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(54) **A TEMPERATURE CONTROLLER DEVICE, A METHOD AND A SYSTEM FOR DETERMINING A SETBACK TEMPERATURE**

(57) Disclosed is a temperature controller device comprising a temperature sensor configured to obtain a first temperature reading within an enclosed area; an air intake sensor configured to derive a second temperature reading outside the enclosed area; a timer configured to measure an operating time of the temperature controller device; an input module configured to obtain a desired temperature and/or a setback duration; a processor operable to calculate: (i.) a first thermal load rate based on the first temperature and second temperature reading, and the operating time of the temperature controller device, and (ii.) a setback temperature; wherein the setback temperature is a function of the first thermal load rate, the setback duration, and the desired temperature. A method and system for determining a setback temperature associated with the temperature controller device are also disclosed.

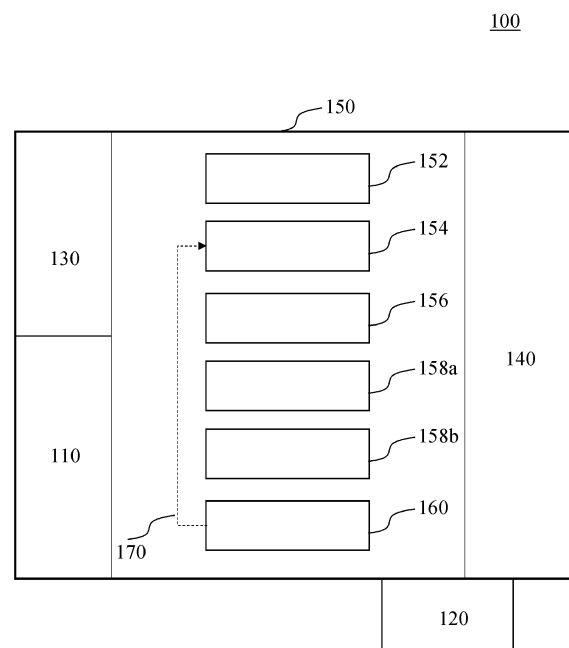


FIG. 1

Description**TECHNICAL FIELD**

5 **[0001]** The disclosure relates to a temperature controller device. The disclosure further relates to a method and system for determining a setback temperature associated with a temperature controller device.

BACKGROUND

10 **[0002]** The following discussion of the background is intended to facilitate an understanding of the present disclosure only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or is part of the common general knowledge of the person skilled in the art in any jurisdiction as of the priority date of the invention.

15 **[0003]** During periods when an enclosed area of a building is unoccupied for a certain duration, there are instances where the heating, ventilation and air-conditioning (HVAC) unit of the enclosed area continues to operate at a pre-set temperature. This results in energy wastage, unnecessary over-working of the HVAC unit, and leads to increased carbon dioxide emissions. Currently, the operating temperature of the HVAC unit can be altered, e.g. to a fixed setback temperature, during a setback duration when the enclosed area is vacant.

20 **[0004]** One solution is based on the use of timers or a pre-programmed scheduling system to alter the temperature of the HVAC unit to a fixed setback temperature during a setback duration. Generally, the setback temperature is defined to be 2 to 3 °C higher (in the cooling mode) or lower (in the heating mode) than the desired temperature so as to maintain a minimum level of comfort, resulting in minimal energy savings.

25 **[0005]** Another solution is based on occupant sensors to determine a setback duration of the enclosed area and to alter the temperature of the HVAC unit to a fixed setback temperature during the setback duration. Occupant sensors often have a limited detection coverage area, and this method is also associated with a delay in activating the setback temperature of the HVAC unit.

30 **[0006]** Another solution uses intelligent thermostats based on machine learning algorithms to define a fixed setback temperature for the HVAC unit during a setback period. Such intelligent thermostats are based on the preference of a single occupant and do not account for the preferences of all the occupants in the enclosed area. The fixed setback temperature is often thus insufficient for maintaining the overall thermal comfort level for all the occupants, leading to user dissatisfaction. The users may thus avoid activating the setback function, which may lead to over-working of the HVAC unit and/or high energy or power consumption.

35 **[0007]** Yet another solution is based on a central controller or cloud computing to determine a fixed setback temperature for an enclosed area during a setback duration. The setback temperature is based on occupant analytics obtained using the occupant sensors, weather conditions and the operating temperature of the HVAC unit. However, this method fails to account for the occupant(s) thermal comfort requirements.

40 **[0008]** Further, the aforementioned solutions are based on defining a fixed setback temperature which do not account for external temperature parameters, and are associated with a trade-off between energy savings and the thermal comfort requirements of the occupant(s).

40 **[0009]** There exists a need for an improved device to alleviate at least one of the aforementioned problem(s).

SUMMARY

45 **[0010]** The disclosure was conceptualized to provide a temperature controller device, and a method and a system for determining a setback temperature associated with the temperature controller device. The disclosure provides means to determine a setback temperature based on at least, external (e.g. outdoor) thermal parameters, occupant(s) thermal comfort requirements, and the thermal load rate of the device. In particular, the device of the present disclosure provide means for the device to establish a setback temperature for a portion of a setback duration, and to establish a target temperature by an end of the setback duration. The device is able to establish a dynamic setback temperature curve during the setback duration, which accounts for the occupant(s) thermal comfort requirements and at the same time, increases energy savings. In addition, the temperature controller device, method and system for determining the setback temperature associated with the temperature controller device does not require additional thermal sensors adapted to measure humidity, carbon dioxide and/or total volatile organic compounds. This provides a relatively simple and cost-effective means for determining the setback temperature during the setback duration.

55 **[0011]** According to a first aspect of the disclosure, there is provided a temperature controller device comprising a temperature sensor configured to obtain a first temperature reading within an enclosed area; an air intake sensor configured to derive a second temperature reading outside the enclosed area; a timer configured to measure an operating time of the temperature controller device; an input module configured to obtain a desired temperature and/or a setback

duration; a processor operable to calculate: (i.) a first thermal load rate based on the first temperature and second temperature reading, and the operating time of the temperature controller device, and (ii.) a setback temperature, wherein the setback temperature is a function of the first thermal load rate, the setback duration, and the desired temperature.

[0012] In some embodiments, the input module may be configured to receive an allowable deviation value associated with the desired temperature, and wherein the processor may be operable to calculate a target temperature based on the desired temperature and the allowable deviation value.

[0013] In some embodiments, the processor may be operable to further calculate: (i.) a first portion of the setback duration, and (ii.) a first recovery portion of the setback duration, wherein the first portion and the first recovery portion of the setback duration may be a function of the first thermal load rate, the desired and target temperature, and the setback duration.

[0014] In some embodiments, the processor may be configured to maintain the setback temperature associated with the first portion of the setback duration, and establish the target temperature by an end of the setback duration.

[0015] In some embodiments, the processor may be operable to calculate the setback temperature as a function of a pre-determined thermal load rate, the setback duration, and the desired temperature, when the processor determines that the operating time of the temperature controller device is less than or equal to a pre-determined threshold duration.

[0016] In some embodiments, the processor may be configured to receive inputs from at least one of the temperature sensor, the air intake sensor, the timer, and the input module at a pre-determined interval.

[0017] In some embodiments, the processor may be operable to further calculate: (i.) a second thermal load rate based on the inputs received from the at least one of the temperature sensor, the air intake sensor, and the timer, at the pre-determined interval, and (ii.) calculate the setback temperature at the pre-determined interval. The processor may be operable to adjust the first portion and/or first recovery portion of the setback duration in response to the setback temperature calculated at the pre-determined interval.

[0018] According to a second aspect of the disclosure, there is provided a system for determining the setback temperature associated with the temperature controller device according to the first aspect of the disclosure, wherein the processor is arranged in signal or data communication with at least one of the temperature sensor, the air intake sensor, the timer, and the input module, such that in operation, the processor: (i.) receives inputs from the at least one of the temperature sensor, the air intake sensor, the timer, and/or the input module; (ii.) calculates the first thermal load rate based on the first temperature and second temperature reading, and the operating time of the temperature controller device, and (iii.) calculates the setback temperature, wherein the setback temperature is a function of the first thermal load rate, the setback duration, and the desired temperature.

[0019] According to third aspect of the disclosure, there is provided a method for determining a setback temperature associated with a temperature controller device comprising the steps of: receiving a first temperature reading associated with an enclosed area; receiving a second temperature reading outside the enclosed area; receiving an operating time of the temperature controller device; receiving a desired temperature and/or a setback duration; and calculating: (i.) a first thermal load rate based on the first temperature and second temperature reading, and the operating time of the temperature controller device, and (ii.) a setback temperature, wherein the setback temperature is a function of the first thermal load rate, the setback duration, and the desired temperature.

[0020] In some embodiments, the method may further comprise: (i.) receiving, an allowable deviation value associated with the desired temperature, and (ii.) calculating, a target temperature based on the desired temperature and the allowable deviation value.

[0021] In some embodiments, the method may further comprise: (i.) calculating, a first portion of the setback duration, and (ii.) calculating, a first recovery portion of the setback duration. The first portion and the first recovery portion of the setback duration may be a function of the first thermal load rate, the desired temperature, the target temperature, and the setback duration.

[0022] In some embodiments, the method may further comprise: (i.) operating, the temperature controller device to maintain the setback temperature during the first portion of the setback duration, and (ii.) operating, the temperature controller device to establish the target temperature by the end of the setback duration.

[0023] In some embodiments, the method may further comprise: (i.) receiving at least one of the first temperature reading, the second temperature reading, the operating time of the temperature controller device, the desired temperature and/or the setback duration at a pre-determined interval.

[0024] In some embodiments, the method may further comprise: (i.) calculating a second thermal load rate based on the inputs received from the at least one of the first temperature reading, the second temperature reading, the operating time of the temperature controller device, at the pre-determined interval, and (ii.) calculating the setback temperature at the pre-determined interval. It may be envisaged that the first portion and/or the first recovery portion of the setback duration may be adjusted in response to the setback temperature calculated at the pre-determined interval.

[0025] In some embodiments, there is a computer program product, comprising software instructions installed thereon, such that when executed on a processor, may execute the steps according to the second aspect of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The invention will be better understood with reference to the detailed description when considered in conjunction with the non-limiting examples and the accompanying drawings, in which:

- FIG. 1 shows a schematic illustration of a temperature controller device 100, in accordance with various embodiments;
- FIGS. 2A and 2B show graphs 200A, 200B in accordance with a use condition of the temperature controller device 100, in accordance with various embodiments;
- FIG. 3 shows a schematic illustration of a system 300 for determining the setback temperature 154 associated with the temperature controller device 100, in accordance with various embodiments;
- FIGS. 4A and 4B show schematic illustrations of methods 400A and 400B for determining a setback temperature associated with a temperature controller device 100, in accordance with various embodiments; and
- FIG. 5 shows a schematic illustration of method 500 for determining the dynamic setback temperature curve 210 associated with the temperature controller device 100, in accordance with various embodiments.

DETAILED DESCRIPTION

[0027] The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure. Other embodiments may be utilized and structural, and logical changes may be made without departing from the scope of the disclosure. The various embodiments are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments.

[0028] The disclosure illustratively described herein may suitably be practiced in the absence of any element or elements, limitation or limitations, not specifically disclosed herein. Thus, for example, the terms "comprising", "including", "containing", etc. shall be read expansively and without limitation. The word "comprise" or variations such as "comprises" or "comprising" will accordingly be understood to imply the inclusion of a stated integer or groups of integers but not the exclusion of any other integer or group of integers. Additionally, the terms and expressions employed herein have been used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the disclosure. Thus, it should be understood that although the present disclosure has been specifically described in exemplary embodiments and optional features, modification and variation of the disclosure embodied herein may be resorted to by those skilled in the art.

[0029] Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments. Features that are described in the context of an embodiment may correspondingly be applicable to the other embodiments, even if not explicitly described in these other embodiments. Furthermore, additions and/or combinations and/or alternatives as described for a feature in the context of an embodiment may correspondingly be applicable to the same or similar feature in the other embodiments.

[0030] In the context of various embodiments, the articles "a", "an" and "the" as used with regard to a feature or element include a reference to one or more of the features or elements. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0031] Throughout the description, the term "temperature controller", as used herein, may refer to a device that may be used to control the temperature of an enclosed area. For example, the temperature controller may be a thermostat controller, or may be a central controller of an environmental regulation system, such as a HVAC system, a heating system, and/or an electric fan or air-conditioning system. In some embodiments, the temperature controller device may operate, e.g. via a mode selector, in an active mode where the system controlled by the temperature controller device may be operating/maintained at a desired temperature; and a setback mode where the device may be operating at a setback temperature.

[0032] Throughout the description, the term "enclosed area", as used herein, may refer to a space between a floor and a ceiling that is enclosed on at least one side by solid walls or windows. For example, the enclosed area may be a part of or a division of a building enclosed by walls, floor, and ceiling, i.e. such as a room which may be enclosed on all sides. As a further example, the enclosed area may be enclosed on two or three sides, and may include enclosed areas such as a warehouse or a hangar.

[0033] Throughout the description, the term "air intake sensor", as used herein, may refer to a mass (air) flow sensor used to determine the mass flow rate of air entering a temperature controller device. The air intake sensor may be configured to measure or sense the temperature of the air outside the enclosed area. For example, the air intake sensor may be a temperature sensor, e.g. thermometer, adapted to measure the temperature of the air outside the enclosed area.

[0034] Throughout the description, the term "operating time", as used herein, may refer to a quantitative measure of

the time interval during which the temperature controller device is in an operating state or condition. For example, the operating time may include the time interval when the temperature controller device is in the active mode and is operating at the desired temperature, and may also include the time when the temperature controller device is in the setback mode and is operating at the setback temperature.

[0035] Throughout the description, the term "desired temperature", as used herein, may refer to a temperature which provides a satisfactory thermal comfort level for one or more occupants in the enclosed area. In some embodiments, the desired temperature may be user defined, for example, defined by the one or more occupants within the enclosed area. In some embodiments, the desired temperature may be determined based on the feedback of the one or more occupants.

[0036] Throughout the description, the term "setback temperature", as used herein, may refer to a temperature distinct, e.g. altered temperature, relative to the desired temperature. For example, when the temperature controller device is in a cooling mode, the setback temperature may be approximately 1 - 5 °C, or preferably 3 - 5 °C higher than the desired temperature. In another example, when the temperature controller device is in a heating mode, the setback temperature may be approximately 1 - 5 °C, or preferably 3 - 5 °C lower than the desired temperature. Accordingly, the term "setback duration", as used herein, may refer to a time interval during which the temperature controller device is operating at the setback temperature.

[0037] Throughout the description, the term "processor", as used herein, may refer to one or more integrated circuit(s) operable to control the temperature controller device. The processor may be a circuit and may include analog circuits or components, digital circuits or components, or hybrid circuits or components. Any other kind of implementation of the respective functions which will be described in more detail below may also be understood as a "circuit" in accordance with an alternative embodiment. A digital circuit may be understood as any kind of a logic implementing entity, which may be special purpose circuitry or a processor executing software stored in a memory, firmware, or any combination thereof. Thus, in various embodiments, a "circuit" may be a digital circuit, e.g. a hard-wired logic circuit or a programmable logic circuit such as a programmable processor, e.g. a microprocessor (e.g. a Complex Instruction Set Computer (CISC) processor or a Reduced Instruction Set Computer (RISC) processor). A "circuit" may also include a processor executing software, e.g. any kind of computer program, e.g. a computer program using a virtual machine code such as e.g. Java.

[0038] FIG. 1 shows an exemplary schematic illustration of a temperature controller device 100. FIGS. 2A and 2B show exemplary graphs 200A, 200B in accordance with a use condition of the temperature controller device 100. Graph 200A shows the dynamic setback temperature curve 210 during the setback duration 144, and the second temperature reading 122; and graph 200B shows the corresponding energy consumption based on the dynamic setback temperature curve 210 established in accordance with the use condition of the device 100.

[0039] Referring to FIGS. 1, 2A and 2B, a temperature controller device 100 includes a temperature sensor 110 configured to obtain a first temperature reading 112 within an enclosed area; an air intake sensor 120 configured to derive a second temperature reading 122 outside the enclosed area; a timer 130 configured to measure an operating time of the temperature controller device; an input module 140 configured to obtain a desired temperature 142 and/or a setback duration 144; a processor 150 operable to calculate: (i.) a first thermal load rate 152 based on the first temperature 112 and second temperature 122 reading, and the operating time of the temperature controller device, and (ii.) a setback temperature 154. The setback temperature 154 is a function of the first thermal load rate 152, the setback duration 144, and the desired temperature 142.

[0040] The device 100 includes a temperature sensor 110 configured to obtain, e.g. measure a first temperature reading 112 within an enclosed area. The first temperature reading 112 may therefore be the indoor temperature of the enclosed area.

[0041] The device 100 includes an air intake sensor 120 configured to derive, e.g. measure a second temperature reading 122 outside the enclosed area, and as such, the second temperature reading 122 may be the outdoor air temperature. In some embodiments, the air intake sensor 120 may be located on the device 100 and adapted to face the outdoor environment. In some other embodiments, the air intake sensor 120 may be separate to the device 100 and may be placed on the exterior of the enclosed area, e.g. on the building façade, to obtain or derive the second temperature reading 122. The second temperature reading 122 may be transmitted to the device 100 via wired or wireless means, as will be explained below.

[0042] The device 100 includes a timer 130 configured to measure an operating time of the temperature controller device 100. The timer 130 may be activated once the device 100 is in operation, e.g. switched on, to measure the operating duration of the device 100. The timer 130 may be deactivated once the device 100 ceases operation, e.g. switched off or standby. In some embodiments, the timer 130 may include means, e.g. calendar and/or clock, configured to measure a date and time, e.g. time of the day.

[0043] The device 100 includes an input module 140 configured to obtain a desired temperature 142. In some embodiments, the input module 140 may include an interface adapted to allow a user to input a desired temperature, e.g. a distinct value of a desired temperature. Alternatively, or in addition, the input module 140 may be configured to allow the user to provide feedback on their thermal comfort level. For example, the input module 140 may include a user

comfort feedback mechanism or system configured to receive the occupant(s) feedback on their thermal comfort level. As a further example, the user comfort feedback mechanism or system may be based on the predictive mean vote index. In some embodiments, the input module 140, e.g. via the user comfort feedback mechanism or system, and/or the processor 150 may be operable to obtain the desired temperature 142 based on the occupant(s) thermal comfort feedback.

[0044] The input module 140 is also configured to receive the setback duration 144. The setback duration 144 may refer to a duration when the enclosed area is vacant or unoccupied, or during conditions when there is no need for the device 100 to operate at the desired temperature 142, e.g. during night time when the occupant(s) body temperature is generally lower. In some embodiments, the input module 140 may include an interface adapted to allow a user to input a defined setback duration 144, e.g. a distinct value of a setback duration 144, and a defined setback date and/or time, e.g. time of the day. Based on the defined setback duration 144, date and/or time, the device 100 may be operable to activate the setback mode at the setback date and/or time for the defined setback duration 144. In some other embodiments, the setback duration 144 may be based on a machine learning algorithm based on historical data obtained from occupant tracking sensors, such as passive infrared motion sensors, micro radar sensors, cameras, which may track the date, time and/or duration during which the enclosed area is unoccupied. The algorithm may be established based on the analysis of such occupant tracking historical data to predict the setback duration 144 and/or the setback date and time. In some other embodiments, the setback duration 144 may be based on a machine learning algorithm based on historical data of a preferred setback duration 144, date and/or time, to predict the setback duration 144 and/or the setback date and time.

[0045] In some embodiments, the device 100 may include or may be connected to a heating and/or cooling device, e.g. device operable to heat and/or cool the enclosed area. An example of a heating device may be electric heaters. An example of a cooling device may be an electric fan or air-conditioning system.

[0046] The device 100 also include a processor 150, which is operable to calculate: (i.) a first thermal load rate 152 based on the first temperature 112 and second temperature 122 reading, and the operating time of the temperature controller device 100. In some embodiments, the processor 150 may calculate the first thermal load rate 152 according to Equation 1:

$$\text{first thermal load rate} = \frac{\text{second temperature reading} - \text{first temperature reading } (^{\circ}\text{C})}{\text{operating time of the device (mins)}} \quad (1)$$

The first thermal load rate 152 (expressed in $^{\circ}\text{C} / \text{mins}$) is thus a representation of the heat transfer balance of the temperature controller device 100 in the enclosed area. Based on the first thermal load rate 152, a user may determine the duration required for the device 100 to establish a desired temperature 142. Without wishing to be bound by theory, the energy consumption of the temperature controller device 100 may be correlated to the second temperature reading 144, e.g. outdoor air temperature. Specifically, the second temperature reading 144 has an effect on heat transfer through the walls and roofs of the enclosed area, and thus, the energy required for the temperature controller device 100 to establish and maintain the desired temperature 142. For example, in a warm environment, e.g. second temperature reading 144 is 35°C , the temperature controller device 100 may have a higher first thermal load rate 152 than the same device 100 in a cooler environment, e.g. second temperature reading 144 is 28°C (assuming the same first temperature reading 112 and operating time of the device 100 in both conditions). As such, to obtain a desired temperature 142, the temperature controller device 100 operating in a warmer environment may have a higher energy consumption as compared to the same device 100 operating in the cooler environment. That is to say, the first thermal load rate 152 is a measure of the effect the second temperature reading 144, e.g. outdoor air temperature, on the operation of the temperature controller device 100. Since the temperature controller device 100 may be operable as a heating or a cooling device, the first thermal load rate 152 may be a positive value when the device 100 is in the cooling mode, and may have a negative value when the device 100 is in the heating mode.

[0047] The processor 150 is further operable to calculate the setback temperature 154, wherein the setback temperature 154 is a function of the first thermal load rate 152, the setback duration 144, and the desired temperature 142. In some embodiments, the setback temperature 154 may be calculated according to Equation 2:

$$\text{setback temperature} = f(\text{first thermal load rate}, \text{setback duration}, \text{desired temperature}) \quad (2)$$

In a non-limiting embodiment, the processor 150 may perform a mathematical operation/calculation to determine the setback temperature 154 by adding (e.g. cooling mode) or subtracting (e.g. heating mode) the desired temperature 142 to a product of the first thermal load rate 152 and the setback duration 144. It is contemplated that other functions based on the parameters of the first thermal load rate 152, the setback duration 144, and the desired temperature 142, may be used to determine the setback temperature 154. The processor 150 is further operable to establish the setback

temperature 154, e.g. may provide instructions to operate the cooling or heating device such that it establishes the setback temperature 154.

[0048] The input module 140 may be further configured to receive a setback temperature limit, e.g. a user defined setback temperature limit. The setback temperature limit may be associated with a desired temperature 144, and/or the occupant(s) thermal comfort level. In some embodiments, the processor 150 may be further operable to determine if the calculated setback temperature 154 is higher, e.g. in the cooling mode, or lower, e.g. in the heating mode, than the setback temperature limit. When it is determined that the calculated setback temperature 154 exceeds or falls below the setback temperature limit, e.g. via a comparative operation performed by the input module 140 or processor 150, the processor 150 may be configured to operate the device 100 at the setback temperature limit. In other words, the setback temperature limit may override the calculated setback temperature 154 when it is determined that the calculated setback temperature 154 exceeds or falls below that of the setback temperature limit.

[0049] The processor 150 may be operable to calculate the setback temperature 154 as a function of a pre-determined thermal load rate, the setback duration 144, and the desired temperature 142, when the processor 150 determines that the operating time of the temperature controller device 100 is less than or equal to a pre-determined threshold duration. In some embodiments, the pre-determined thermal load rate may be a default thermal load rate for the temperature controller device 100, which may be based on historical data of the thermal load rate of the device 100 under exemplary conditions, e.g. exemplary first temperature 112 and/or second temperature readings 114. Alternatively, or in addition, the pre-determined thermal load rate may be in accordance with the manufacturer specifications for the device 100. It is envisaged that the pre-determined thermal load rate is associated with a satisfactory thermal comfort level for the occupant(s) in the enclosed area. In an example, a user may wish to operate the device 100 at the setback temperature 154 once the device 100 is activated, e.g. when the operating time of the device 100 is 0 mins, which may be less than or equal to the pre-determined threshold duration. In another example, the processor 150 may be operable to calculate the setback temperature 154 based on the pre-determined thermal load rate, when the calculated first thermal load rate 152 may not be indicative of the thermal load rate of the device 100, e.g. when the operating time of the device 100 is less than or equal to the pre-determined threshold duration of about 10 mins, or about 5 mins, or less. This may in part, be due to the ramp-up phase that the device 100 requires upon activation of the device 100.

[0050] The input module 140 may be configured to receive an allowable deviation value associated with the desired temperature, and the processor 150 may be operable to calculate a target temperature 156 based on the desired temperature and the allowable deviation value. In some embodiments, the input module 140 may include an interface to allow the user to input the allowable deviation value. Alternatively, a pre-determined allowable deviation value may be stored in a memory (not shown) of the device 100. The processor 150 may calculate the target temperature 156 according to Equation 3:

$$\text{target temperature} = \text{desired temperature} \pm \text{allowable deviation value} \quad (3)$$

For example, in the cooling mode, the target temperature 156 may be calculated by adding the desired temperature and the allowable deviation value, and in the heating mode, the target temperature 156 may be calculated by subtracting the allowable deviation value from the desired temperature. The allowable deviation value may be a measure of the difference between the target 156 and desired 142 temperature, and may be about 2 °C, about 3 °C, about 5 °C, but no more than about 10 °C. Within the context of the disclosure, when the device 100 operates at the target temperature 156, the user or occupant(s) do not perceive any change, or perceives minimal changes to their thermal comfort level.

[0051] The processor 150 may be operable to further calculate: (i.) a first portion 158a of the setback duration 144, and (ii.) a first recovery portion 158b of the setback duration 144. The first portion 158a and the first recovery portion 158b of the setback duration may be a function of the first thermal load rate 152 (or pre-determined thermal load rate), the desired 142 and target 156 temperature, and the setback duration 144. In some embodiments, the processor 150 may perform a mathematical operation to calculate the first portion 158a and first recovery portion 158b, in accordance with Equation 4:

$$\begin{aligned} &\text{first portion and first recovery portion of setback duration} = \\ &f(\text{first thermal load rate, desired temperature, target temperature}) \end{aligned} \quad (4)$$

In a non-limiting embodiment, the first portion 158a of the setback duration 144 may be a pre-determined time interval, e.g. 15 min interval, and the processor 150 may be configured to calculate the setback temperature 154, e.g. based on Equation 2, at the end of the first portion 158a to determine the setback temperature 154 for the next block of the pre-determined time interval, e.g. 15 mins. For example, at a desired temperature 142 of 25 °C, the setback temperature

154 for the first portion 158a (pre-determined time interval of 15 mins) of the setback duration 144 may be determined to be 25.8 °C when the second temperature reading 122 (outside the enclosed area) is at 35 °C; and the setback temperature 154 for the next portion (pre-determined time interval of 15 mins) of the setback duration 144 may be determined to be 27 °C when the second temperature reading 122 is at 30 °C. As may be seen, the setback temperature 154 was increased by +2 °C, i.e. from 25 to 27 °C, over the cumulative period of the 30 min interval, when the second temperature reading 122 dropped from 35 to 30 °C. Accordingly, the dynamic setback temperature curve 210 may be obtained. The first recovery portion 158b may be the remaining duration of the setback duration 144, and the processor 150 may be operable to establish the target temperature 156 by the end of the setback duration 144. Alternatively, it is envisaged that the first portion 158a and first recovery 158b of the setback duration 144 may be a function of the first thermal load rate 152, the desired 142 and target 156 temperature, the setback duration 144, and additionally, the first thermal reading 112, the second thermal reading 122 and the operating time of the device 100. It is further contemplated that the processor 150 may be configured to perform other mathematical operation/calculations, e.g. simultaneous equation algorithms, to determine the first portion 158a and first recovery portion 158b based on the indicated parameters in Equation 4.

[0052] The processor 150 may be configured to maintain the setback temperature 154 during the first portion 158a of the setback duration 144, and to establish the target temperature 156 by an end of the setback duration 144. In some embodiments, the processor 150 may be configured such that the cooling or heating device establishes and maintains the setback temperature 154 during the first portion 158a of the setback duration 144. The processor 150 may also be configured to operate the cooling or heating device to establish the target temperature 156 during the first recovery portion 158b, such that the temperature of the enclosed area is at the target temperature 156 by the end of the setback duration, e.g. when the enclosed area is predicted to be occupied, or when device 100 exits the setback mode.

[0053] The processor 150 may be configured to receive inputs from at least one of the temperature sensor 110, the air intake sensor 120, the timer 130, and the input module 140 at a pre-determined interval. For example, the processor 150 may receive at least one of the first temperature reading 112, the second temperature reading 122, the operating time of the device 100, the desired temperature 142 and/or the setback duration 144 at the pre-determined time interval. The pre-determined interval may be a user defined time interval, and may be about 5 mins, about 15 mins, about 30 mins, about 1 hour, about 2 hours, but no more than 3 hours.

[0054] Based on the at least one input received at the pre-determined interval, the processor 150 may be further operable to calculate: (i.) a second thermal load rate 160. In some embodiments, calculation of the second thermal load rate 160 may be based on the received inputs from at least one of the temperature sensor 110, e.g. first temperature reading 112, the air intake sensor 120, e.g. second temperature reading 122, and the timer 130, e.g. operating time of the device 100, and the second thermal load rate 160 may be calculated according to Equation 1. Based on the second thermal load rate 160 at the pre-determined interval, the processor 150 may be further operable to calculate the setback temperature 154 at the pre-determined interval (see feedback arrow 170 in FIG. 1). The setback temperature 154 may be a function of the second thermal load rate 162, the setback duration 144, and the desired temperature 142, and may be calculated in accordance with Equation 2.

[0055] In some embodiments, the processor 140 may be operable to calculate the target temperature 156 based on the desired temperature 142 and/or the allowable deviation value received at the pre-determined interval. In some other embodiments, the processor 150 may also receive and update the setback duration 144 received from the input module 140 at the pre-determined interval. As such, the processor 150 may be further operable to calculate the second thermal load rate 160 and/or the setback temperature 154 at the pre-determined interval.

[0056] Based on the calculated second thermal load rate 160 and the setback temperature 154 at the pre-determined interval, the processor 150 may adjust, e.g. lengthen and/or shorten, the first portion 158a and first recovery portion 158b of the setback duration 144. In an example, in the cooling mode, a shorter recovery portion may be required when the setback temperature 154 determined at the pre-determined interval is less than the originally calculated setback temperature 154. Since the difference between setback temperature 154 and target temperature 156 is smaller, a shorter duration may be required for the device 100 to establish the target temperature 156 by the end of the setback duration 144. In other words, since the second temperature reading 122, e.g. derived via the air intake sensor 120, is correlated to the thermal load rate of the device 100, the device 100 may require less time to establish the target temperature 156 in cooler conditions and as such, the first recovery portion 158b may be shortened.

[0057] The processor 150 may continuously calculate and update the setback temperature 154 for the device 100, based on the inputs received from at least one of the temperature sensor 110, the air intake sensor 120, the timer 130, and the input module 140, at the pre-determined interval. The processor 150 may thus be configured to establish a dynamic setback temperature curve 210 (as shown in FIG. 2A) which is dependent on the inputs received from at least one of the temperature sensor 110, the air intake sensor 120, the timer 130, and the input module 140 at the pre-determined interval. That is to say, the calculated setback temperature 154 may form or may be a dynamic setback temperature curve 210 which is calculated and updated at specific pre-determined intervals (see feedback arrow 170 in FIG. 1). As shown in FIG. 2A, the dynamic setback temperature 154 may be based at least on the second temperature

reading 122, e.g. outdoor air temperature, received at the pre-determined intervals, which has an effect on the setback temperature 154, and consequently, the energy consumption of the device 100.

[0058] Referring to the graph 200B as shown in FIG. 2B, graph 220 may represent the energy consumption of conventional temperature controller devices where the device is configured to operate at a fixed setback temperature for the setback duration 144. The energy savings from operating the device at the fixed setback temperature may be represented by area 222. Graph 230 may represent the energy consumption according to the temperature controller device 100 of the disclosure. The energy savings due to the dynamic setback temperature curve 210 may be represented by areas 222 and 232. In particular, because the temperature controller device 100 of the disclosure is configured to establish and maintain the setback temperature 154 for the first portion 158a of the setback duration 144, and establish the target temperature 156 by the end of the setback duration 144, there may be additional energy savings, represented by area 232, due to the establishment of the dynamic setback temperature curve 210. In addition, since the device 100 is configured to establish the target temperature 156 which is based on the desired temperature 142 and the allowable deviation value, e.g. higher (in the cooling mode) or lower (in the heating mode) than the desired temperature 142, there may be additional energy savings since the device 100 requires less energy to establish the target temperature 156 (as opposed to the desired temperature 154). Further, the establishment of the target temperature 156, at the end of the setback duration 144, has minimal or no effect on the perceived thermal comfort level of the occupant(s). As a result, the device 100 of the disclosure advantageously provides maximum energy savings (represented by areas 222 and 232), while maintaining the desired comfort level of the occupant(s) within the enclosed area.

[0059] FIG. 3 shows an exemplary schematic illustration of a system 300 for determining the setback temperature 154 associated with the temperature controller device 100. System 300 discloses a system 300 for determining the setback temperature associated with the temperature controller device 100, wherein the processor is arranged in signal or data communication with at least one of the temperature sensor 110, the air intake sensor 120, the timer 130, and/or the input module 140, such that in operation, the processor: (i.) receives inputs from the at least one of the temperature sensor 110, the air intake sensor 120, the timer 130, and/or the input module 140; (ii.) calculates the first thermal load rate 152 based on the first temperature 112 and second temperature 122 reading, and the operating time of the temperature controller device, and (iii.) calculates the setback temperature 154, wherein the setback temperature 154 is a function of the first thermal load rate 152, the setback duration 144, and the desired temperature 142.

[0060] System 300 may be based on the temperature controller device 100 described above, and may include the temperature sensor 110, the air intake sensor 120, the timer 130, the input module 140, and the processor 150, described with reference to FIGS. 1 to 2B. Repeated description are omitted for brevity. In system 300, the processor 150 may be arranged in signal or data communication with at least one of the temperature sensor 110, the air intake sensor 120, the timer 130, and the input module 140 (see dotted arrows in FIG. 3).

[0061] In some embodiments, the various components of system 300 may be integrated on the temperature controller device 100, and may be in signal or data communication via wired means.

[0062] In some other embodiments, the various components of the system 300 may not be integrated on the temperature controller device 100. For example, the various components of system 300 may be placed at different locations in the enclosed area, e.g. the air intake sensor 120 may be located on the building façade, the input module 140 may be a handheld device, the processor 150 may be on a cloud network, or in a location remote to the location at which the device 100 is placed at. In such embodiments, the processor 150 may be in signal or data communication with the temperature sensor 110, the air intake sensor 120, the timer 130, the input module 140 via wireless means, and data may be transmitted from the various components to the processor 150 in accordance with a pre-defined wireless communication protocol. Examples of the pre-defined wireless communication protocols include: global system for mobile communication (GSM), enhanced data GSM environment (EDGE), wideband code division multiple access (WCDMA), code division multiple access (CDMA), time division multiple access (TDMA), wireless fidelity (Wi-Fi), voice over Internet protocol (VoIP), worldwide interoperability for microwave access (Wi-MAX), Wi-Fi direct (WFD), an ultra-wideband (UWB), infrared data association (IrDA), Bluetooth, ZigBee, SigFox, LPWan, LoRaWan, GPRS, 3G, 4G, LTE, and 5G communication systems.

[0063] In operation, the processor 150 in system 300 may (i.) receive the inputs from the at least one of the temperature sensor 110, the air intake sensor 120, the timer 130, and/or the input module 140. In particular, the processor 150 may receive the first temperature reading 112, the second temperature reading 122, the operating time of the device 100, the desired temperature 142, and/or the setback duration 144. In some embodiments, the processor 150 may also receive at least one of the first temperature reading 112, the second temperature reading 122, the operating time of the device 100, the desired temperature 142, and/or the setback duration 144 at the pre-determined interval.

[0064] The processor 150 may then (ii.) calculate the first thermal load rate 152 based on the first temperature 112 and second temperature reading 122, and the operating time of the temperature controller device 100. The first thermal load rate 152 may be calculated according to Equation 1. In some embodiments, the processor 150 may be operable to further calculate the second thermal load 160 based on the inputs received from the at least one of the temperature sensor 110, the air intake sensor 120, and/or the timer 130 at the pre-determined interval. The second thermal load rate

160 may be calculated according to Equation 1.

[0065] Based on the first thermal load rate 152, the processor 150 may (iii.) calculate the setback temperature 154. The setback temperature 154 may be a function of the first thermal load rate 152, the setback duration 144, and the desired temperature 142, and may be calculated in accordance with Equation 2. In some embodiments, the processor 150 may calculate the setback temperature 154 which may be a function of the second thermal load rate 160, the setback duration 144 and/or the desired temperature 142 received at the pre-determined interval. As explained with reference to FIGS 2A and 2B, when in operation, the processor 150 may be configured to calculate and update the setback temperature 154 (see feedback arrow 170 in FIG. 3) to establish the dynamic setback temperature curve 210.

[0066] FIGS. 4A and 4B show schematic illustrations of methods 400A and 400B for determining a setback temperature associated with a temperature controller device 100, by way of example. Methods 400A and 400B discloses a method 400A, 400B for determining a setback temperature associated with a temperature controller device 100 comprising the steps of: receiving a first temperature reading associated with an enclosed area 412; receiving a second temperature reading outside the enclosed area 414; receiving an operating time of the temperature controller device 416; receiving a desired temperature 418 and/or a setback duration 420; calculating: (i.) a first thermal load rate 430 based on the first temperature 412 and second temperature reading 414, and the operating time of the temperature controller device 416, and (ii.) a setback temperature 440, wherein the setback temperature is a function of the first thermal load rate 430, the setback duration 420, and the desired temperature 418. The temperature controller device 100 may be the same as the device 100 described above. Specifically, the temperature controller device 100 may include the temperature sensor 110, the air intake sensor 120, the timer 130, the input module 140, and the processor 150, described with reference to FIGS. 1 to 3, and repeated description are omitted for conciseness.

[0067] Methods 400A, 400B includes at step 412, receiving a first temperature reading associated with an enclosed area. The first temperature reading may be obtained using the temperature sensor 110, and may be the indoor temperature of the enclosed area. At step 414, method 400A includes receiving a second temperature reading outside the enclosed area. The second temperature reading may be derived using the air intake sensor 120 and may be the outdoor air temperature. Methods 400A, 400B also includes at step 416, receiving an operating time of the temperature controller device 100, which may be measured using a timer 130.

[0068] Methods 400A, 400B also includes, at step 418, receiving a desired temperature, and/or at step 420, receiving a setback duration. The desired temperature and/or setback duration may be obtained by input module 140. In some embodiments, the desired temperature, e.g. received at step 418, may be a user defined desired temperature. Alternatively, or in addition, the desired temperature may be based on the occupant(s) thermal comfort level, e.g. via a user comfort feedback mechanism or system based on predictive mean vote index. In some embodiments, the setback duration, e.g. received at step 420, may be a user defined setback duration, and may also include the date and time at which the device 100 enters the setback mode. Alternatively, the setback duration, setback time and/or date, may be based on a machine learning algorithm based on historical data to predict the setback duration, setback date and/or time at which the device 100 enters the setback mode and operates at the setback temperature.

[0069] Methods 400A, 400B further includes, at step 430, calculating a first thermal load rate based on the first temperature and second temperature readings, obtained at steps 412 and 414, respectively, and the operating time of the temperature controller device, obtained at step 416. Step 430 may be performed by the processor 150, and the calculation of the first thermal load rate may be in accordance with Equation 1.

[0070] Methods 400A, 400B further includes, at step 440, calculating a setback temperature. The setback temperature is a function of the first thermal load rate, the setback duration, and the desired temperature. Step 440 may be performed by the processor 150, and the calculation of the setback temperature may be in accordance with Equation 2.

[0071] Methods 400A, 400B may further include: (i.) receiving an allowable deviation value associated with the desired temperature 450, and (ii.) calculating a target temperature based on the desired temperature and the allowable deviation value 460. In some embodiments, at step 450, the allowable deviation value may be received using the input module 140, and may be a user defined deviation value. Step 460 may include calculating the target temperature based on the desired temperature and the allowable deviation value. In some embodiments, calculation of the target temperature may be performed by the processor 150, and may be calculated in accordance with Equation 3. Within the context of the disclosure, when the device 100 operates at the target temperature, the occupant(s) within the enclosed area do not perceive any change, or perceives minimal changes to their thermal comfort level.

[0072] Methods 400A, 400B may further include, at steps 470a and 470b, (i.) calculating a first portion of the setback duration 470a; and (ii.) a first recovery portion of the setback duration 470b. The first portion and the first recovery portion of the setback duration may be a function of the first thermal load rate, the desired and target temperature, and the setback duration. In some embodiments, steps 470a and 470b may be performed by the processor 150, in accordance with Equation 4 as described above.

[0073] Methods 400A, 400B may further include, (i.) operating the temperature controller device 100 to maintain the setback temperature during the first portion of the setback duration 480; and (ii.) operating the temperature controller device 100 to establish the target temperature by the end of the setback duration 490. In some embodiments, the

temperature controller device 100 may be operable, e.g. via a heating or cooling device, to maintain the setback temperature during the first portion of the setback duration at step 480, and to establish the target temperature by the end of the setback duration at step 490.

[0074] FIG. 5 shows an exemplary schematic illustration of method 500 for determining the dynamic setback temperature curve 210 associated with the temperature controller device 100. Method 500 may include: (i.) receiving, at least one of the first temperature reading, the second temperature reading, the operating time of the temperature controller device, the desired temperature and/or the setback duration at a pre-determined interval, at step 510. For example, the first temperature reading may be obtained using the temperature sensor 110 at step 412, the second temperature reading may be derived via the air intake sensor 120 at step 414, the operating time of the temperature controller device 100 may be measured via the timer 130 at step 416, the desired temperature and/or the setback duration may be obtained at steps 418 and 420, respectively, via the input module 140. In some embodiments, the pre-determined interval may be a user defined time interval of about 5 mins, about 15 mins, about 30 mins, about 1 hour, about 2 hours, but no more than 3 hours.

[0075] Method 500 also includes, at step 520, (i.) calculating, a second thermal load rate based on the inputs received from the at least one of the first temperature reading, the second temperature reading, the operating time of the temperature controller device, at the pre-determined interval; and at step 530, (iii.) calculating the setback temperature at the pre-determined interval. In some embodiments, at step 520, the second thermal load rate may be calculated based on the first temperature reading, the second temperature reading and/or the operating time of the temperature controller device received at the pre-determined interval, and may be calculated in accordance with Equation 1. At step 530, the calculation of the setback temperature at the pre-determined interval may be performed, and may be calculated as a function of second thermal load rate, e.g. calculated at preceding step 520, the desired temperature and the setback duration obtained at the pre-determined interval. As mentioned above, the setback temperature at the pre-determined interval may be calculated in accordance with Equation 2.

[0076] Method 500 may also include, at step 540, establishing a dynamic setback temperature curve 210 (as shown in FIG. 2A) during the setback duration. Since the setback temperature is continuously calculated and updated based on the inputs received at the pre-determined interval, a dynamic setback temperature curve 210 may be established. As explained above, the dynamic setback temperature curve 210 may be based at least on the second temperature reading, e.g. outdoor air temperature, received at the pre-determined intervals, which has an effect on the setback temperature calculated at the pre-determined intervals, and consequently, the energy consumption of the device 100.

[0077] Method 500 may also include, at step 550, exiting the setback mode at the end of the setback duration. As mentioned above, the target temperature may be established, e.g. at step 490, by the end of the setback duration. Since the device 100 is configured to establish the target temperature at the end of the setback duration, there may be additional energy saving due to reduced power consumption, and at the same time, maintaining the thermal comfort requirements of the occupant(s). After exiting the setback mode, the device 100 may operate in the active mode, and may thus operate at the desired temperature.

[0078] In some embodiments, there is a computer program product, comprising software instructions installed thereon, such that when executed on a processor, may execute the steps according to the methods 400A, 400B and 500.

[0079] Advantageously, the temperature controller device 100, the system 300 and method 400A, 400B and 500 for determining a setback temperature associated with the temperature controller device 100, may establish a dynamic setback temperature curve 210, based at least on the second temperature reading, e.g. outdoor air temperature. As a result, additional energy saving may be provided without compromising the occupant(s) thermal comfort satisfaction level.

[0080] While the disclosure has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

Claims

1. A temperature controller device (100) comprising:

a temperature sensor (110) configured to obtain a first temperature reading (112) within an enclosed area;
 an air intake sensor (120) configured to derive a second temperature reading (122) outside the enclosed area;
 a timer (130) configured to measure an operating time of the temperature controller device (100);
 an input module (140) configured to obtain a desired temperature (142) and/or a setback duration (144);
 a processor (150) operable to calculate:

- (i.) a first thermal load rate (152) based on the first temperature (112) and second temperature (122) reading, and the operating time of the temperature controller device (100), and
- (ii.) a setback temperature (154),

wherein the setback temperature (154) is a function of the first thermal load rate (152), the setback duration (144), and the desired temperature (142).

2. The device (100) of claim 1, wherein the input module (140) is configured to receive an allowable deviation value associated with the desired temperature (142), and wherein the processor (150) is operable to calculate a target temperature (156) based on the desired temperature (142) and the allowable deviation value.

3. The device (100) of claim 2, wherein the processor (150) is operable to further calculate:

- (i.) a first portion (158a) of the setback duration (144), and
- (ii.) a first recovery portion (158b) of the setback duration (144),

wherein the first portion (158a) and the first recovery portion (158b) of the setback duration (144) is a function of the first thermal load rate (152), the desired (142) and target (156) temperature, and the setback duration (144).

4. The device (100) of claim 3, wherein the processor (150) is configured to maintain the setback temperature (154) associated with the first portion (158a) of the setback duration (144), and establish the target temperature (156) by an end of the setback duration (144).

5. The device (100) of any one of claims 1 to 4, wherein the processor (150) is operable to calculate the setback temperature (154) as a function of a pre-determined thermal load rate, the setback duration (144), and the desired temperature (142), when the processor determines that the operating time of the temperature controller device (100) is less than or equal to a pre-determined threshold duration.

6. The device (100) of any one of claims 1 to 5, wherein the processor (150) is configured to receive inputs from at least one of the temperature sensor (110), the air intake sensor (120), the timer (130), and the input module (140) at a pre-determined interval.

7. The device (100) of claim 6, wherein the processor (150) is operable to further calculate:

- (i.) a second thermal load rate (160) based on the inputs received from the at least one of the temperature sensors (110), the air intake sensor (120), and the timer (130), at the pre-determined interval, and
- (ii.) the setback temperature (154) at the pre-determined interval.

8. A system (300) for determining the setback temperature (154) associated with the temperature controller device (100) of any one of claims 1 to 7,

wherein the processor (150) is arranged in signal or data communication with at least one of the temperature sensor (110), the air intake sensor (120), the timer (130), and the input module (140), such that in operation, the processor (150):

- (i.) receives inputs from the at least one of the temperature sensor (110), the air intake sensor (120), the timer (130), and the input module (140);
- (ii.) calculates the first thermal load rate (152) based on the first temperature (112) and second temperature (122) reading, and the operating time of the temperature controller device (100), and
- (iii.) calculates the setback temperature (154),

wherein the setback temperature (154) is a function of the first thermal load rate (152), the setback duration (144), and the desired temperature (142).

9. A method (400A, 400B) for determining a setback temperature associated with a temperature controller device comprising the steps of:

receiving a first temperature reading associated with an enclosed area (412);

receiving a second temperature reading outside the enclosed area (414);
 receiving an operating time of the temperature controller device (416);
 receiving a desired temperature (418) and/or a setback duration (420);
 calculating:

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- (i.) a first thermal load rate based on the first temperature and second temperature reading, and the operating time of the temperature controller device (430), and
- (ii.) a setback temperature (440),

10 wherein the setback temperature is a function of the first thermal load rate, the setback duration, and the desired temperature.

10. The method (400A, 400B) of claim 9, further comprising:

- 15 (i.) receiving an allowable deviation value associated with the desired temperature (450), and
- (ii.) calculating a target temperature based on the desired temperature and the allowable deviation value (460).

11. The method (400A, 400B) of claim 10, further comprising:

- 20 (i.) calculating a first portion of the setback duration (470a), and
- (ii.) calculating a first recovery portion of the setback duration (470b),

wherein the first portion and the first recovery portion of the setback duration is a function of the first thermal load rate, the desired and target temperature, and the setback duration.

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12. The method (400A, 400B) of claim 11, further comprising:

- (i.) operating the temperature controller device to maintain the setback temperature during the first portion of the setback duration (480), and
- 30 (ii.) operating the temperature controller device to establish the target temperature by the end of the setback duration (490).

13. The method (400A, 400B) of any one of claims 9 to 12, further comprising:

- 35 (i.) receiving at least one of the first temperature reading, the second temperature reading, the operating time of the temperature controller device, the desired temperature and/or the setback duration at a pre-determined interval (510).

14. The method (400A, 400B) of claim 13, further comprising:

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- (i.) calculating a second thermal load rate based on the inputs received from the at least one of the first temperature reading, the second temperature reading, the operating time of the temperature controller device, at the pre-determined interval (520), and
- (ii.) calculating the setback temperature at the pre-determined interval (530)

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15. A computer program product, comprising software instructions installed thereon, such that when executed on a processor, executes the steps of any one of claims 9 to 14.

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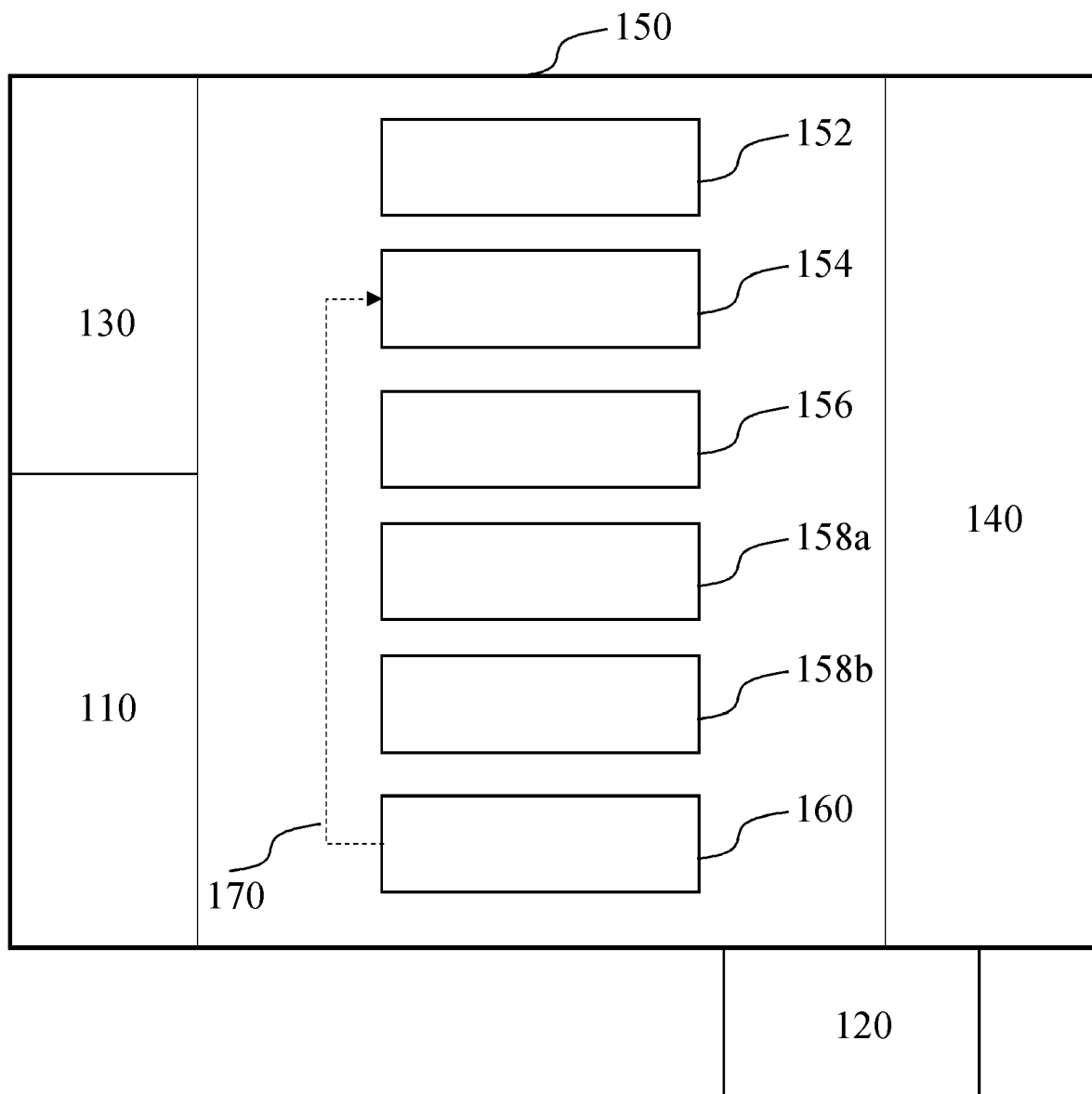


FIG. 1

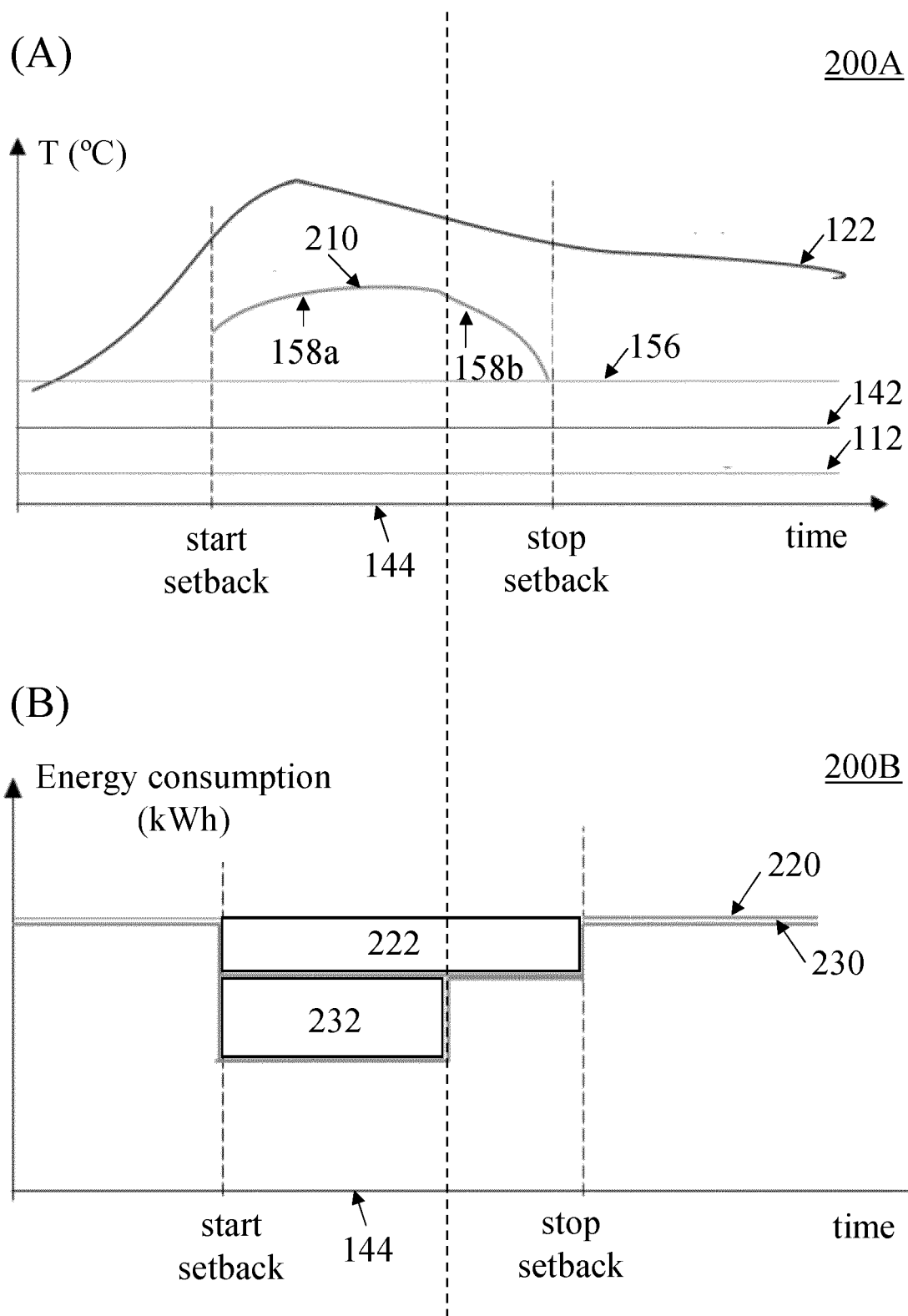


FIG. 2

300

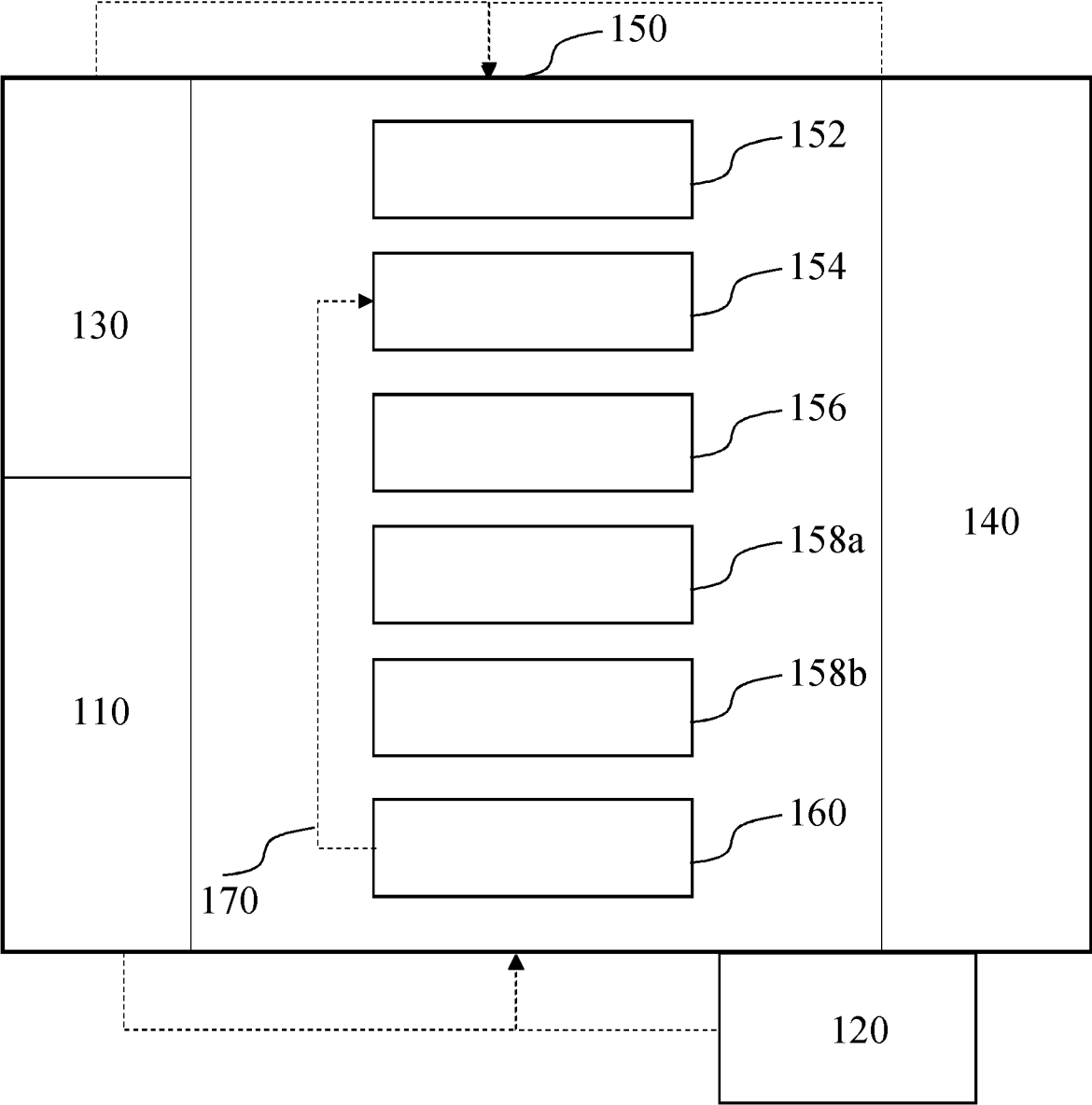


FIG. 3

400A

(A)

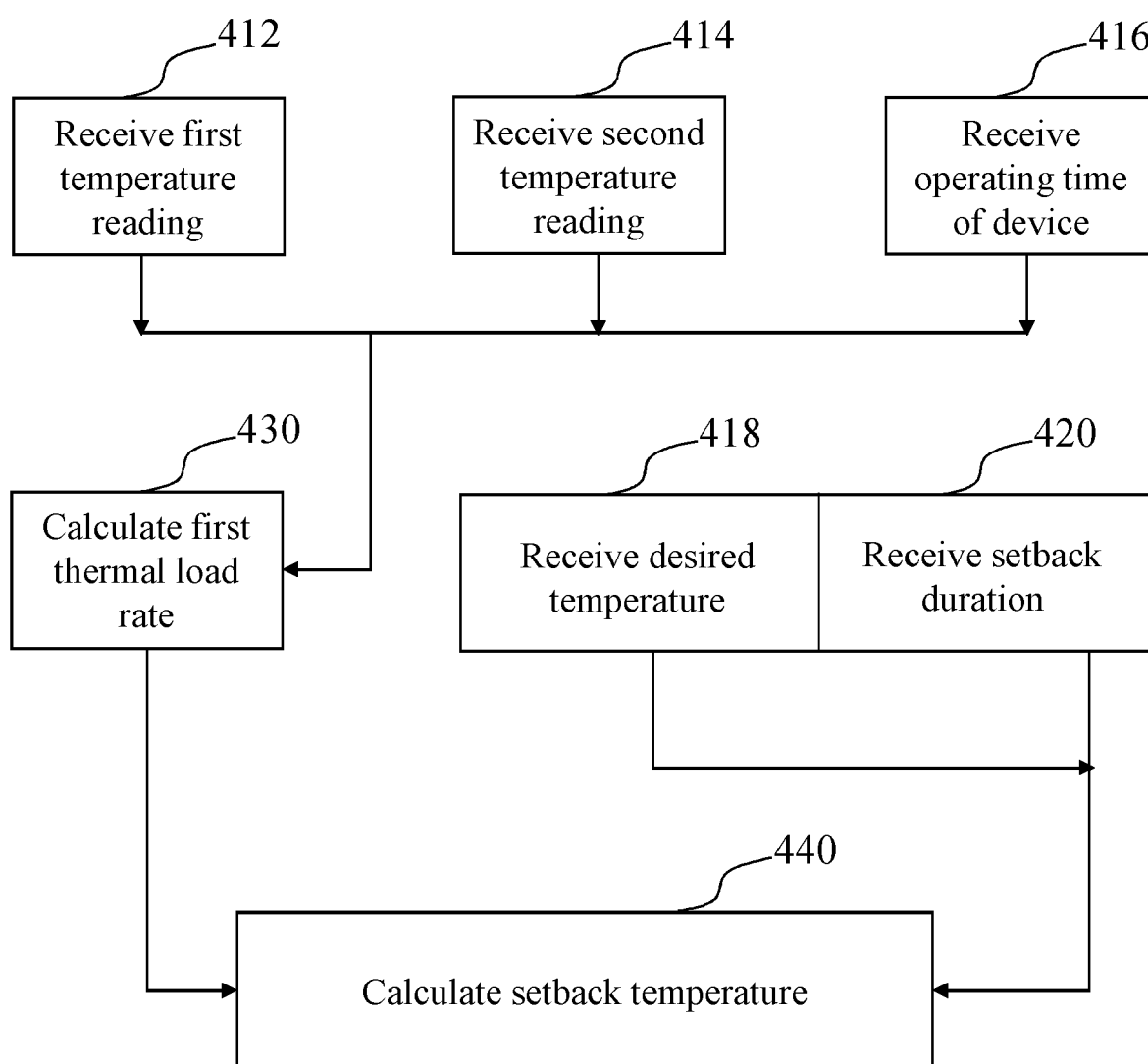


FIG. 4

400B

(B)

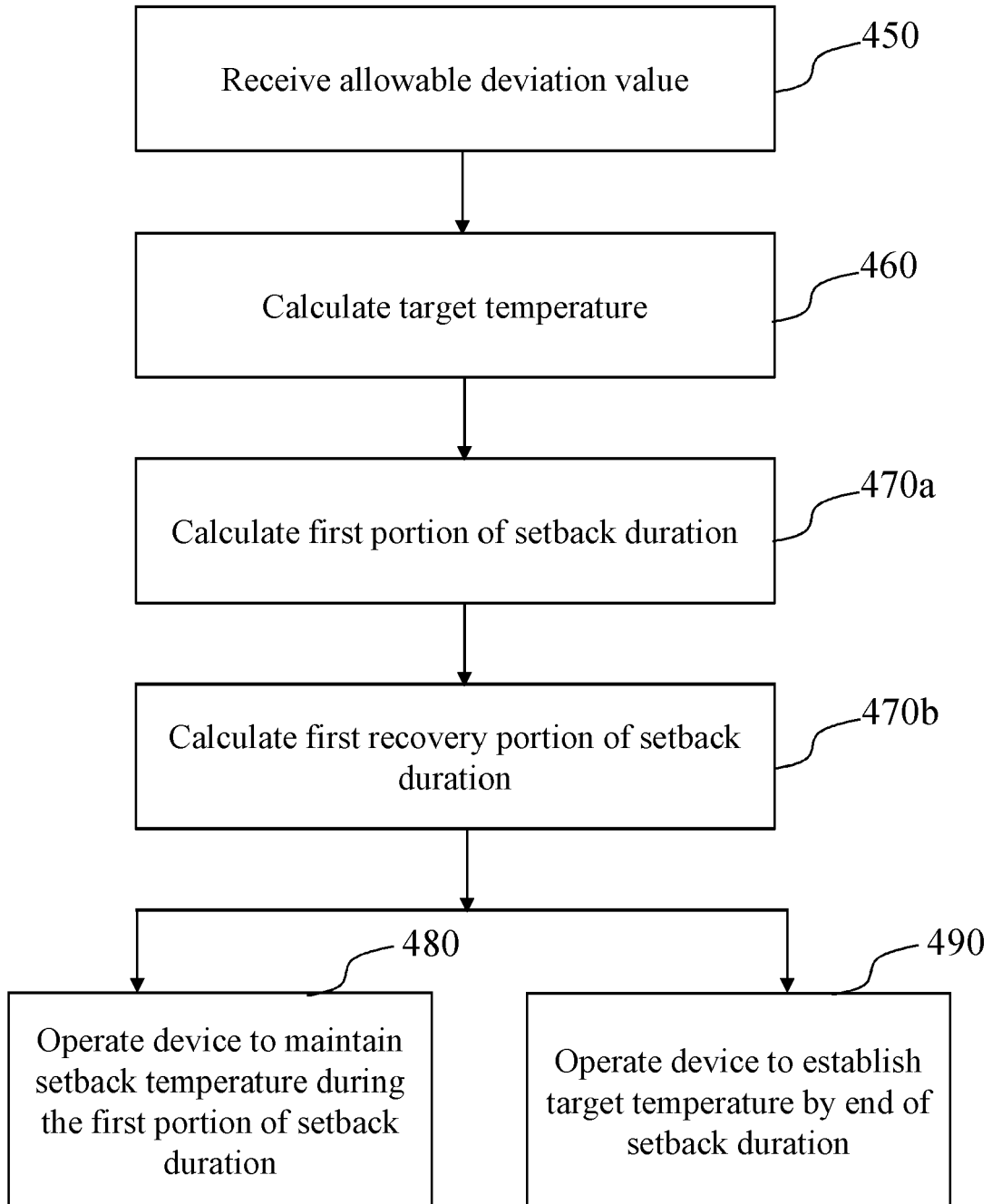


FIG. 4 (continued)

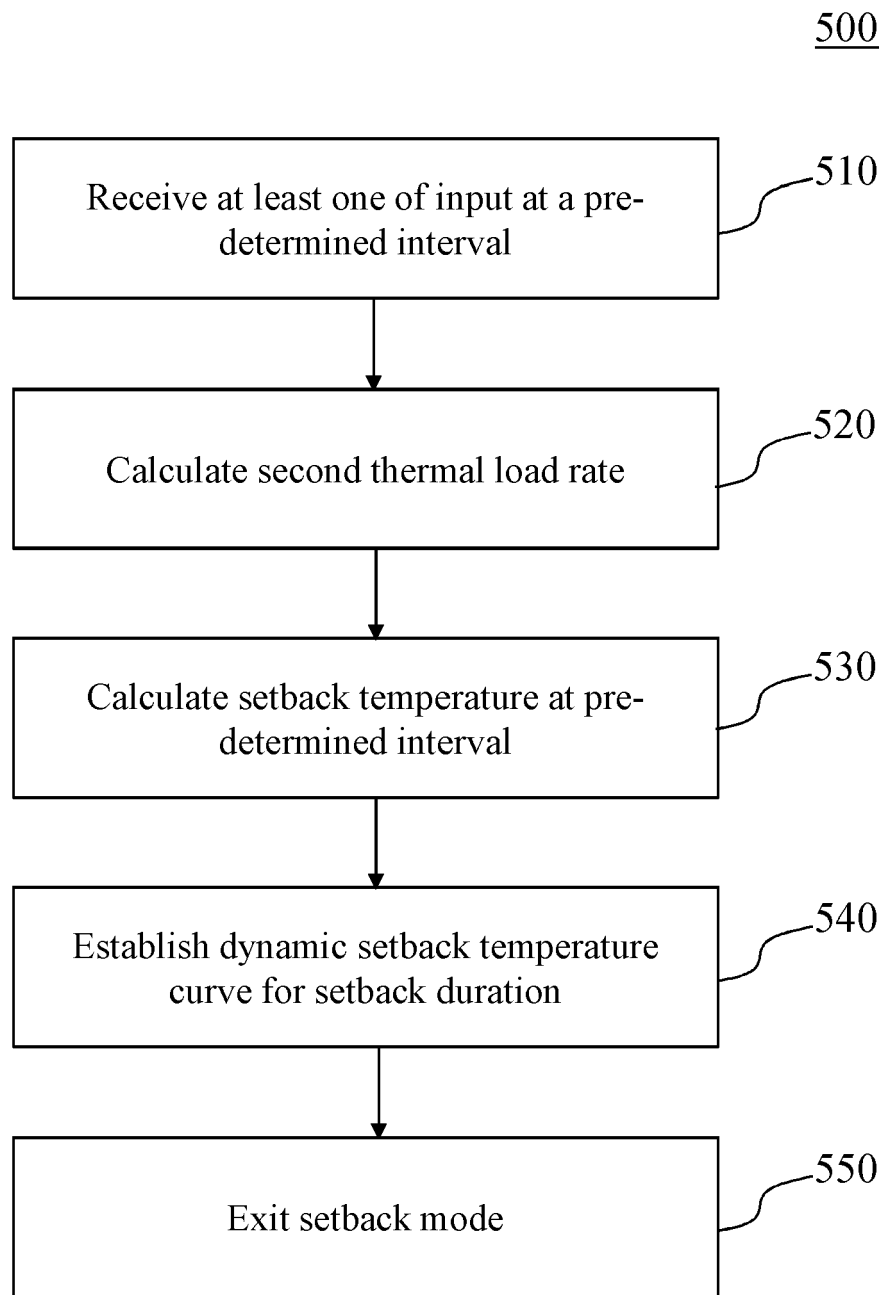


FIG. 5



EUROPEAN SEARCH REPORT

Application Number

EP 21 21 1724

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 May 2022	Examiner Ismail, Youssef
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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