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(54) **Refrigerator for preventing and/or reducing condensation and method for controlling same**

(57) A method for controlling a refrigerator includes measuring temperature or humidity around the refrigerator (100) using a temperature sensor (10) and/or humidity sensor (20). Further, the method includes controlling a cooling fan to continuously operate or controlling

the cooling fan (40) or a heater (60) to turn on for a fraction of a preset period and then turn off for the remainder of the preset period in accordance with the temperature measured by the temperature sensor and/or the humidity measured by the humidity sensor.

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**Description****CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application is based on and claims priority from Korean Patent Application No. 10-2013-0164301, filed on December 26, 2013, the disclosure of which is incorporated herein in its entirety by reference.

**TECHNICAL FIELD**

[0002] The present invention relates to a refrigerator capable of preventing and/or reducing condensation of water in or on the refrigerator and a method for controlling the refrigerator to prevent and/or reduce condensation of water in or on the refrigerator, particularly preventing and/or reducing condensation by measuring temperature and humidity of a space around the refrigerator (e.g., the environment surrounding the refrigerator) and controlling a heater and a cooling fan in or of the refrigerator based on the measured temperature and humidity to maintain the temperature of a location in or on the refrigerator where water may condense above a dew point.

**BACKGROUND**

[0003] In general, various heaters and hot pipes are employed refrigerators in order to prevent and/or reduce condensation of water ("dew") in or on the refrigerator. However, these components add cost, and a hot pipe may suffer from adhesion and/or mounting/fixture problems resulting in condensation on the surface refrigerator. Thus, in order to solve the above problems resulting from the use of the hot pipe, attempts have been made to change the structure of the hot pipe. However, this approach adds costs caused by the design changes and manufacturing of the hot pipe. Accordingly, a more fundamental solution to condensation of water in or on the refrigerator is needed.

**SUMMARY**

[0004] The present disclosure has been made in an effort to provide a refrigerator and a method for controlling the refrigerator capable of preventing and/or reducing condensation by measuring temperature and humidity around the refrigerator and controlling a heater and a cooling fan in the refrigerator based on the measured temperature and humidity to maintain the temperature of a location where the water may condense above a dew point.

[0005] The objects of the present invention are not limited thereto, and other objects that are not described above will be apparently understood by those skilled in the art from the following description.

[0006] Exemplary embodiments of the present disclosure provide a method for controlling a refrigerator including measuring temperature or humidity around the

refrigerator using a temperature sensor or humidity sensor, and continuously operating a cooling fan or causing a cooling fan or heater to turn on for a fraction of a preset period and then turn off for the remainder of the preset period based on the temperature measured by the temperature sensor and/or the humidity measured by the humidity sensor.

[0007] The cooling fan may operate continuously where the temperature in the space measured by the temperature sensor is equal to or higher than a first preset temperature.

[0008] When the measured humidity is relatively high, the operating ratio of the heater may increase (e.g., the heater may run for a longer period of time).

[0009] When the measured humidity is relatively low, the operating ratio of the heater may decrease (e.g., the heater may run for a shorter period of time).

[0010] Another exemplary embodiment of the present disclosure provides a refrigerator including a heater (HTR) configured to prevent and/or reduce condensation of water and/or moisture, a temperature sensor configured to measure a temperature around the refrigerator, a humidity sensor configured to measure humidity in the refrigerator, a cooling fan configured to radiate heat in the refrigerator, and a controller configured to control the cooling fan and the heater based on the measured temperature and/or humidity, wherein the controller may cause the cooling fan to continuously operate or cause the cooling fan or the heater to turn on for a fraction of a preset period and then turn off for the remainder of the preset period, based on the temperature measured by the temperature sensor and/or the humidity measured by the humidity sensor.

[0011] The cooling fan may continuously operate, for example, when the temperature measured by the temperature sensor is equal to or higher than a first preset temperature.

[0012] In accordance with exemplary embodiments of the present disclosure, it is possible to prevent and/or reduce water and/or moisture condensation by measuring temperature and humidity around the refrigerator and controlling a heater (HTR) and a cooling fan (C-FAN) of the refrigerator based on the measured temperature and humidity to maintain the temperature of the location on the refrigerator where water/moisture condenses above the dew point.

[0013] Further, the refrigerant R-600a (isobutane) has a cycle temperature lower than the refrigerant R-134a (tetrafluoroethane, or  $\text{CH}_2\text{FCF}_3$ ). As a result, the likelihood of condensation in refrigerators using R600a or similar low temperature cycle refrigerants increases due to the relatively low temperature of the hot pipe (caused by a relatively low refrigerant temperature).

[0014] An additional heater or structural changes to the hot pipe to overcome the adhesion problem have been attempted in the prior art. Unlike the prior art, exemplary embodiments of the present disclosure cause a cooling fan to operate for a fraction of a preset period

and to not operate for the remainder of the preset period so that the temperature of the cooling cycle increases. As a result, the temperature of the refrigerant increases and more heat is transferred to locations in/on a refrigerator where water/moisture condenses, such as a partition or gasket, thereby preventing and/or reducing and/or reducing the likelihood of condensation in or on the refrigerator.

**[0015]** The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

#### **[0016]**

FIG. 1 is a block diagram of an exemplary refrigerator capable of preventing and/or reducing condensation in accordance with embodiments of the present invention.

FIGS. 2A and 2B are flow diagrams illustrating an exemplary method for preventing and/or reducing and/or reducing condensation in a refrigerator in accordance with embodiments of the present invention.

### **DETAILED DESCRIPTION**

**[0017]** Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

**[0018]** In the following description, well-known functions or constitutions will not be described in detail if they would obscure the invention in unnecessary detail.

**[0019]** The present disclosure also includes algorithms, computer program(s), computer-readable media and/or software, implementable and/or executable in a general purpose computer or refrigerator a or freezer equipped with a conventional digital signal processor, and configured to perform one or more of the methods and/or one or more operations of the hardware disclosed herein. Thus, a further aspect of the invention relates to algorithms and/or software that implement a method for controlling a refrigerator that is capable of preventing moisture in a refrigerator compartment from freezing in a refrigerator compartment return duct as cold air in a cooling chamber flows back into the refrigerator compartment return duct. For example, the computer program or computer-readable medium generally contains a set of instructions which, when executed by an appropriate processing device (e.g., a signal processing device, such as a microcontroller, microprocessor or DSP device), is configured to perform the above-described method(s), operation(s), and/or algorithm(s).

**[0020]** The computer-readable medium may comprise

any medium that can be read by a signal processing device configured to read the medium and execute code stored thereon or therein, such as a floppy disk, CD-ROM, magnetic tape or hard disk drive. Such code may comprise object code, source code and/or binary code. The code is generally digital, and is generally configured for processing by a conventional digital data processor (e.g., a microprocessor, microcontroller, or logic circuit such as a programmable gate array, programmable logic circuit/device or application-specific integrated circuit [ASIC]).

**[0021]** Hereinafter, the operation of the respective components of a refrigerator capable of preventing and/or reducing condensation in accordance with an embodiment of the present invention will be described with reference to FIG. 1.

**[0022]** Referring to FIG. 1, an exemplary refrigerator 100 capable of preventing and/or reducing condensation of water comprises a temperature sensor (RT-sensor) 10 that measures temperature around the refrigerator 100, a humidity sensor 20 that measures humidity around the refrigerator 100, a compressor 30 that discharges high-temperature and/or high-pressure refrigerant, a cooling fan (C-FAN) 40 that cools a condenser in a machine compartment of the refrigerator 100, a cooling fan driver 50 to drive the cooling fan, and at least one heater (HTR) 60, and a controller 70 that controls the temperature sensor 10, the humidity sensor 20, the compressor 30, the cooling-fan driving unit 50, and the heater (HTR) 60.

**[0023]** The temperature sensor 10 and the humidity sensor 20 sense temperature and humidity around the refrigerator 100, respectively. The temperature sensor 10 may be in a cover used to cover a hinge of an upper portion of a door, and the humidity sensor 20 may be in a control panel on a front surface of the door or in the same location as the temperature sensor 10.

**[0024]** The compressor 30 compresses the refrigerant to liquefy the vaporized refrigerant. The cooling fan 40 radiates the heat of a condenser in the machine compartment of the refrigerator 100. One or more heaters (HTR) 60 may be used in the refrigerator, and may be, for example, positioned next to a part of the refrigerator not requiring a low temperature (e.g., a water or ice dispenser, a dispenser switch or lever, or a home bar (all not shown)), etc. The heater(s) 60 may increase the temperature of that part of the refrigerator.

**[0025]** The controller 70 issues signals to control the operations of the temperature sensor 10, the humidity sensor 20, the compressor 30, the cooling-fan driver 50, and the heater (HTR) 60. Further, the controller 70 turns on and turns off the heater 60 and the cooling fan 40 based on the temperature and humidity that are measured by the temperature sensor 10 and the humidity sensor 20.

**[0026]** Specifically, the controller 70 causes the cooling fan 40 to continue its operation when the temperature measured by the temperature sensor 10 is above a first

preset temperature.

**[0027]** Further, the controller 70 may control the heater 60 so that the operating ratio of the heater 60 increases, for example, when the measured humidity is relatively high.

**[0028]** Further, the controller 70 may control the heater 60 so that the operating ratio of the heater 60 decreases, for example, when the measured humidity is relatively low.

**[0029]** Further, when the measured humidity is above a preset humidity, the controller 70 may control the heater 60 so that the heater 60 operates for more than a preset time period.

**[0030]** Further, when the measured temperature is below a preset temperature, the controller 70 may control the heater 60 so that the heater 60 operates for less than a preset time period.

**[0031]** Hereinafter, a method of preventing and/or reducing condensation of water in or on the refrigerator will be described with reference to FIGS. 2A and 2B in detail. For reference, it is understood that the embodiment illustrated in FIGS. 2A and 2B is only an example where the cooling fan 40 and the heater 60 are controlled depending on the results of the temperature sensor 10 and the humidity sensor 20 and/or based on a control method for controlling the refrigerator in accordance with one or more embodiments of the present invention. There may be many other different embodiments similar thereto.

**[0032]** Referring to FIGS. 2A and 2B, it may be determined that the temperature ( $T_R$ ) measured by the temperature sensor 10 around the refrigerator is equal to or higher than a first preset temperature, for example, 36 °C, in block 20. However, the first preset temperature may have any value between 28 °C and 38 °C. In block 22, when the measured temperature is equal to or higher than the first preset temperature, it may be determined if the humidity ( $H_R$ ) measured by the humidity sensor 20 around the refrigerator is equal to or higher than a first preset humidity, e.g., 70%. However, the first preset humidity may have any value between 60 and 80%.

**[0033]** As a result of the determination of block 20, when the humidity ( $H_R$ ) is equal to or higher than the first preset humidity, the heater (HTR) 60 in the refrigerator is turned on for about fifty-five minutes, turned off for about five minutes, and operates the cooling fan 40 continuously in block 24. The heater (HTR) 60 may be turned on once and then turned off once during the operation period of the heater 60, and the heater 60 may be turned on for about 27 to 118 minutes, and turned off for about two to ten minutes. The operation period of the heater 60 may be between 30 and 120 minutes, and in one example, is about 60 minutes. As a result, the heater may have a duty cycle (e.g., ratio of the length of time on to the length of time off) of at least 8:1. Hereinafter, the heater (HTR) 60 will be considered to have an exemplary operation period of 60 minutes.

**[0034]** However, as a result of the determination in block 22, if the humidity ( $H_R$ ) is not equal to or higher

than the first preset humidity (or less than the first preset humidity), it may be determined that the humidity ( $H_R$ ) is equal to or higher than the second preset humidity (for example, 55%) and is less than the first preset humidity in block 26. In various embodiments, the second preset humidity may have a value between 40 and 70%, but less than the first preset humidity. As a result of the determination, when the humidity ( $H_R$ ) is equal to or higher than the second preset humidity and is less than the first preset humidity, the heater (HTR) 60 in the refrigerator is turned on for about fifty minutes and then turned off for about ten minutes, and the cooling fan 40 continuously operates in block 28. However, per 60 minutes of operation cycle, the heater 60 may be turned on for about 42 to 54 minutes, and turned off for about six to 18 minutes. As a result, the heater may have a duty cycle of from 7:3 to about 9:1, but less than the duty cycle when the humidity is greater than the first preset humidity.

**[0035]** As a result of the determination in block 26, when the humidity ( $H_R$ ) is not equal to or higher than the second preset humidity and is not less than the first preset humidity (e.g., less than the second preset humidity), the heater (HTR) 60 in the refrigerator is turned on for about forty-five minutes and then turned off for about fifteen minutes and the cooling fan 40 continuously operates in block 30. However, per 60 minutes of operation cycle, the heater 60 may be turned on for about 36 to 50 minutes, and turned off for about six to 18 minutes. As a result, the heater may have a duty cycle of from 3:2 to about 6:1, but less than the duty cycle when the humidity is between the first and second preset humidities.

**[0036]** As a result of the determination in block 20, when the measured temperature ( $T_R$ ) around the refrigerator is not equal to or higher than the first preset temperature, it is determined whether the temperature ( $T_R$ ) is equal to or higher than a second preset temperature and less than the first preset temperature in block 32. As a result of the determination, when the temperature ( $T_R$ ) is equal to or higher than the second preset temperature and is less than the first preset temperature, it is determined whether the humidity ( $H_R$ ) is equal to or higher than the first preset humidity in block 34. The second preset temperature may have any value between 10 °C and 25 °C. In one example, the second preset temperature is about 20 °C.

**[0037]** As a result of the determination in block 34, when the humidity ( $H_R$ ) is equal to or higher than the first preset humidity, the heater (HTR) 60 provided in the refrigerator is turned on for about fifty-five minutes and then turned off for about five minutes and the cooling fan 40 is turned on for ten minutes and then tuned-off for fifty minutes in block 36. The cooling fan 40 may be turned on once and then turned off once during the operation period of the cooling fan 40. Hereinafter, the cooling fan 40 will be considered to have an exemplary operation period of 60 minutes.

**[0038]** Under these temperature and humidity conditions, per 60 minutes of operation cycle, the heater 60

may be turned on for about 50 to 57 minutes, and turned off for about 3 to 10 minutes. As a result, the heater may have a duty cycle of at least 6:1. In addition, per 60 minutes of operation cycle, the fan 40 may be turned on for about 5 to 15 minutes, and turned off for about 45 to 55 minutes. As a result, the fan may have a duty cycle of at least 3:1.

**[0039]** However, as a result of the determination in block 34, if the humidity ( $H_R$ ) is not equal to or higher than the first preset humidity (or less than the first preset humidity), it is determined whether the humidity ( $H_R$ ) is equal to or higher than the second preset humidity and less than the first preset humidity in block 38. As a result of the determination, when the humidity ( $H_R$ ) is equal to or higher than the second preset humidity and is less than the first preset humidity, the heater (HTR) 60 in the refrigerator is turned on for about forty minutes and then turned off for about fifteen to 30 minutes (e.g., about twenty minutes), and the cooling fan 40 is turned on for five minutes and then is turned off for about fifty-five minutes after block 40.

**[0040]** Under these temperature and humidity conditions, per 60 minutes of operation cycle, the heater 60 may be turned on for about 30 to 45 minutes, and turned off for about 15 to 30 minutes. As a result, the heater may have a duty cycle of from 1:1 to 3:1. In addition, per 60 minutes of operation cycle, the fan 40 may be turned on for about 2 to 10 minutes, and turned off for about 50 to 58 minutes. As a result, the fan may have a duty cycle of at least 6:1.

**[0041]** However, as a result of the determination in block 38, when the humidity ( $H_R$ ) is not equal to or higher than the second preset humidity and is not less than the first preset humidity, the heater (HTR) 60 in the refrigerator is turned on for about thirty minutes and then turned off for about thirty minutes, and the cooling fan 40 is continuously operated in block 42. Under these temperature and humidity conditions, per 60 minutes of operation cycle, the heater 60 may be turned on for about 20 to 40 minutes, and turned off for about 20 to 40 minutes. As a result, the heater may have a duty cycle of from 1:2 to 2:1.

**[0042]** As a result of the determination in block 32, when the temperature ( $T_R$ ) is not equal to or higher than the second preset temperature and not less than the first preset temperature (i.e., the temperature is less than the second preset temperature), the control method advances to block 44 (FIG. 2B) where it is determined that whether the humidity ( $H_R$ ) is equal to or higher than a first preset humidity. As a result of the determination, when the humidity ( $H_R$ ) is equal to or higher than the first preset humidity, the heater (HTR) 60 in the refrigerator is turned on for about forty minutes and then turned off for about twenty minutes, and the cooling fan 40 is turned on for ten minutes and then turned off for fifty minutes in block 46.

**[0043]** Under these temperature and humidity conditions, per 60 minutes of operation cycle, the heater 60 may be turned on for about 30 to 45 minutes, and turned

off for about 15 to 30 minutes. As a result, the heater may have a duty cycle of from 1:1 to 3:1. In addition, per 60 minutes of operation cycle, the fan 40 may be turned on for about 5 to 20 minutes, and turned off for about 40 to 55 minutes. As a result, the fan may have a duty cycle of at least 2:1.

**[0044]** However, as a result of the determination in block 44, when the humidity ( $H_R$ ) is not equal to or higher than the first preset humidity (e.g., less than the first preset humidity, it is determined whether the humidity ( $H_R$ ) is equal to or higher than a second preset humidity and (optionally) less than the first preset humidity in block 48. As a result of the determination, when the humidity ( $H_R$ ) is equal to or higher than the second preset humidity and is less than the first preset humidity, the heater (HTR) 60 in the refrigerator is turned on for about twenty-five minutes and then turned off for about thirty-five minutes, and the cooling fan 40 is turned on for five minutes and then turned off for fifty-five minutes after block 50.

**[0045]** Under these temperature and humidity conditions, per 60 minutes of operation cycle, the heater 60 may be turned on for about 18 to 33 minutes, and turned off for about 27 to 42 minutes. As a result, the heater may have a duty cycle of from 3:7 to 11:9. In addition, per 60 minutes of operation cycle, the fan 40 may be turned on for about 3 to 10 minutes, and turned off for about 50 to 57 minutes. As a result, the fan may have a duty cycle of 1:19 to 1:5.

**[0046]** However, as a result of the determination of in block 48, when the humidity ( $H_R$ ) is not equal to or higher than the second preset humidity and is not less than the first preset humidity, the heater (HTR) 60 in the refrigerator is turned on for about twelve minutes and then turned off for about forty-eight minutes and the cooling fan 40 is continuously operated in block 52. Thus, under these temperature and humidity conditions, per 60 minutes of operation cycle, the heater 60 may be turned on for about 6 to 18 minutes, and turned off for about 42 to 54 minutes. As a result, the heater may have a duty cycle of from 1:9 to 3:7.

**[0047]** As set forth above, while the present invention has been described in connection with a specific embodiment of the refrigerator controlling apparatus and method for preventing and/or reducing condensation of water, it is only an example and the present invention is not limited thereto. It should be construed that the present invention has the widest range in compliance with the basic idea disclosed in the disclosure. Although it is possible for those skilled in the art to combine and substitute the disclosed embodiments to embody the other types that are not specifically disclosed in the disclosure, they do not depart from the scope of the present invention as well. In addition, it will be apparent to those skilled in the art that various modifications and changes may be made with respect to the disclosed embodiments based on the disclosure in easy and these changes and modifications also fall within the scope of the present invention.

**Claims**

1. A method for controlling a refrigerator, the method comprising:
- measuring temperature around the refrigerator using a temperature sensor measuring humidity around the refrigerator using a humidity sensor; and  
controlling a cooling fan to continuously operate, controlling the cooling fan to turn on for a first fraction of a preset period and then turn off for a first remainder of the preset period, or controlling a heater to turn on for a second fraction of the preset period and then turn off for a second remainder of the preset period based on the temperature detected by the temperature sensor and/or the humidity detected by the humidity sensor.
2. The method of claim 1, wherein the cooling fan continuously operates when the temperature measured by the temperature sensor is equal to or higher than a preset temperature.
3. The method of claim 1, wherein the heater operates for more than a preset time period when the measured humidity is above a preset humidity.
4. The method of claim 1, wherein the heater operates for less than the preset time period when the measured temperature is below the preset temperature.
5. The method of claim 1, further comprising:
- turning on a heater in the refrigerator when the measured humidity is equal to or higher than a preset humidity;  
turning on a heater in the refrigerator when the measured humidity is lower than a first preset humidity and equal to or higher than a second preset humidity;  
turning on a heater in the refrigerator when the measured temperature is lower than a first preset temperature, the measured temperature is equal to or higher than a second preset temperature, and the measured humidity is equal to or higher than a first preset humidity; and  
turning on a cooling fan in the refrigerator when the measured temperature is lower than a first preset temperature, the measured temperature is equal to or higher than a second preset temperature, and the measured humidity is equal to or higher than a first preset humidity.
6. The method of claim 1, wherein the preset period is about 60 minutes.
7. A refrigerator, comprising:
- a heater;  
a temperature sensor configured to measure temperature around the refrigerator;  
a humidity sensor configured to measure humidity around the refrigerator;  
a cooling fan configured to radiate the heat in the refrigerator; and  
a controller configured to control a cooling fan to continuously operate, control a cooling fan to turn on for a first fraction of a preset period and then turn off for a first remainder of the preset period, or control a heater to turn on for a second fraction of the preset period and then turn off for a second remainder of the preset period, based on the temperature measured by the temperature sensor and/or the humidity measured by the humidity sensor.
8. The refrigerator of claim 7, wherein the controller continuously operates the cooling fan when the temperature measured by the temperature sensor is equal to or higher than a preset temperature.
9. The refrigerator of claim 7, wherein the controller operates the heater for more than a preset time period when the measured humidity is above a preset humidity, or when the measured temperature is below a preset temperature.
10. The refrigerator of claim 7, wherein the controller is further configured to:
- turn on the heater when the measured humidity is equal to or higher than a first preset humidity, or when the measured humidity is lower than a second preset humidity and equal to or higher than a third preset humidity; and  
turn on a heater in the refrigerator when the measured humidity is lower than a first present humidity and equal to or higher than a second preset humidity.
11. The refrigerator of claim 7, further comprising a tangible computer-readable medium containing a set of instructions embodied therein, comprising:
- measuring the temperature around the refrigerator using the temperature sensor and measuring the humidity around the refrigerator using the humidity sensor; and  
based on the temperature detected by the temperature sensor and/or the humidity detected by the humidity sensor, controlling the cooling fan to continuously operate, or to turn on for a first fraction of a preset period and then turn off for a first remainder of the preset period, and/or con-

trolling a heater to turn on for a second fraction of the preset period and then turn off for a second remainder of the preset period.

12. The refrigerator of claim 8, wherein the controller is further configured to turn on the heater when the measured temperature is lower than a first preset temperature, the measured temperature is equal to or higher than a second preset temperature, and the measured humidity is equal to or higher than a first preset humidity. 5 10

13. The refrigerator of claim 8, wherein the controller is further configured to turn on the cooling fan when the measured temperature is lower than a first preset temperature, the measured temperature is equal to or higher than a second preset temperature, and the measured humidity is equal to or higher than a first preset humidity. 15 20

14. The refrigerator of claim 8, wherein the controller is further configured to cause the cooling fan and/or the heater to maintain a temperature of a location on the refrigerator where water may condense above a dew point. 25

15. A tangible computer-readable medium containing a set of instructions embodied therein, configured to execute the method of claim 1. 30

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*FIG. 1*

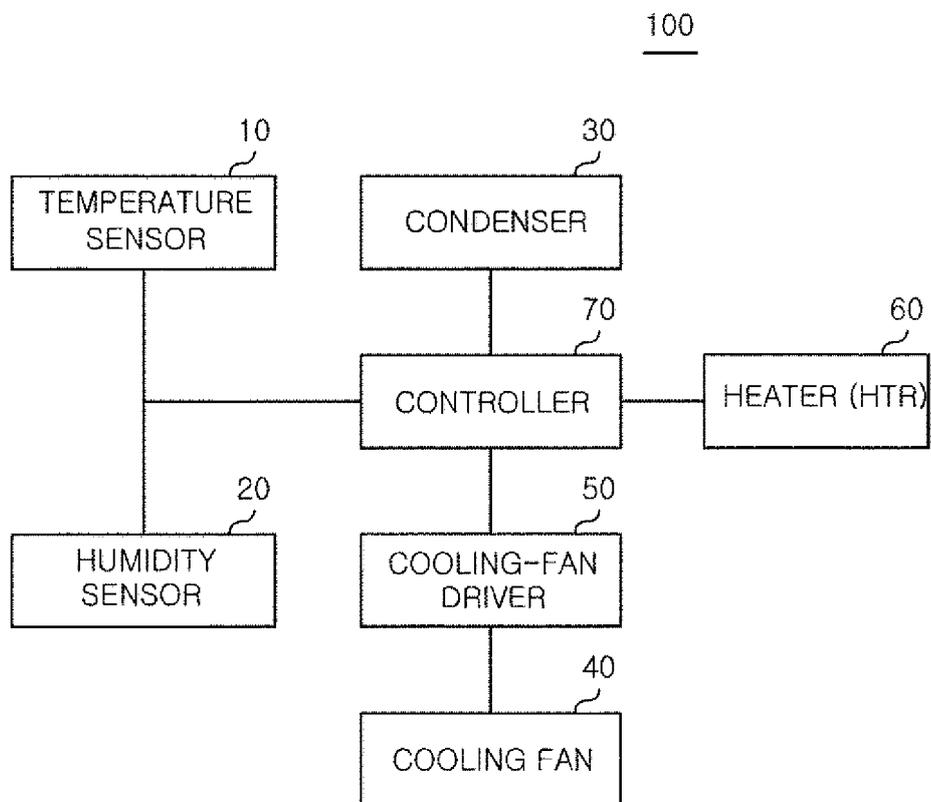


FIG. 2A

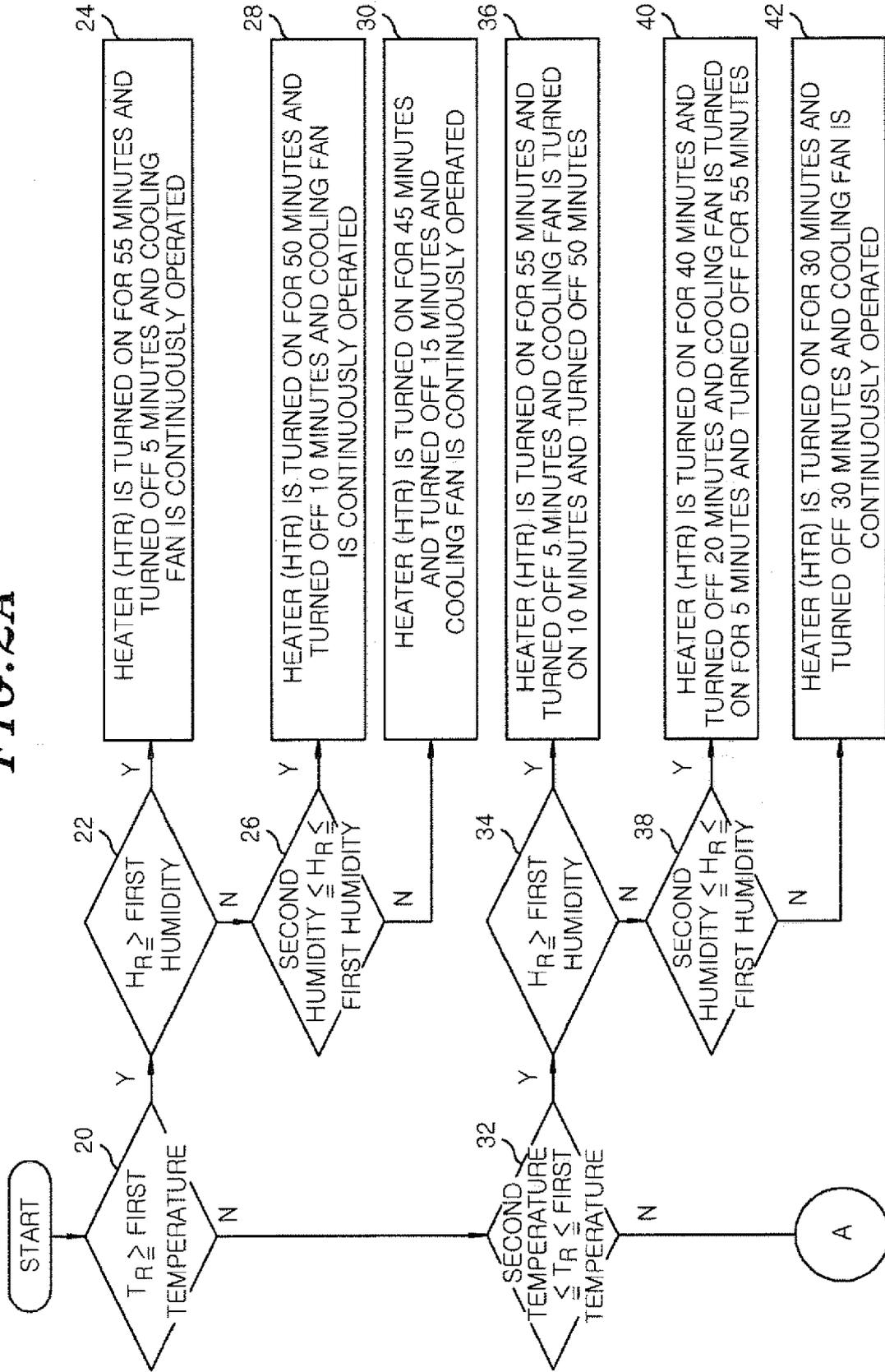
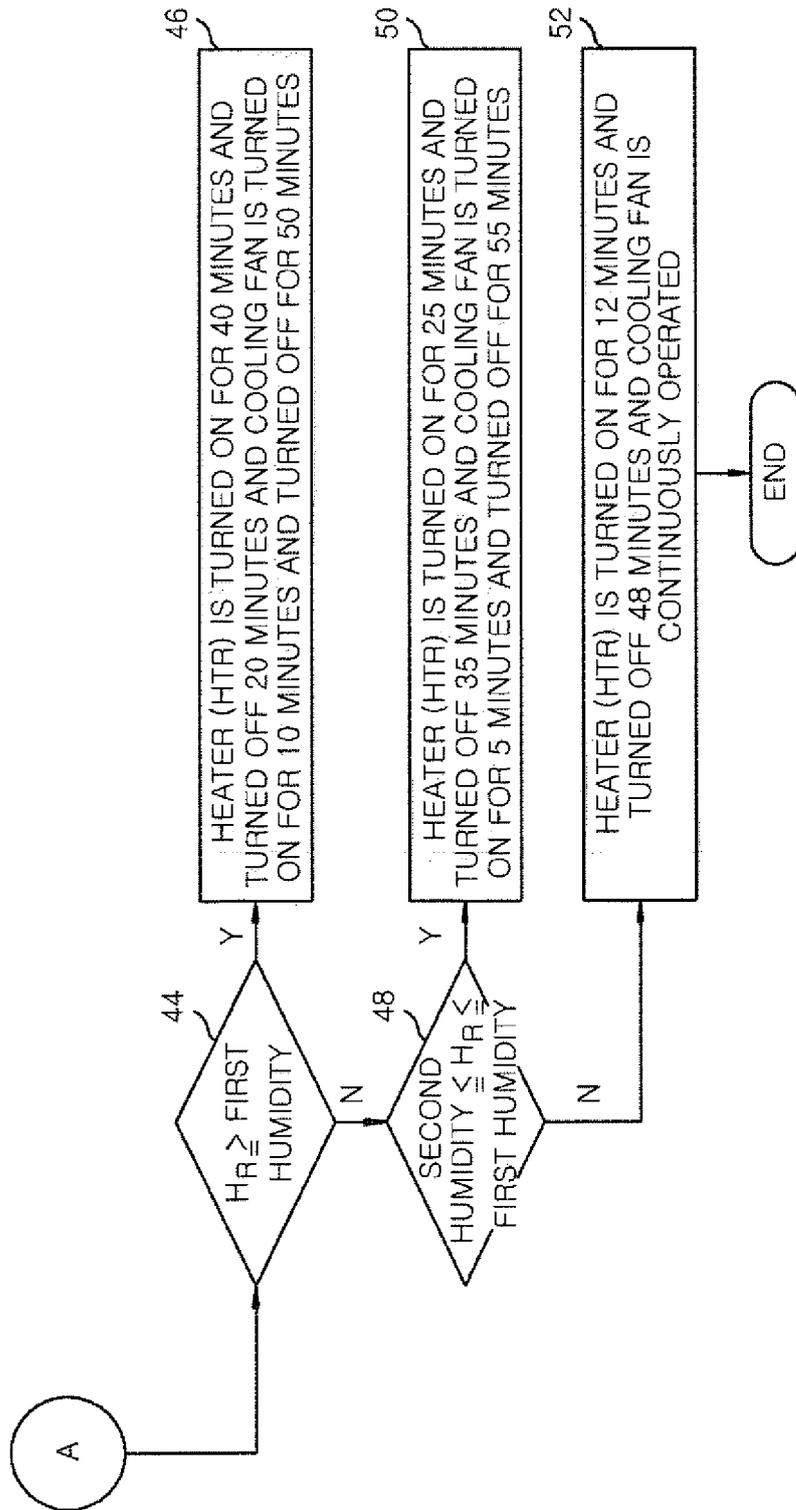


FIG. 2B





EUROPEAN SEARCH REPORT

Application Number  
EP 14 17 7014

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Place of search The Hague		Date of completion of the search 29 April 2015	Examiner Kuljis, Bruno
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT  
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**REFERENCES CITED IN THE DESCRIPTION**

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