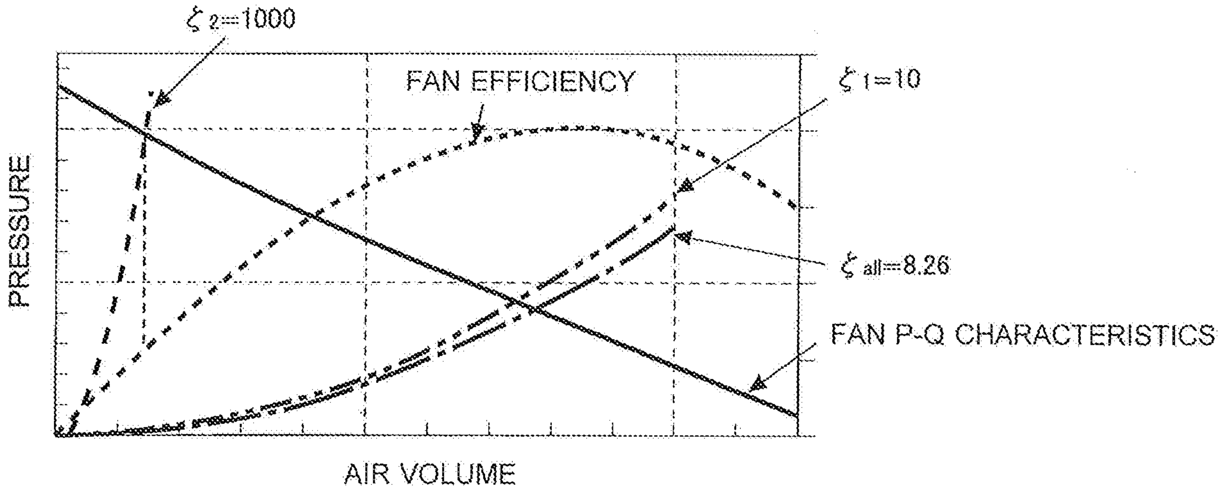
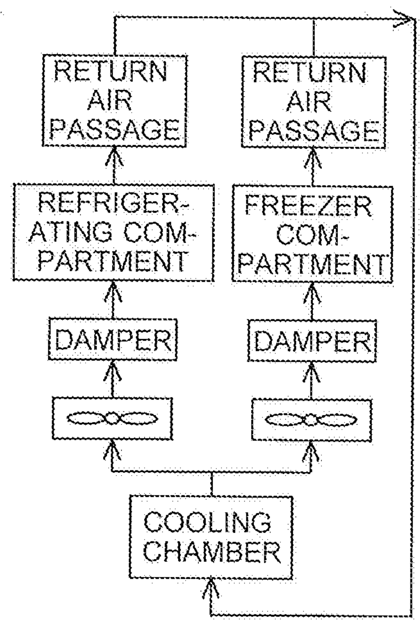

ζ2=1000
FAN EFFICIENCY
ζ1=10
ζall=8.26
FAN P-Q CHARACTERISTICS
PRESSURE
AIR VOLUME

FIG. 12


RETURN AIR PASSAGE
RETURN AIR PASSAGE
REFRIGER-ATING COM-PARTMENT
FREEZER COM-PARTMENT
DAMPER
DAMPER
COOLING CHAMBER