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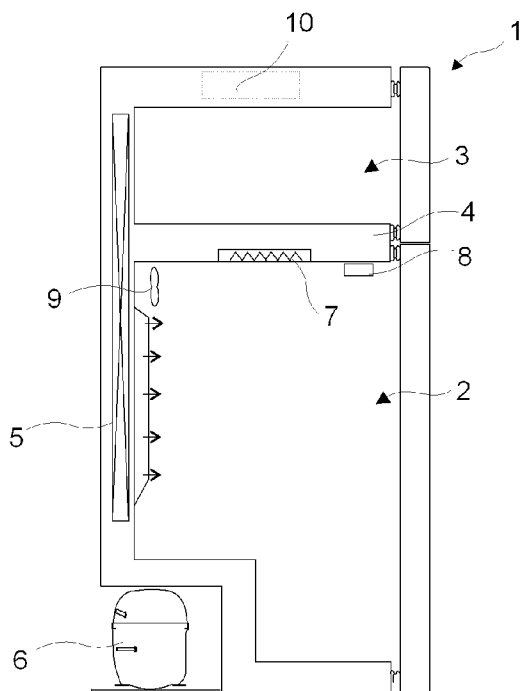
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(54) Title: A REFRIGERATOR OPERATING INDEPENDENTLY OF THE AMBIENT TEMPERATURE

Figure 1



(57) Abstract: The present invention relates to a cooling device (1) comprising at least one cooling compartment (2); at least one freezing compartment (3); an insulative intermediate wall (4) that separates the compartments (2 and 3) from each other; at least one evaporator (5) that provides the cooling of the air circulated in the compartments (2 and 3); a compressor (6) that compresses the refrigerant passing through the evaporator (5) and circulates in the refrigeration cycle; a heater (7) that heats the cooling compartment (2) in order that it can maintain the desired temperature, a sensor (8) that measures the cooling compartment (2) temperature, a fan (9) that is located in the cooling compartment (2) and that circulates the air, which is cooled by the evaporator (5) or heated by the heater (7), and a control unit (10) that regulates the operation of the compressor (6), heater (7) and fan (9) according to the data received from the sensor (8).



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Description**A REFRIGERATOR OPERATING INDEPENDENTLY OF THE AMBIENT TEMPERATURE**

- [0001] The present invention relates to a refrigerator having cooling and freezing compartments at different temperatures.
- [0002] Conventional refrigerators have cooling and freezing compartments that are cooled at different temperatures. Cooling compartment is utilized preferably for storing fresh food and freezing compartment for storing frozen food.
- [0003] Refrigerators are cooled by operating the compressor by using a heat sensor disposed to the cooling compartment. The main problems in the refrigerators wherein the cooling is performed by taking the temperature of the cooling compartment as reference are encountered when the external ambient temperature is much lower or much higher than normal conditions. When the external ambient temperature is low, the heat gain of the cooling compartment of the refrigerator is very low, and the operation ratio of the compressor and hence the cooling efficiency of the freezing department decreases. When the compressor does not operate for a long time, the temperature of the freezing compartment exceeds the desired temperature value, and causes the storage time of the frozen foods to decrease or the foods to be spoiled. A heater is disposed in the cooling compartment for solving this problem. In case the external ambient temperature is lower than the determined value, the temperature of the cooling compartment is increased by the heater being activated and thus, the operation of the compressor is provided. When the external ambient temperature is high or the door is opened frequently, the compressor operates almost continuously to decrease the temperature of the cooling compartment. This causes icing on the evaporator and its capillaries, and the foods close to the evaporator to freeze. In the state of the art, various heaters are used on the evaporator and capillaries to prevent this problem. These heaters used in conventional refrigerators cause high power consumption.
- [0004] In the state of the art International Patent Application No WO0231419, a

refrigerator is explained wherein the moment of the actuation of the heater is dynamically determined, depending on the operating rate of the compressor.

[0005] In the state of the art United States of America Patent Application No US2003145617, operating a heater by considering the compressor operation rate to adjust the cooling and freezing compartment temperatures according to the external ambient temperature is explained.

[0006] In the state of the art International Patent Application No WO2006124004, a control method which activates the heater in the cooling compartment when the temperature of the freezing compartment increases is explained. According to this method, the heater can be activated during the operation of the compressor, and the fan is also operated if required.

[0007] In the state of the art Japanese Patent Application No JP2005114326, reduction of the evaporator fan rotation and operation of the heater in situations wherein the atmospheric temperature is low are explained.

[0008] The aim of the present invention is the realization of a refrigerator, the cooling performance of which is improved at high or low external ambient temperatures.

[0009] The refrigerator realized in order to attain the aim of the present invention is explicated in the attached claims.

[0010] The operation of the refrigerator is regulated by a control unit. The control unit of the present invention controls the operation time and stopping time of the compressor. The sum of the operation and stopping is called cycle. When the compressor stops, the control unit obtains the compressor operation ratio from the ratio of the operation time to the cycle time that is the sum of the operation time and stopping time in the previous cycle.

[0011] If the compressor operation ratio is smaller than the lower limit operation ratio stored in the memory of the control unit when the compressor stops, the control unit prevents the freezing on and around the evaporator by operating the fan and the heater. If the operation ratio is between the lower limit operation ratio and the upper limit operation ratio, the control unit waits for the compressor to operate at a number equal to a limit value within this interval stored in the memory of the control unit, and to reach

the turn-off number, and operates the heater without turning the fan on when the number is reached. If the operation ratio is at the upper limit operation ratio or above, the control unit provides the compressor to reach the compressor cut-in temperature by operating the heater and the fan. Thus, the control unit regulates the operation of the heater and the fan by considering the operation ratios of the compressor. The air heated by the heater is delivered to the evaporator by means of the fan. An effective cooling is provided to be performed in different situations that change according to the cooling device ambient temperature and the door opening frequency.

[0012] The control unit turns the heater off and maintains the cooling process by operating the compressor again when the sensor detects that the compartment temperature has reached the compressor cut-in temperature after the control unit has operated the heater.

[0013] In an embodiment of the present invention, the control method of the refrigerator starts with a step wherein the stopping of the compressor is controlled. After the compressor stops, the steps in which it is controlled whether or not the operation ratio is lower than the lower limit operation ratio or higher than the upper limit operation ratio are started. If the operation ratio is lower than the lower limit operation ratio or higher than the upper limit operation ratio, the step wherein the heater and the fan are operated is performed. If the operation ratio is between the lower limit operation ratio and the upper limit operation ratio, it is inquired whether or not the compressor operation ratio remains between the lower limit operation ratio and the upper limit operation ratio in all of the cycles, the amount of which is a consecutively predetermined number. If the operation ratio remains between the lower limit operation ratio and the upper limit operation ratio in all of the cycles, the amount of which is a consecutively predetermined number, the step wherein the heater is operated is started. In all of the steps wherein the heater is operated, it is controlled whether or not the cooling compartment temperature has reached the compressor cut-in temperature. When the cooling compartment temperature reaches the compressor cut-in temperature, the heater is turned off and the

compressor is operated again, returning to the first step wherein the stopping of the compressor is controlled.

[0014] By means of the control unit of the present invention, by considering the compressor operation ratios that change according to the external ambient temperature, it is determined whether or not freezing has occurred inside the cooling compartment and in the evaporator, and accordingly, the heater and the fan are operated and the heated air is directed to the areas wherein freezing can occur. Thus, the areas which can be heated by using a plurality of heaters are heated by means of a single heater and an advantage in power consumption is provided.

[0015] A refrigerator realized in order to attain the aim of the present invention is illustrated in the attached figures, where:

[0016] Figure 1 – is the sideways schematic view of a refrigerator.

[0017] Figure 2 – is the flow chart of the control method in an embodiment of the present invention.

[0018] The elements illustrated in the figures are numbered as follows:

1. Refrigerator
2. Cooling compartment
3. Freezing compartment
4. Intermediate wall
5. Evaporator
6. Compressor
7. Heater
8. Sensor
9. Fan
10. Control unit

[0019] The refrigerator (1) comprises at least one cooling compartment (2), at least one freezing compartment (3),

- an insulative intermediate wall (4) that separates the compartments (2 and 3) from each other,
- at least one evaporator (5) that is disposed on the rear wall of the cooling compartment (2),
- a compressor (6) that compresses the refrigerant passing through the

evaporator (5) and circulates in the cooling cycle,

- a heater (7) that is disposed on the cooling compartment (2) ceiling and used for preventing the occurrence of sweating therein,
- a sensor (8) that measures the cooling compartment (2) temperature,
- a fan (9) that is located in the cooling compartment (2) and that circulates the air, which is cooled by the evaporator (5), inside the cooling compartment (2), and
- a control unit (10) that regulates the operation of the compressor (6), heater (7) and fan (9) according to the data received from the sensor (8)

[0020] (Figure 1).

[0021] The control unit (10) of the present invention measures the operation time (t_a) and stopping time (t_b) of the compressor (6). The operation and stopping, in total, are called the cycle. When the compressor (6) stops, the control unit (10), furthermore, determines the compressor (6) operation ratio (Γ) from the ratio of the previous operation time (t_a) to the cycle time ($t_a + t_b$) that is the sum of the previous operation time (t_a) and the previous stopping time (t_b).

[0022] The refrigerator (1) of the present invention, furthermore, comprises

- a fan (9) and a heater (7) which are activated by the control unit (10) if the operation ratio (Γ) is lower than the predetermined lower limit operation ratio (Γ_{ll}) or higher than the predetermined upper limit operation ratio (Γ_{ul}) or equal thereto, and
- a heater (7) that is activated by the control unit (10) if all of the cycles, the amount of which is a consecutively predetermined number, are realized at an operation ratio (Γ) remaining between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul})

[0023] when the compressor (6) stops (Figure 1).

[0024] The fan (9) that is located inside the cooling compartment (2) circulates the air, which is cooled by the evaporator (5) near the rear wall, inside the cooling compartment (2) and thus, provides a homogeneous heat. A sensor (8) is used to be able to detect whether or not the cooling compartment (2) is sufficiently cooled. When the compressor (6) cut-out temperature ($T_{cut-out}$) is reached, it is determined that the cooling

compartment (2) is sufficiently cooled. When this temperature ($T_{\text{cut-out}}$) is reached, the compressor (6) is stopped and hence the refrigerant flow to the evaporator (5) is cut off. Excessive cooling is prevented by stopping the compressor (6). The time elapsing while the compressor (6) is operating is the operation time (t_a), the time elapsing while the compressor (6) is being stopped is the stopping time (t_b), and the sum of both (t_a , t_b) is the cycle time ($t_a + t_b$). When the compressor (6) is stopped, the operation ratio (Γ) is determined from the ratio of the operation time (t_a) of the compressor (6) measured in the previous cycle to the cycle time ($t_a + t_b$).

[0025] After operating the heater (7), the control unit (10) of the present invention turns off the heater (7) and operates the compressor (6) upon receiving the data from the sensor (8) that the compressor (6) cut-in temperature ($T_{\text{cut-in}}$) is reached. Thus, determining the operation time of the heater (7) is not required and when the compressor (6) cut-in temperature ($T_{\text{cut-in}}$) which is required for the compressor (6) to start operating is reached, the heater (7) is turned off.

[0026] When the external ambient is cooler than normal conditions, the compressor (6) operation ratio (Γ) is lower than the predetermined lower limit operation ratio (Γ_{ll}). The compressor (6) operation ratio (Γ) being low causes the freezing compartment (3) not to be cooled sufficiently. The heater (7) and the fan (9) are operated and thus, the compressor (6) is provided to operate again by the cooling compartment (2) being heated, meanwhile local freezing is prevented by the heated air being delivered to the evaporator (5) by means of the fan (9), and a homogeneous heat distribution is provided inside the cooling compartment (2). Thus, using a separate heating device to heat the evaporator (5) is not required, and freezing around the evaporator (5) is prevented by the air, which is heated by the heater (7) used inside the cooling compartment (2), being circulated inside the cooling compartment (2) by means of the fan (9).

[0027] When the external ambient temperature is not too high or too low, the compressor (6) operation ratio (Γ) is between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}). In this situation, the control unit (10) saves how many times the compressor (6) has operated between

the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) to its memory to decide whether or not the heater (7) will be operated.

When the compressor (6) operates between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) for the first time, the one time operation-data is saved to the control unit (10) memory.

- [0028] If the number of successive operations reaches a limit value previously stored in the memory between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) of the compressor (6), the heater (7) is operated. When the temperature of the cooling compartment (2) heated by the heater (7) reaches the compressor (6) cut-in temperature (T_{cut-in}), the heater (7) is turned off and the compressor (6) is activated. After the heater (7) operates, the number of successive operations in the control unit (10) memory is set to zero.
- [0029] If the value of the limit number is not reached when the compressor (6) operation ratio (Γ) is between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}), the heater (7) is not operated, and instead the cooling compartment (2) temperature is awaited until it reaches the compressor (6) cut-in temperature (T_{cut-in}), and then the compressor (6) is operated. After the compressor (6) operates, the operation ratio (Γ) is controlled again. If the compressor (6) operation ratio (Γ) is realized out of the range between the upper limit operation ratio (Γ_{ul}) and the lower limit operation ratio (Γ_{ll}) in any cycle, the number of successive operations is set to zero.
- [0030] When the external ambient is warm, the compressor (6) operation ratio (Γ) is equal to the upper limit operation ratio (Γ_{ul}) or higher than the upper limit operation ratio (Γ_{ul}). The heater (7) is operated since the compressor (6) operation ratio (Γ) being high causes freezing on and around the evaporator (5), and the fan (9) is also operated for the heated air to reach the evaporator (5). The heater (7) is turned off when the temperature of the cooling compartment (2) heated by the heater (7) reaches the compressor (6) cut-in temperature (T_{cut-in}). In an embodiment, the fan (9) is also turned off when the compressor (6) starts operating, whereas in another embodiment the fan (9) continues to operate since it will also be

used while the compressor (6) is operating. Thus, the compressor (6), which has exceeded the upper limit operation ratio (Γ_{ul}) due to the external ambient being warm, is prevented from causing freezing on and around the evaporator (5).

[0031] Thus, it can be determined that the external ambient temperature is very high or very low by considering the operation ratio (Γ) when the compressor (6) stops, and the heat distribution inside the cooling compartment (2) can be provided by using heater (7) and fan (9) as required.

[0032] In an embodiment of the present invention, the refrigerator (1) is operated according to the following method:

- Inquiring whether or not the compressor (6) is operating (1000),
- If the compressor (6) is operating, returning to the first step in which it is inquired whether or not the compressor (6) is operating (1000),
- If the compressor (6) is not operating, inquiring whether or not the operation ratio (Γ) is lower than the lower limit operation ratio (Γ_{ll}) (1020),
- If the operation ratio (Γ) is lower than the lower limit operation ratio (Γ_{ll}), operating the fan (9) and the heater (7) (1021),
- Inquiring whether or not the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature (t_{cut-in}) (121),
- Turning off the heater (7) and operating the compressor (6) if the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature (t_{cut-in}) (1030),
- Continuing with the operation of the fan (9) and the heater (7) if the cooling compartment (2) temperature is not greater than the compressor (6) cut-in temperature (t_{cut-in}) (1021),
- If the operation ratio (Γ) is higher than the lower limit operation ratio (Γ_{ll}), inquiring whether or not the operation ratio (Γ) is lower than the upper limit operation ratio (Γ_{ul}) (1022),
- If the operation ratio (Γ) is higher than the upper limit operation ratio (Γ_{ul}), operating the fan (9) and the heater (7) (1024),
- Inquiring whether or not the cooling compartment (2) temperature is

- greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (124),
- Turning off the heater (7) and operating the compressor (6) if the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1030),
 - Continuing with the operation of the fan (9) and the heater (7) if the cooling compartment (2) temperature is not greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1024),
 - If the operation ratio (Γ) is lower than the upper limit operation ratio (Γ_{ul}), comparing the number of consecutive operations of the compressor (6) between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) with the limit value stored in the memory of the control unit (10) (1023),
 - Keeping the fan (9) turned off and turning on the heater (7) if the compressor (6) has operated consecutively at the limit value between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) (1025),
 - Inquiring whether or not the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (125),
 - Turning off the heater (7) and operating the compressor (6) if the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1030),
 - After the step wherein the compressor (6) is operated (1030), returning to the step wherein the operation of the compressor (6) is controlled (1000),
 - Continuing with the operation of the fan (9) and the heater (7) if the cooling compartment (2) temperature is not greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1025),
 - Keeping the fan (9) and the heater (7) turned off if the compressor (6) has not operated consecutively as much as the limit value between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) (1026),
 - Inquiring whether or not the cooling compartment (2) evaporator (5) temperature is greater than the compressor (6) cut-in temperature

($t_{\text{cut-in}}$) (126),

- Keeping the fan (9) and the heater (7) turned off if the cooling compartment (2) temperature is not greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1026),
- If the cooling compartment (2) evaporator (5) temperature is greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$), operating the compressor (6) and increasing the number of operations of the compressor (6) by one in the memory of the control unit (10) between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) (1028), and
- Returning to the step wherein the operation ratio (Γ) is controlled after the compressor (6) is operated (1000) (Figure 2).

[0033] By means of this method, the control unit (10) first detects the operation or stopping state of the compressor (6), and regulates the operations of the fan (9) and the heater (7) for an effective and economic cooling when the compressor (6) stops. When the compressor (6) stops, it detects the heat distribution inside and outside the cooling compartment (2) by the operation ratio (Γ), and prevents local freezing by operating the heater (7) and the fan (9) if required.

[0034] By means of the control unit (10) of the present invention, the need of cooling and/or heating is detected by considering the operation ratio (Γ) when the compressor (6) stops. The heater (7) and the fan (9) are operated according to the determined need and a homogeneous heat is provided inside the cooling compartment (2) and thus, freezing on and around the evaporator (5) and heating in the freezing compartment (3) are prevented. The utilization of additional heating devices for the evaporator (5) is not required by the heat of the heater (7) used in the cooling compartment (2) being directed to the evaporator (5) by means of the fan (9), and savings of cost and power consumption are provided.

[0035] It is to be understood that the present invention is not limited to the embodiments disclosed above and a person skilled in the art can easily introduce different embodiments. These should be considered within the scope of the protection postulated by the claims of the present invention.

Claims

1. A refrigerator (1) comprising at least one cooling compartment (2) and at least one freezing compartment (3),
 - an insulative intermediate wall (4) that separates the compartments (2 and 3) from each other,
 - at least one evaporator (5) that is disposed on the rear wall of the cooling compartment (2),
 - a compressor (6) that compresses the refrigerant passing through the evaporator (5) and circulates in the refrigeration cycle,
 - a heater (7) that is disposed on the cooling compartment (2) ceiling and used for preventing the occurrence of sweating therein,
 - a sensor (8) that measures the cooling compartment (2) temperature,
 - a fan (9) that is located in the cooling compartment (2) and that circulates the air, which is cooled by the evaporator (5) or heated by the heater (7), inside the cooling compartment (2), and
 - a control unit (10) that regulates the operation of the compressor (6), heater (7) and fan (9) according to the data received from the sensor (8) characterized by the control unit (10) that measures the operation time (t_a) and stopping time (t_b) of the compressor (6), and determines the compressor (6) operation ratio (Γ) from the ratio of the previous operation time (t_a) to the cycle time ($t_a + t_b$) that is the sum of the previous operation time (t_a) and previous stopping time (t_b) when the compressor (6) stops, and
 - the fan (9) and the heater (7) that are activated by the control unit (10) if the operation ratio (Γ) is lower than the predetermined lower limit operation ratio (Γ_{II}) or higher than the predetermined upper limit operation ratio (Γ_{Ul}) or equal thereto when the compressor (6) stops, and
 - the heater (7) that is activated if all of the cycles, the amount of which is a consecutively predetermined number, are realized at an operation ratio (Γ) remaining between the lower limit operation ratio (Γ_{II}) and the upper limit operation ratio (Γ_{Ul}).
2. A refrigerator (1) as in Claim 1, characterized by the control unit (10) which, after operating the heater (7), turns off the heater (7) and operates the compressor (6) upon receiving the data from the sensor (8) that the

compressor (6) cut-in temperature ($T_{\text{cut-in}}$) is reached.

3. For a refrigerator (1) as in any one of the above Claims, a method comprising the following steps:

- Inquiring whether or not the compressor (6) is operating (1000),
- If the compressor (6) is operating, returning to the first step in which it is inquired whether or not the compressor (6) is operating (1000),
- If the compressor (6) is not operating, inquiring whether or not the operation ratio (Γ) is lower than the lower limit operation ratio (Γ_{ll}) (1020),
- If the operation ratio (Γ) is lower than the lower limit operation ratio (Γ_{ll}), operating the fan (9) and the heater (7) (1021),
- Inquiring whether or not the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (121),
- Turning off the heater (7) and operating the compressor (6) if the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1030),
- Continuing with the operation of the fan (9) and the heater (7) if the cooling compartment (2) temperature is not greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1021),
- If the operation ratio (Γ) is higher than the lower limit operation ratio (Γ_{ll}), inquiring whether or not the operation ratio (Γ) is lower than the upper limit operation ratio (Γ_{ul}) (1022),
- If the operation ratio (Γ) is higher than the upper limit operation ratio (Γ_{ul}), operating the fan (9) and the heater (7) (1024),
- Inquiring whether or not the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (124),
- Turning off the heater (7) and operating the compressor (6) if the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1030),
- Continuing with the operation of the fan (9) and the heater (7) if the cooling compartment (2) temperature is not greater than the compressor (6) cut-in temperature ($t_{\text{cut-in}}$) (1024),
- If the operation ratio (Γ) is lower than the upper limit operation ratio (Γ_{ul}), comparing the number of consecutive operations of the compressor (6)

between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) with the limit value stored in the memory of the control unit (10) (1023),

- Keeping the fan (9) turned off and turning on the heater (7) if the compressor (6) has operated consecutively at the limit value between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) (1025),
- Inquiring whether or not the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature (t_{cut-in}) (125),
- Turning off the heater (7) and operating the compressor (6) if the cooling compartment (2) temperature is greater than the compressor (6) cut-in temperature (t_{cut-in}) (1030),
- After the step wherein the compressor (6) is operated (1030), returning to the step wherein the operation of the compressor (6) is controlled (1000),
- Continuing with the operation of the fan (9) and the heater (7) if the cooling compartment (2) temperature is not greater than the compressor (6) cut-in temperature (t_{cut-in}) (1025),
- Keeping the fan (9) and the heater (7) turned off if the compressor (6) has not operated consecutively as much as the limit value between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) (1026),
- Inquiring whether or not the cooling compartment (2) evaporator (5) temperature is greater than the compressor (6) cut-in temperature (t_{cut-in}) (126),
- Keeping the fan (9) and the heater (7) turned off if the cooling compartment (2) temperature is not greater than the compressor (6) cut-in temperature (t_{cut-in}) (1026),
- If the cooling compartment (2) evaporator (5) temperature is greater than the compressor (6) cut-in temperature (t_{cut-in}), increasing the number of operations of the compressor (6) by one in the memory of the control unit (10) between the lower limit operation ratio (Γ_{ll}) and the upper limit operation ratio (Γ_{ul}) (1028), and
- Returning to the step wherein the operation ratio (Γ) is controlled after the compressor (6) is operated (1000).

Figure 1

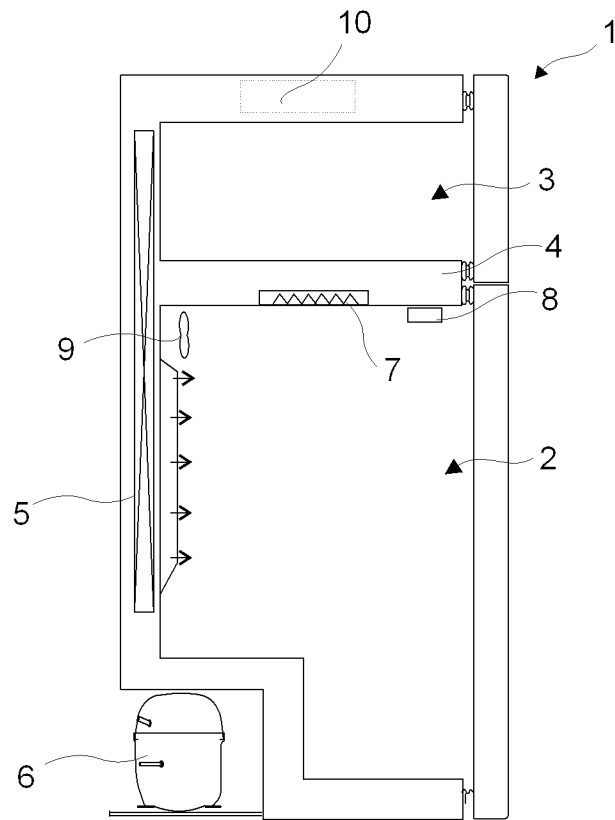


Figure 2

