(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 141 423 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.01.2010 Bulletin 2010/01

(51) Int Cl.:
F24F 11/00 *(2006.01)*

(21) Application number: **08159497.0**

(22) Date of filing: **02.07.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(71) Applicant: **Tac AB**
213 75 Malmö (SE)

(72) Inventor: **Persson, Per-Göran**
277 31, Kivik (SE)

(74) Representative: **Milanov, Nina Vendela Maria**
Awapatent AB
P.O. Box 5117
200 71 Malmö (SE)

(54) Sequence control

(57) There is provided a system (101) for controlling supply airflow temperature along a supply airflow line (102), wherein the supply airflow line comprises a first temperature-affecting device (104), a second temperature-affecting device (106), a first sensor (110) and a second sensor (112). The system further comprises a controller (116), wherein the controller (116) is configured to receive a first actual value from the first sensor (110), a second actual value from the second sensor (112), and a set-point value from a receiver (142), and to control the first temperature-affecting device (104) based on the first actual value and the set-point value, and to control the second temperature-affecting device (106) based on the second actual value and the set-point value.

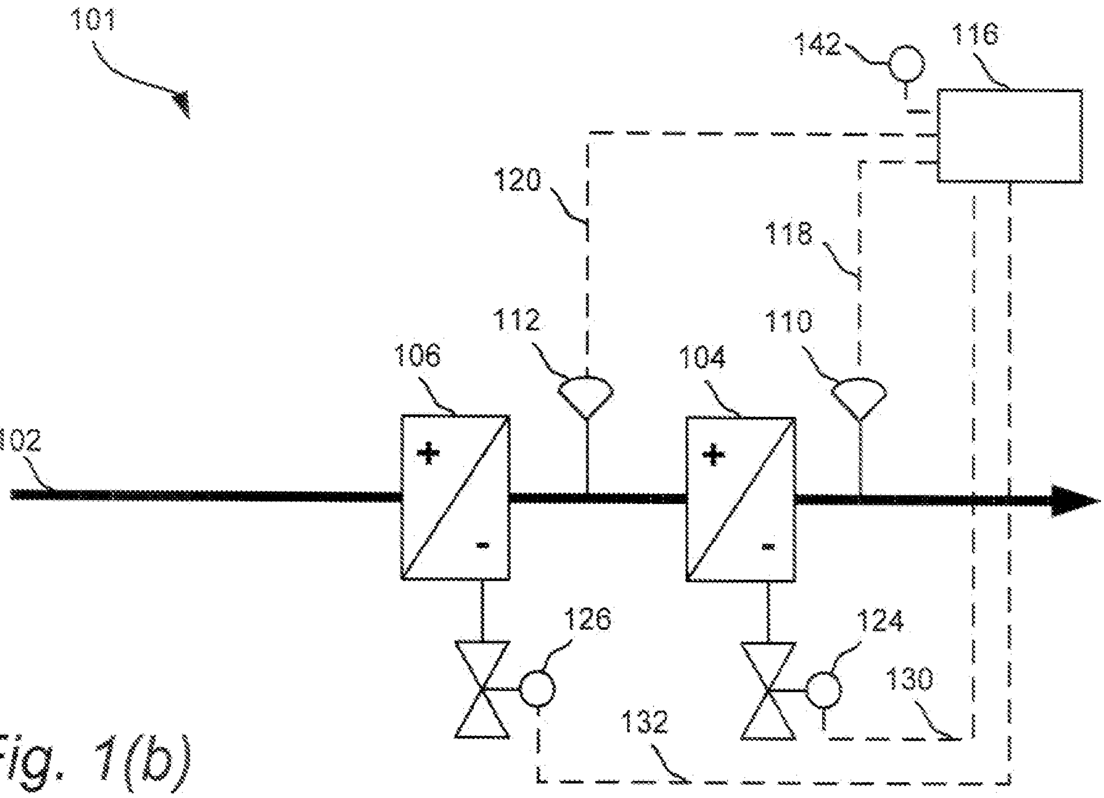


Fig. 1(b)

EP 2 141 423 A1

Description

Technical Field of the Invention

[0001] The present invention relates to HVAC (heating, ventilation and air conditioning) systems, and more particularly to systems and methods for controlling supply airflow temperature.

Background of the Invention

[0002] Various types of facilities, such as office and/or residential buildings, industrial production facilities, medical buildings, manufacturing assemblies and laboratories, often use air handling units or HVAC systems to control indoor temperature. HVAC systems generally utilize outside air, temperature-affecting deuces and the like to supply air at designated temperatures to different areas, zones or rooms.

[0003] HVAC systems may e.g. be classified as either central or local. Central HVAC systems may be used in cold climates to heat facilities, such as the facilities disclosed above. Such a system may comprise a boiler, furnace, or heat pump to heat water, steam, or air, all in a central location such as a furnace room in a home or a maintenance room in a large building. The system may also comprise either ductwork, for forced air systems, or piping to distribute a heated fluid, and radiators to transfer this heat to the air. Central HVAC systems may also comprise various cooling means to be used in warm climates to cool facilities, such as the facilities disclosed above, HVAC systems thus generally comprise one or more temperature affecting deuces.

[0004] However, a problem arises when the system comprises several such temperature affecting devices, since it may be difficult to simultaneously control several temperature affecting devices, A particular problem may be to control several temperature affecting devices in terms of comfort, energy, or wear-and-tear point-of-views.

[0005] For example, one problem may be that a control signal to one or more of the temperature affecting devices may oscillate in an undesired fashion. For example, the envelope of the oscillations may be large and/or the frequency of the oscillations may be high. There is thus a need for improved controlling of HVAC systems comprising one or more temperature affecting devices.

[0006] US patent 5,350,113 discloses a dual-duct HVAC system for providing a desired comfort level in a room, wherein the system includes a controller that carries out a simple operation that determines the total open damper positions for dual dampers in a dual-duct system to effect a desired air flow. However there is still a problem with controlling the temperature of the cold decks and hot decks, which provide the dual-duct system with cold and hot air, respectively.

Summary of the Invention

[0007] In view of the above, an objective of the invention is to solve or at least reduce the problems discussed above.

[0008] In light of the present invention it has been discovered that sequential control systems, composing e.g. a controller arranged to control a heat exchanger, a cooler and a heater arranged along an airflow line, may be difficult to control in terms of undesired oscillating control signals.

[0009] If the controller is a PI (proportional, integrate) controller or a PID (proportional, integrate, derivate) controller, a common solution to mitigate the problem of undesired oscillating control signals, wherein the envelope of the oscillations may be large and/or the frequency of the oscillations may be high, has been to calculate new values for the P-gain and the I-time. Particularly, a common solution has been to increase the values of the P-gain and I-time, respectively. However, in light of the present invention it has been realized that the problem may remain even if new values for the P-gain and I-time are calculated. In light of the present invention it has further been realized that the problem may be associated with utilising only one sensor.

[0010] It is thus an object of the present invention to provide improved control of the temperature in a sequential control system, wherein e.g. a heat exchanger, a cooler and a heater are utilized in sequence.

[0011] It is a further object of the present invention to provide improved control of the airflow temperature from comfort or energy point-of-views. It is a further object to minimize, or at least to mitigate, the wear of driving devices, actuators, valve bodies, gears, dampers, other mechanical and electrical components in the air flow control system, and the like.

[0012] Generally, the above objectives are achieved by the attached independent patent claims.

[0013] According to a first aspect, the present invention is realized by a system for controlling supply airflow temperature.

[0014] There is thus disclosed a system for controlling supply airflow temperature, wherein the supply airflow flows from an upstream position to a downstream position along a supply airflow line, wherein the supply airflow line comprises a first temperature-affecting device, a second temperature-affecting device arranged in series with the first temperature-affecting device, a first sensor positioned at a first position downstream the first temperature-affecting device, and a second sensor positioned at a second position downstream the second temperature-affecting device and upstream the first temperature-affecting device, wherein the system further comprises a controller, wherein the controller is configured to receive a first actual value from the first sensor, a second actual value from the second sensor, and a set-point value from a receiver, wherein the controller is configured to control the first temperature-affecting device based on the first actual value and the set-point value and thereby control the supply airflow temperatures at the first position, and the controller is configured to control the second temperature-affecting device based on the second actual value and the set-point value and thereby control the supply airflow temperatures at the second position.

[0015] The disclosed system may thus enable control of the first and/or second temperature-affecting device based on input information, such as the set-point values, and one or more feedback values such as the first and/or second actual values, respectively.

[0016] The present invention may thus enable improved control of each device associated with control of the supply airflow line, such as heating coils, cooling coils, heat recovery devices as thermal wheels, plate heat exchangers, liquid coupled coils, heat pipes, and the like. The disclosed system may enable improved control of recirculation of air. Advantages of the present invention may include, but are not be limited to, better indoor climate, less wearing of control devices, such as control valve, dampers and actuators, as hunting will be mitigated.

[0017] As a consequence of the improved control the present invention may also allow for saving energy.

[0018] It may thus be possible to tune every control device separately as a new sensor is located after each device along the supply airflow line. Every device may be controlled based on its own sensor, directly located after each device along the supply airflow line. Each of these sensors may receive a set-point value from the main controller to which the first (main) sensor is connected.

[0019] In case the first temperature-affecting device is a heater, the second temperature-affecting device may be a cooler. In case the first temperature-affecting device is a cooler, the second temperature-affecting device may be a heater. The heater may comprise a heating coil. The cooler may comprise a cooling coil.

[0020] The first actual value and the second actual value may pertain to the temperature of the supply airflow at the first position and the second position, respectively.

[0021] The controller may comprise a first sub-controller and a second sub-controller, the first temperature-affecting device and the second temperature-affecting device may be controlled by a first and a second control signal, respectively, The first control signal may be associated with the first sub-controller and the second control signal may be associated with the second sub-controller.

[0022] The first control signal may control a first control valve associated with the first temperature-affecting device. The second control signal may control a second control valve associated with the second temperature-affecting device.

[0023] In case the first control valve is under operation the second control valve may either be fully closed or fully opened. In case the second control valve is under operation the first control valve may either be fully closed or fully opened.

[0024] The supply airflow line may further comprise a third sensor positioned at a third position upstream the second temperature-affecting device, and a third temperature-affecting device positioned upstream the third sensor, wherein the controller may be configured to receive a third actual value from the third sensor, and the controller may be configured to control the third temperature-affecting device based on the third actual value and the set-point value and thereby control the supply airflow temperature at the third position.

[0025] The third temperature-affecting device may be a heat exchanger.

[0026] The third actual value may pertain to the temperature of the supply airflow at the third position.

[0027] The first and the second temperature-affecting devices may receive a second desired value during the control of the first and the second temperature-affecting devices, respectively. The second desired value may be associated with a control error pertaining to the third actual value and a desired value at the third position.

[0028] The first temperature-affecting device may comprise a first body of water. The second temperature-affecting device may comprise a second body of water. The airflow temperature at the first position may be affected by the first body of water. The airflow temperature at the second position may be affected by the second body of water.

[0029] According to a second aspect, the present invention is realized by a method for controlling supply airflow temperature. There is thus disclosed a method for controlling supply airflow temperature comprising receiving a first actual value from a first sensor, wherein the first sensor is located at a first position along a supply airflow line, receiving a set-point value from a receiver, receiving a second actual value from a second sensor, wherein the second sensor is located at a second position along the supply airflow line, controlling a first temperature-affecting device based on the first actual value and the set-point value and thereby control the supply airflow temperature at the first position, wherein the first temperature-affecting device is positioned upstream the first sensor and downstream the second sensor, and controlling a second temperature-affecting device based on the second actual value and the set-point value and thereby control the supply airflow temperature at the second position, wherein the second temperature-affecting device is upstream the second sensor.

[0030] The first temperature-affecting devices may be controlled by a first centrol signal controlling a first control valve. The second temperature-affecting devices may be controlled by a second control signal controlling a second control valve, In case the first controls valve is under operation the second control valve may either be fully closed or fully opened. In case the second controls valve is under operation the first control valve may either be fully closed or fully opened.

[0031] The method may further comprise receiving a third actual value from a third sensor, wherein the third sensor may be located at a third position upstream the second temperature-affecting device along the supply airflow line, and controlling a third temperature-affecting device based on the third actual value and the set-point value and thereby control the supply airflow temperature at the third position. The third temperature-affecting device may be positioned upstream the third sensor.

[0032] The third temperature-affecting devices may be controlled by a third control signal controlling a third control valve. In a case the first controls valve is under operation the second control valve and the third control valve may independently be either fully closed or fully opened. In case the second controls valve is under operation the first control valve and the third control valve may independently be either fully closed or fully opened. In case the third controls valve is under operation the first control valve and the second valve may independently be either fully closed or fully opened.

[0033] According to a third aspect, the present invention is realized by a computer program stored on a computer readable medium for controlling supply airflow temperature. There is thus provided a computer program stored on a computer readable medium, which comprises software instructions that, when executed in a computer, performs a method for controlling supply airflow temperature according to the above. Such a computer program enables for efficient implementation of the method for controlling supply airflow temperature.

[0034] According to a fourth aspect the present invention is realized by a controller for controlling supply airflow temperature. There is thus provided a controller for controlling supply airflow temperature, said controller comprising a receiver for receiving a first actual value from a first sensor, wherein the first sensor is located at a first position along a supply airflow line, a receiver for receiving a set-point value from a receiver, a receiver for receiving a second actual value from a second sensor, wherein the second sensor is located at a second position along the supply airflow line, a first processor for controlling a first temperature-affecting device based on the first actual value and the set-point value and thereby control the supply airflow temperature at the first position, wherein the first temperature-affecting device is positioned upstream the first sensor and downstream the second sensor, and a second processor for controlling a second temperature-affecting device based on the second actual value and the set-point value and thereby control the supply airflow temperature at the second position, wherein the second temperature-affecting device is positioned upstream the second sensor. Functionalities of the first processor and the second processor may be performed by the same processor. Alternatively, some of the functionalities may be performed by separate processors.

[0035] The second, third and fourth aspects may generally have the same features and advantages as the first aspect.

[0036] Other objectives, features and advantages of the present invention will appear from the following detailed disclosure, from the attached claims as well as from the drawings.

Brief Description of the Drawings

[0037] Other features and advantages of the present invention will become apparent from the following detailed description of a presently preferred embodiment, with reference to the accompanying drawings, in which

Fig. 1a is a block diagram of a prior art system;
Fig. 1b-d are block diagrams of systems for controlling supply airflow temperature according to embodiments;
Fig. 1e is a block diagram of a controller according to an embodiment;
Fig. 2 is a flowchart of a method for controlling supply airflow temperature according to an embodiment; and
Fig. 3 is a flowchart of a method for controlling supply airflow temperature according to an embodiment.

Detailed Description

[0038] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

[0039] Fig. 1a illustrates a block diagram of a system 100 for controlling supply airflow temperature according to prior art. The system comprises a cooler 103 and a heater 105. The heater 105 is arranged in series with the cooler 103 along a supply airflow line 102.

[0040] The supply airflow flows from an upstream position to a downstream position along the supply airflow line 102. In the illustrative example of Fig. 1a the airflow direction is indicated by the arrow comprised in the airflow line 102. That is, the arrow comprised in the airflow line 102 points in the downstream direction. The supply airflow line 102 may *inter alia* be an air duct, which may be part of a ductwork. Air ducts as such may be utilized for ensuring acceptable indoor air quality and/or thermal comfort. The supply airflow line 102 may *inter alia* be made of galvanised steel, polyurethane duct board (pre-insulated aluminium ducts), fibre glass duct board (pre-insulated non-metallic ductwork), flexible tubing and the like.

[0041] The system 100 further comprises a sensor 109. The sensors 109 is positioned at a position downstream the cooler 103. The sensor 109 may thus be a temperature sensor arranged to measure the temperature of the supply airflow at the position along the supply airflow line 102.

[0042] The system further comprises a controller 115 arranged to control the cooler 103 and the heater 105 based on a set-point value receded from a receiver 142 and an actual value from the sensor 109. The controller 115 may be a PI (proportional integrate) controller. Alternatively the control 115 may be a PID (proportional, integrate, derivate) controller.

[0043] In order to improve the control of the system 100 a solution has been to tune parameters of the controller 115. For example, if the controller 115 is a PI controller or a PID controller, new values for the P-gain and the I-time may be calculated in order to improve the control of the system 100. The P-gain and I-time may e.g. be tuned by using the Ziegler-Nichols method to J. G. Ziegler and N. B. Nichols: "Optimum settings for automatic controllers," ASME Transactions, vol. 64 (1942), pp, 759-768. A further solution has been to manually tune the values of the P-gain and I-time, respectively.

[0044] In particular, a common solution to mitigate the problem of undesired oscillating control signals, wherein the envelope of the oscillations may be large and/or the frequency of the oscillations may be high, has been to calculate new values for the P-gain and the I-time. Particularly, a common solution has been to increase the values of the P-gain and I-time, respectively.

[0045] However, in light of the present invention it has been realized that the problem may remain even if new values for the P-gain and I-time are calculated. In light of the present invention it has further been realized that the problem may be associated with utilising only one sensor.

[0046] Fig, 1b illustrates a block diagram of a system 101 for controlling supply airflow temperature according to an embodiment. The system 101 according to the present invention comprises a first temperature-affecting device 104 and a second temperature-affecting device 106. The second temperature-affecting device 106 is arranged in series with the first temperature-affecting device 104 along the supply airflow line 102. As in Fig. 1a the supply airflow flows from an upstream position to a downstream position along the supply airflow line 102.

[0047] The system 101 further comprises a first sensor 110. The first sensor 110 is positioned at a position downstream the first temperature-affecting device 104. The first sensor 110 may thus be a temperature sensor arranged to measure the temperature of the supply airflow at the position, wherein the position is a position along the supply airflow line 102,

[0048] The system further comprises a controller 116 arranged to control the first temperature-affecting device 104 and the second tempersture-affecting device 106 based on a set-point value received from a receiver 142 and an actual value from the first sensor 110. The controller 116 may be a PI controller. Alternatively the controller 116 may be a PID controller.

[0049] The system further comprises a second sensor 112. The second sensor 112 its positioned at a second position downstream the second tempeirature-affecting device 106, The second sensor 112 is further positioned upstream the first temperature-affecting device 104, The second sensor 112 may thus be a temperature sensor arranged to measure the temperature of the supply airflow at the second position, wherein the second position is a position along the supply airflow line 102.

[0050] The controller 116 is configured to receive a first actual value from the first sensor 110. The first actual value may pertain to the temperature of the supply airflow at the first position. Thus in a state of operation the controller 116 is operatively connected to the first sensor 110 via connection means 118. The controller 116 is further configured to receive a second actual value from the second sensor 112. The second actual value may pertain to the temperature of the supply airflow at the second position. Thus, in estate of operation, the controller 116 is operatively connected to the second sensor 112 via connection means 120. The connection means, 118, 120 may be any conventional connection means, such as a wired or a wireless connection, or any combination thereof. The values of the first sensor 110 and/or the second sensor 112 may be stored at one or more intermediate storage facilities, such as a database (not shown). Thus such a intermediate storage facility enables further analysis of the measured signals. Alternatively the one or more storage facility may be comprised in the first sensor 110 and/or the second sensor 112. Alternatively the one or more storage facility may be comprised in the controller 116.

[0051] The controller 116 is further configured to receive a set-point value from a receiver 142, The set-point value may thus define a desired value. The desired value may pertain to a desired temperature value. The desired value may pertain to a temperature value of an enclosed space, such as a room in a building, wherein the enclosed space is further associated with a destination of the supply airflow line 102. The destination may be a termination point of the supply airflow line 102. Thus, by actuating the set-point value, a desired temperature of e.g. a room in a building may be changed. The set-point value may be actuated by an operator, such as a service person, a maintenance person, or other personnel. Alternatively the set-point value may be actuated by an operator device (not shown). The operator device may thus be arranged to provide the controller 116 with instructions pertaining to a desired temperature of the enclosed space.

[0052] The controller 116 is thus further configured to control the first temperature-affecting device 104 based on the first actual value and the set-point value and thereby control the supply airflow temperatures at the first position. The controller 116 is thus further configured to control the second temperature-affecting device 106 based on the second actual value and the set-point value and thereby control the supply airflow temperatures at the second position.

[0053] Alternatively the controller 116 may be configured to control the first temperature-affecting device 104 based on the first actual value, the second actual value and the set-point value. Similarly, the controller 116 may be configured to control the second temperature-affecting device 106 based on the first actual value, the second actual value and the set-point value.

[0054] The disclosed system 101 may thus enable control of a first and/or second temperature-affecting device 104, 106 based on input information, such as the set-point value, and one or more feedback values such as the first and/or second actual values, respectively.

[0055] In a case the first temperature-affecting device 104 is a heater the second temperature-affecting device 106 may be a cooler. The heater may comprise a heating coil. The cooler may comprise a cooling coil, In a case the first temperature-affecting device 104 is a cooler the second temperature-affecting device 106 may be a heater. Thus the first temperature-affecting device 104 and the second temperature-affecting device 106 may provide different means for affecting the airflow temperature. Hence by utilizing two different temperature-affecting device 104, 106 associated with different functionalities the heater may be separated from the cooler. In addition the heater and the cooler may be allowed to switch places in the control system, This may lead to better control and higher flexibility.

[0056] The controller 116 may comprise a first sub-controller 136 and a second sub-controller 138. The first sub-controller 136 and a second sub-controller 138 may be controlled by a master controller.

[0057] Further, the first temperature-affecting device 104 may be controlled by a first control signal. The second temperature-affecting device 106 may be controlled by a second control signal. Thus, in a state of operation, the controller 116 may be operatively connected to the first temperature-affecting device 104 via connection means 130. The first control signal may thus be communicated from the controller 116 to the first temperature-affecting device 104 via the connection means 130, In a state of operation the controller 116 may be operatively connected to the second temperature-affecting device 106 via connection means 132. The second control signal may thus be communicated from the controller 116 to the second temperature-affecting device 106 via the connection means 132. The first control signal may further be associated with the first sub-controller 136, The second control signal may be associated with the second sub-controller 138. Hence the controller 116 may comprise separate sub-controllers 136,138 for controlling the temperature-affecting devices 104,106.

[0058] The first control signal may further control a first control valve 124. The first control valve 124 may be associated with the first temperature-affecting device 104. The second control signal may further control a second control valve 126. The second control valve 126 may be associated with the second temperature-affecting device 106.

[0059] Thus the controller 116 and/or the sub-controllers 136,138 may thus be arranged to control the first and second control valves 124, 126 respectively thereby controlling the temperature-affecting devices 104, 106 In a case the first control valve 124 is under operation the second control valve 126 may be either fully closed or fully opened. In a case the second control valve 126 is under operation, the first control valve 124 may be either fully closed or fully opened.

[0060] For example, according to a first scenario the second control valve 126 is fully closed and the first controls valve 124 may thus be under operation. In a case the first temperature-affecting device 104 is a cooler, the controller 116 of the system 101 is thus associated with cooling regulation of the system 101.

[0061] Thus such a system 101 enables improved control since it may enable separate and individual control of the temperature-affecting devices 102, 104. Alternatively the control of the first temperature-affecting device 102 may be affected by the control of the first temperature-affecting device 104, and vice versa. Thus, such a system 101 enables improved control since it may enable combined control of the temperature-affecting devices 102, 104, Thus, such a system 101 enables improved control since it may switch between a first mode enabling separate and individual control and second mode enabling combined control of the temperature-affecting devices 102, 104.

[0062] Fig. 1c illustrates a block diagram of a system 150 for controlling supply airflow temperature. The system 150 is similar to the system 101 of Fig. 1b and may thus be said to comprise all advantages and features of the system 101. In comparison to the system 101 of Fig. 1b the system 150 of Fig. 1c further comprises a third sensor 114. The third sensor 114 may be positioned at a third position upstream the second temperature-affecting device 106. The third sensor 114 may comprise features and advantages of the first and second sensors 110, 112, respectively, The system 150 further comprises a third temperature-affecting device 108. The third temperature-affecting device 108 may be positioned upstream the third sensor 114. The controller 116 may then be configured to recede a third actual value from the third sensor 114.

[0063] The controller 116 may then further be configured to control the third temperature-affecting device 108 based on the third actual value and the set-point va!ue and thereby control the supply airflow temperature at the third position.

[0064] The third actual value may pertain to the temperature of the supply airflow at the third position The third sensor 114 may thus be arranged to measure the temperature of the supply airflow at the third position, wherein the third position is a position along the supply airtlew line 102.

[0065] Thus in a state of operation the controller 116 may be operatively connected to the third sensor 114 via connection means 122. The connection means 122 may be any conventional connection means, such as a wired or a wireless connection, or any combination thereof. The values of the third sensor 114 may be stored at one or more intermediate storage facilities, such as a database (not shown). The third temperature-affecting device 108 may be a heat exchanger. Thus the system 150 may comprise a heater, a cooler and a heat exchanger.

[0066] In addition the first and the second temperature-affecting devices 104 106 may, independently of each other, receive a second desired value during the control of the first and the second temperature-affecting devices 104, 106, respectively. The second desired value may be associated with a control error pertaining to the third actual value and a desired value at the third position. The desired value at the third position may be a set-point value similar to the set-point value disclosed above with reference to the system 101 of Fig. 1b. Thus, such a desired value further improves the control of the temperature-affecting devices.

[0067] The first temperature-affecting device 104 may comprises a first body of water. Likewise, the second temperature-affecting device 106 may comprise a second body of water. The airflow temperature at the first position may thus be affected by the first body of water. The airflow temperature at the second and position may thus be affected by the second body of water.

[0068] For example, if the second temperature-affecting device 108 acts as a heater, the second body of water may have a temperature which is higher than the temperature of the supply airflow at the second position. By passing through the second body of water, the supply airflow may thus be affected by the temperature of the second body of water. By passing through is here meant that the supply airflow line, which may be embodied as a pipeline or any other conventional means for realizing a supply airflow line, passes through the second body of water,

[0069] The supply airflow line 102 may further comprise one or more outlets 182,184 along the supply airflow line 102. The one or more outlets 182, 184 may further be operatively connected to other parts (not shown) of the supply airflow system 101, 150, Such parts may include, but are not limited to, additional enclosed spaces such as rooms, one or more additional supply airflow line, ductwork, and the like.

[0070] For example, some of the sensors 110, 112, 114, may be arranged to measure the airflow temperature at the one or more outlets 182, 184. Thus the controller 116 may control the airflow temperature at the one or more outlets 182, 184. Advantageously the controller 116 may control the individual airflow temperature at each one of the one or more outlets 182,184 independently. For example the individual airflow temperatures may be controlled by utilizing one or more sub-controllers 136, 138, 140.

[0071] Fig. 1d illustrates a controller 185 comprising a first sub-controller 136, a second sub-controller 138 and a third sub-controller 140. The first sub-controller 136 is arranged to, in a state of operation, receive a set-point value from a receiver 142 and an auxiliary value via connecting means 188. The first sub-controller 136 is further arranged to control a first auxiliary device via connecting means 186. The first sub-controller 136 may further be arranged to transmit feedback values to the second and/or third sub-controller(s) 138, 140, respectively via connecting means 144 and 146, respectively. The feedback values may pertain to a control error.

[0072] The second sub-controller 138 is arranged to, in a state of operation, receive a feedback value from the first sub-controller 136 via connecting means 144 and to receive an auxiliary value via connecting means 192. The second sub-controller 138 is further arranged to control a second auxiliary device via connecting means 190.

[0073] The third sub-controller 140 is arranged to, in a state of operation, receive a feedback value from the first sub-controller 136 via connecting means 146 and to receive an auxiliary value via connecting means 196. The second sub-controller 140 is further arranged to control a third auxiliary device via connecting means 194.

[0074] The second sub-controller 138 may be arranged to, in a state of operation, provide a feedback value to the third sub-controller 140 via connecting means 198. Thus the third sub-controller 140 may be arranged to, in a state of operation, receive a feedback value from the second sub-controller.

[0075] Thus the controller 185 comprising the first sub-controller 136, the second sub-controller 138 and the third sub-controller 140 may control a first auxiliary device, a second auxiliary device and a third auxiliary device, respectively, Depending on the feedback signal from the first sub-controller 136 the second sub-controller 138 and the third sub-controller 140 may control the second auxiliary device and the third auxiliary device more or less independently.

[0076] Fig, 1e illustrates a block diagram of a system 160 for controlling supply airflow temperature. The system 160 is similar to the system 101 of Fig. 1b and/or the system 150 of Fig. 1c and may thus be said to comprise all advantages and features of the system 101 and/or the system 150.

[0077] The system 160 comprises a controller, similar to the controller 185 of Fig. 1d, which controller comprises a first sub-controller 136, a second sub-controller 138 and a third sub-controiier 140. In the illustrative example of Fig. 1d the first sub-controller 136 is arranged to, in a state of operation, receive a set-point value from a receiver 142 and an actual value from the first sensor 110 via the connecting means 118. The first sub-controller 136 is further arranged to, in a state of operation, control the first temperature-affecting device 104 via the connecting means 130.

[0078] The second sub-controller 138 is arranged to, in a state of operation, receive a feedback value from the first sub-controller 136 and an actual value from the second sensor 112 via the connecting means 120. The second sub-controller 138 is further arranged to, in a state of operation, control the second temperature-affecting device 106 via the connecting means 132.

[0079] The third sub-controller 140 is arranged to, in a state of operation, receive a feedback value from the first sub-ootitroller 136 and an actual value from the third sensor 114 via the connecting means 122, The third sub-controller 140 is further arranged to, in a state of operation, control the third temperature-affecting device 108 via the connecting means 134.

[0080] Fig. 2 is a flowchart illustrating a method for controlling supply airflow temperature. The method for controlling supply airflow temperature comprises receding, in a step 202, a first actual value from a first sensor 110, wherein the first sensor 110 is located at a first position along a supply airflow line 102.

[0081] The method further comprises receiving, in a step 202, a set-point value from a receiver 142.

[0082] A second actual value is received, in a step 204, from a second sensor 112, wherein the second sensor 112 is located at a second position along the supply airflow line.

[0083] In a step 206 a first temperature-affecting device 104 may be controlled based on the first actual value and the set-point value. Thereby the supply airflow temperature at the first position may be controlled.

[0084] In a step 208 a second temperature-affecting device 106 may be controlled based on the second actual value and the set-point value. Thereby the supply airflow temperature at the second position may be controlled.

[0085] The first temperature-affecting device 104 may be positioned upstream the first sensor 110 and downstream the second sensor 112. The second temperature-affecting device 106 may be positioned upstream the second sensor 112.

[0086] The disclosed method may be embodied as any of the systems disclosed above with references to Figs, 1b-1e, respectively, *mutatis*

mutandis.

[0087] Fig. 3 is a flowchart of a method for controlling supply airflow temperature according to an embodiment.

[0088] In the flowchart of Fig. 3 step 302 is similar to step 202 of Fig. 2; step 304 is similar to step 204; step 306 is similar to step 206; step 308 is similar to step 208; and step 310 is similar to step 210.

[0089] In case the first temperature-affecting devices 104 is controlled by a first control signal controlling a first control valve 124, and the second temperature-affecting devices 106 is controlled by a second control signal controlling a second control valve 126, the method may further comprise a step 312 wherein it is investigated whether the first control valve 124 or the second control valve 126 is under operation.

[0090] In case the first control valve 124 is under operation the second control valve 126 is in a step 314 set to be either fully closed or fully opened.

[0091] In case it is decked that the second control valve 126 is under operation the first control valve 124 is in a step 316 set to be either fully closed or fully opened.

[0092] The method may further comprise receiving, in a step 318, a third actual value from a third sensor 114, and, in a step 320, controlling a third temperature-affecting device 108 based on the third actual value and the set-point value. Thereby the supply airflow temperature may be controlled at a third position. The third sensor 114 may located at the third position, which may be a position upstream the second temperature-affecting device 106 along the supply airflow line The third temperature-affecting device 108 may be positioned upstream the third sensor 114.

[0093] The third temperature-affecting devices 108 may be controlled by a third control signal controlling a third control valve 128. If it is decided, in a step 322, that the first controls valve 124 is under operation, the second control valve 126 and the third control valve 128 are, in a step 324, independently set to be either fully closed or fully opened.

[0094] Alternatively, if it is decided, in a step 326, that the second controls valve 126 is under operation, the first control valve 124 and the third control valve 12B are, in a step 328, independently set to be either fully closed or fully opened. In a case the third controls valve 128 is under operation the first control valve 124 and the second control valve 126 are, in a step 330, independently set to be either fully closed or My opened.

[0095] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the [element, devices, component, means, step, etc]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

Claims

1. A system (101, 150, 160) for controlling supply airflow temperature, wherein the supply airflow flows from an upstream position to a downstream position along a supply airflow line (102), the supply airflow line comprising

    - a first temperature-affecting device (104),
    - a second temperature-affecting device (106) arranged in series with the first temperature-affecting device (104),
    - a first sensor (110) positioned at a first position downstream the first temperature-affecting device (104), and
    - a second sensor (112) positioned at a second position downstream the second temperature-affecting device (106) and upstream the first temperature-affecting device (104),

the system further comprising a controller (116), wherein

- the controller (116) is configured to receive a first actual value from the first sensor (110), a second actual value from the second sensor (112), and a set-point value from a receiver (142),
- the controller (116) is configured to control the first temperature-affecting device (104) based on the first actual value and the set-point value and thereby control the supply airflow temperatures at the first position, and
- the controller (116) is configured to control the second temperature-affecting device (106) based on the second actual value and the set-point value and thereby control the supply airflow temperatures at the second position.

2. The system according to claim 1, where

- in a case the first temperature-affecting device (104) is a heater the second temperature-affecting device (106) is a cooler, and
- in a case the first temperature-affecting device (104) is a cooler the second temperature-affecting device (106) is a heater.

3. The system according to any one of claims 1-2, wherein the first actual value and the second actual value pertain to the temperature of the supply airflow at the first position and the second position, respectively.

4. The system according to any one of claims 1-3, wherein

- the controller (116) comprises a first sub-controller (136) and a second sub-controller (138), wherein
- the first temperature-affecting device (104) and the second temperature-affecting device (106) are controlled by a first and a second control signal, respectively, and wherein
- the first control signal is associated with the first sub-controller (136) and the second control signal is associated with the second sub-controller (138),

5. The system according to claim 4, wherein

- the first control signal controls a first control valve (124) associated with the first temperature-affecting device (104), and
- the second control signal controls a second control valve (126) associated with the second temperature-affecting device (106).

6. The system according to claim 5, where

- in a case the first control valve (124) is under operation the second control valve (126) is either fully closed or fully opened, and
- in a case the second control valve (126) is under operation the first control valve (124) is either fully closed or fully opened.

7. The system according to any one of claims 1-6, wherein the supply airflow line further comprises

- a third sensor (114) positioned at a third position upstream the second temperature-affecting device (106), and
- a third temperature-affecting device (108) positioned upstream the third sensor (114), wherein
- the controller (116) is configured to receive a third actual value from the third sensor (114),
- the control (116) is configured to control the third temperature-affecting device (108) based on the third actual value and the set-point value and thereby control the supply airflow temperature at the third position.

8. The system according to claim 7, wherein the third temperature-affecting device (108) is a heat exchanger.

9. The system according to any one of claims 7-8, wherein the third actual value pertains to the temperature of the supply airflow at the third position.

10. The system according to any one of claims 7-9, wherein

- the first and the second temperature-affecting devices (104, 106) receive a second desired value during the control of the first and the second temperature-affecting devices (104, 106), respectively: and wherein
- the second desired value is associated with a control error pertaining to the third actual value and a desired value at the third position.

11. The system according to any one of claims 1-10, wherein

- the first temperature-affecting device (104) comprises a first body of water,
- the second temperature-affecting device (106) comprises a second body of water, wherein
- the airflow temperature at the first position is affected by the first body of water, and
- the airflow temperature at the second position is affected by the second body of water.

12. A method for controlling supply airflow temperature comprising

- receiving a first actual value from a first sensor (110), wherein the first sensor (110) is located at a first position along a supply airflow line (102),
- receiving a set-point value from a receiver (142),
- receiving a second actual value from a second sensor (112), wherein the second sensor (112) is located at a second position along the supply airflow line,
- controlling a first temperature-affecting device (104) based on the first actual value and the set-point value and thereby control the supply airflow temperature at the first position, wherein the first temperature-affecting device (104) is positioned upstream the first sensor (110) and downstream the second sensor (112), and
- controlling a second temperature-affecting device (106) based on the second actual value and the set-point value and thereby control the supply airflow temperature at the second position, wherein the second temperature-affecting device (106) is positioned upstream the second sensor (112).

13. The method according to claim 12 wherein

- the first temperature-affecting device (104) is controlled by a first control signal controlling a first control valve (124),
- the second temperature-affecting device (106) is controlled by a second control signal controlling a second control valve (126), wherein
- in a case the first control valve (124) is under operation the second control valve (126) is either fully closed or fully opened, and
- in a case the second control valve (126) is under operation the first control valve (124) is either fully closed or fully opened.

14. The method according to any one of claims 12-13 further comprising

- receiving a third actual value from a third sensor (114), wherein the third sensor (114) is located at a third position upstream the second temperature-affecting device (106) along the supply airflow line, and
- controlling a third temperature-affecting device (108) based on the third actual value and the set-point value and thereby control the supply airflow temperature at the third position, wherein the third temperature-affecting device (108) is positioned upstream the third sensor (114).

15. The method according to claim 14 when dependent on claim 13 wherein

- the third temperature-affecting devices (108) is controlled by a third control signal controlling a third control valve (128), wherein
- in a case the first control valve (124) is under operation the second control valve (126) and the third control valve (128) are independently either fully closed or fully opened,
- in a case the second control valve (126) is under operation the first control valve (124) and the third control valve (128) are independently either fully closed or fully opened, and
- in a case the third control valve (128) is under operation the first control valve (124) and the second control valve (126) are independently either fully closed or fully opened.

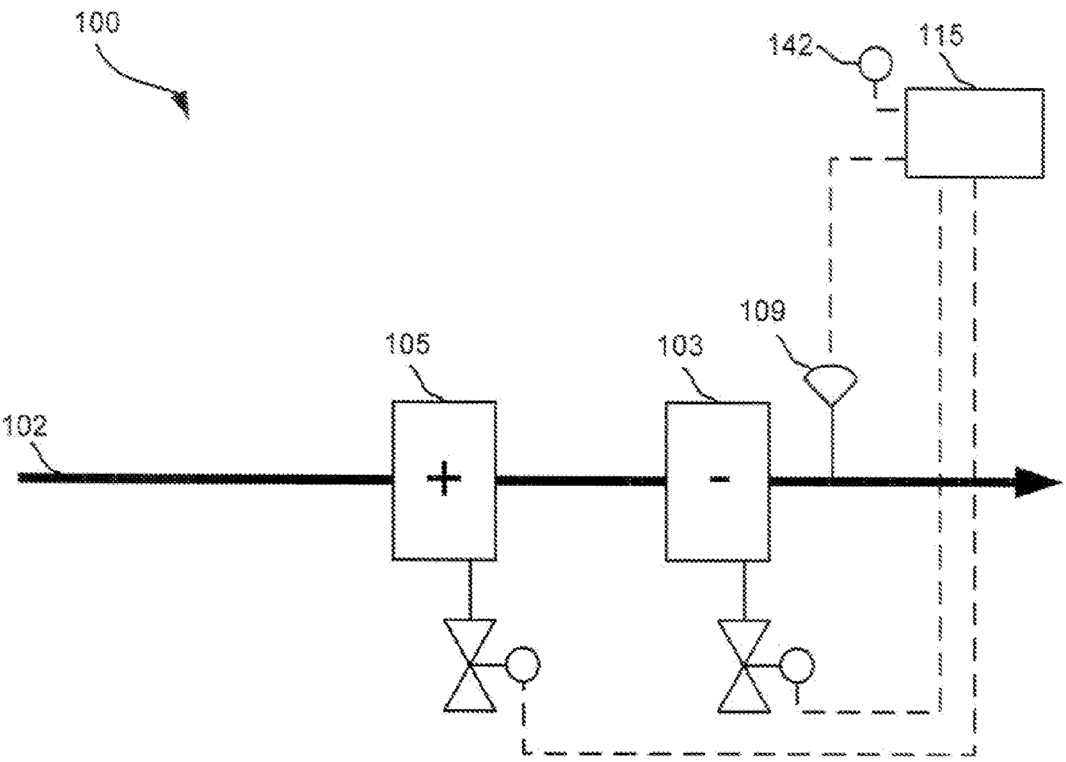


Fig. 1(a) (Prior Art)

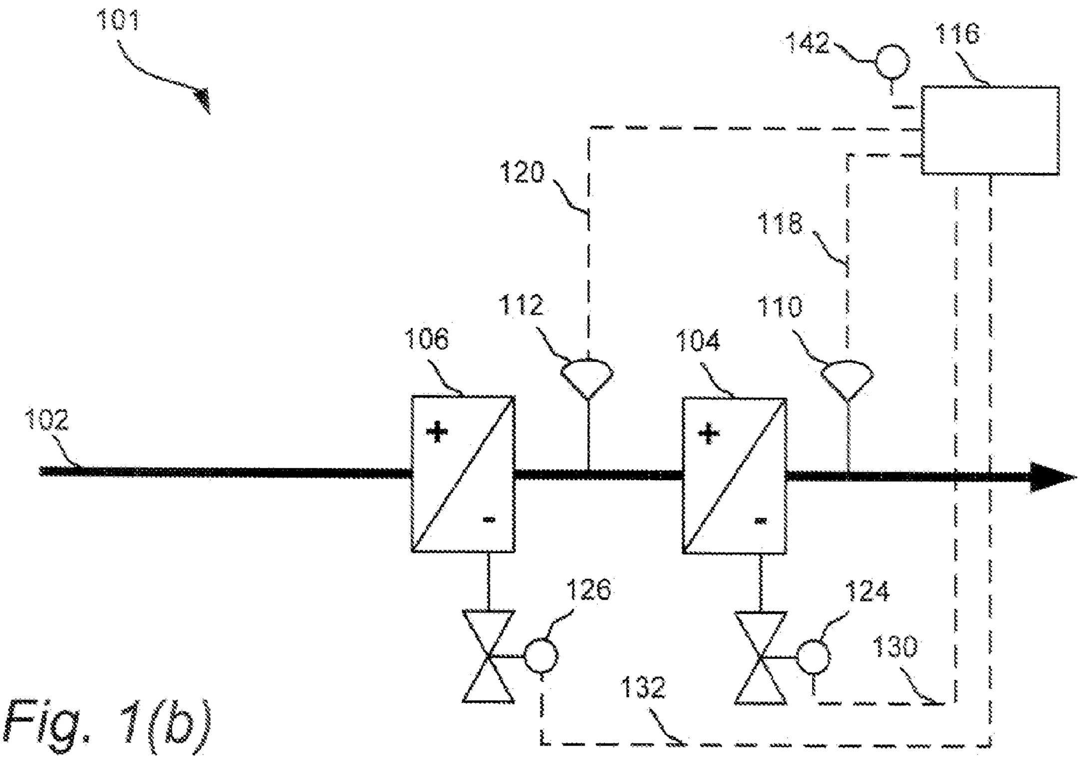

101
142
116
120
118
112
110
106
104
102
126
124
130
132

Fig. 1(b)

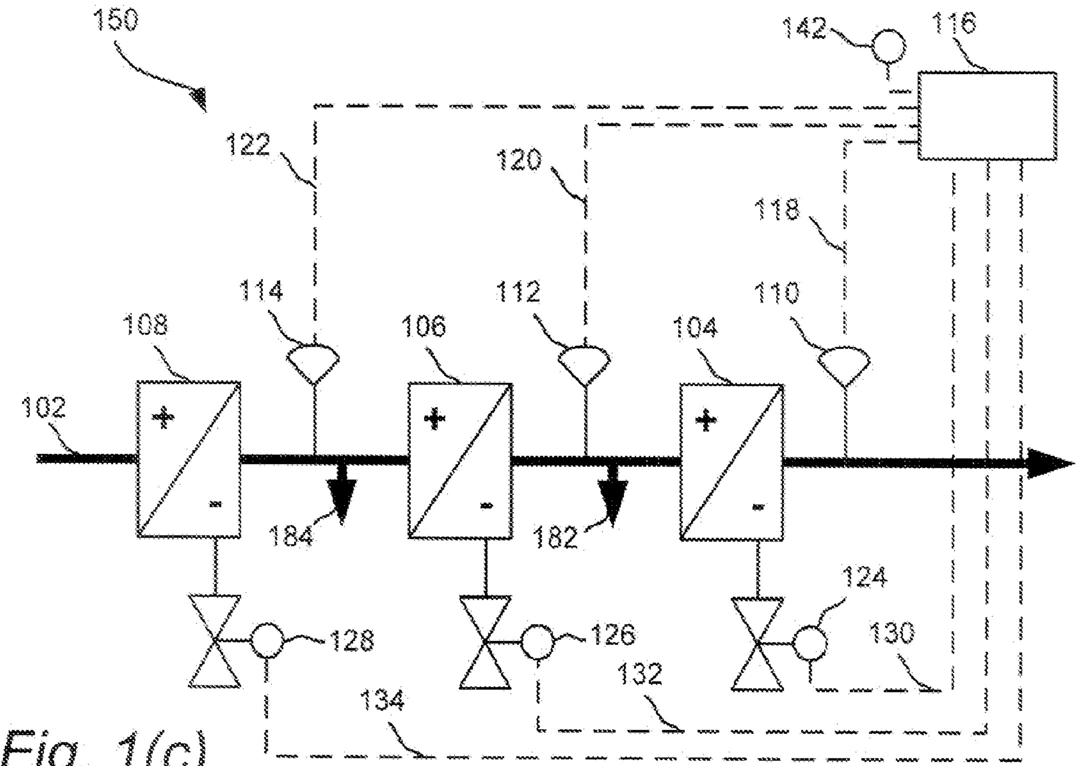

150
142
116
122
120
118
114
112
110
108
106
104
102
184
182
124
128
126
130
132
134

Fig. 1(c)

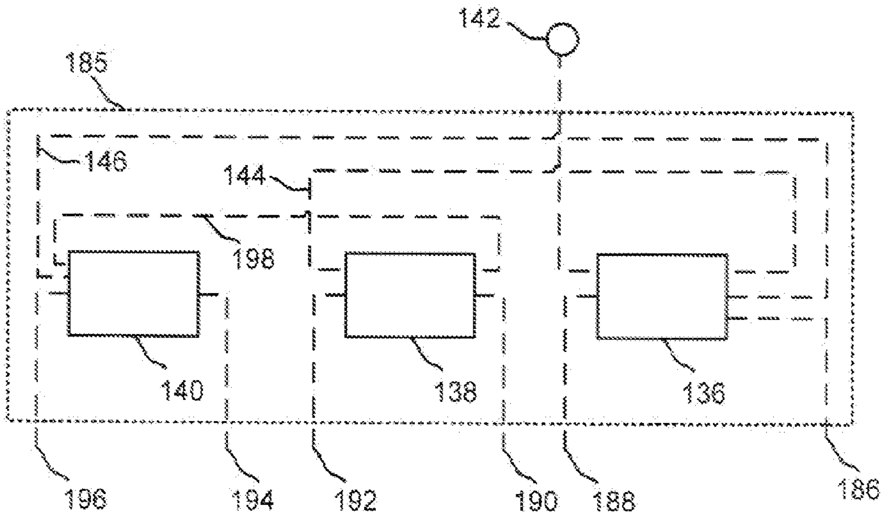

142
185
146
144
198
140
138
136
196
194
192
190
188
186

Fig. 1(d)

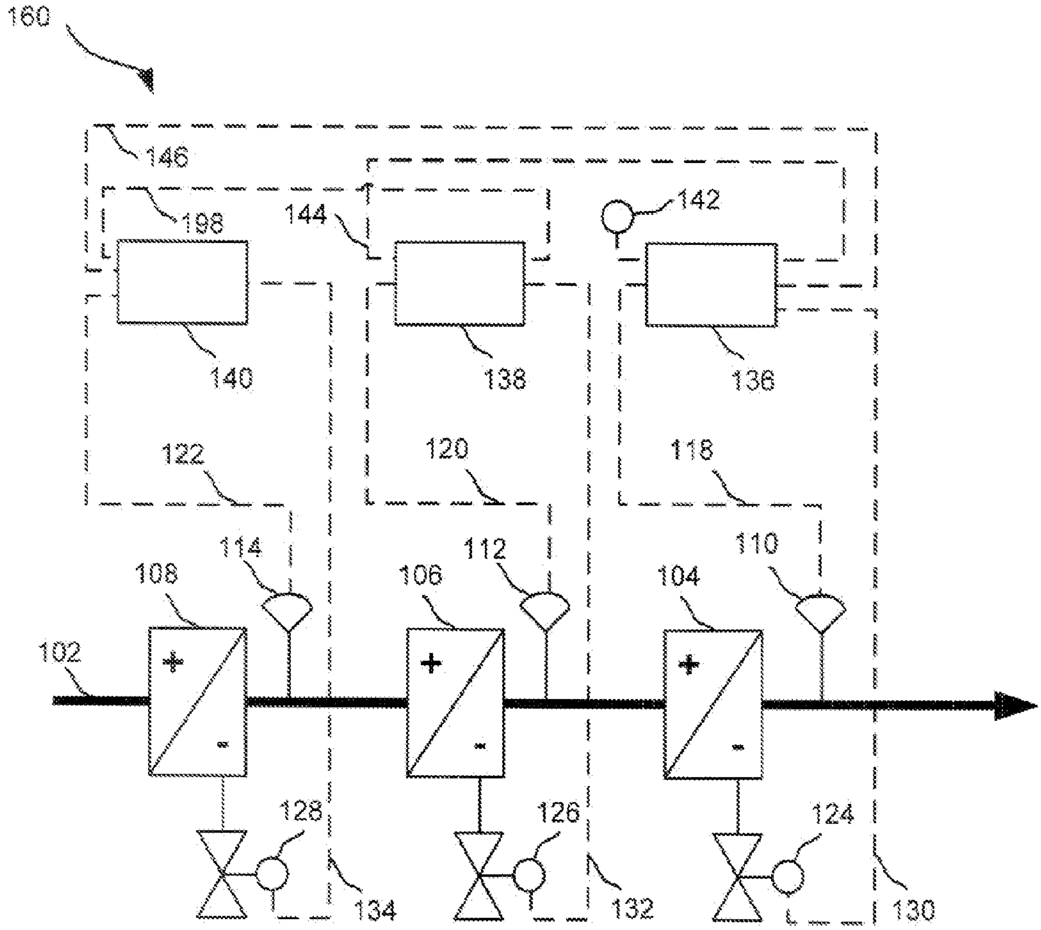

160
146
198
144
142
140
138
136
122
120
118
114
112
110
108
106
104
102
+
-
+
-
+
-
128
126
124
134
132
130

Fig. 1(e)

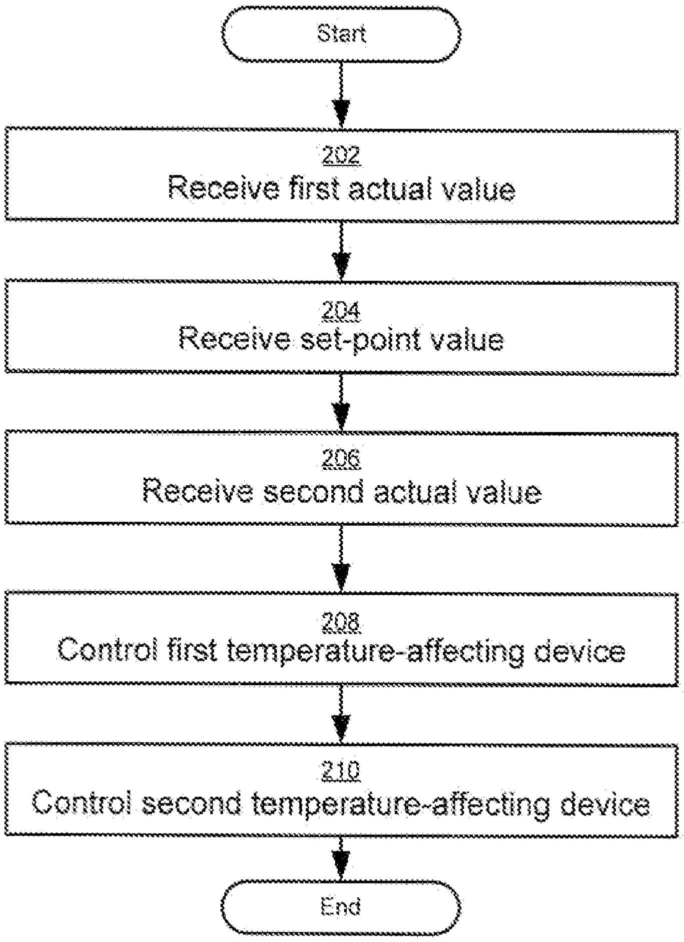
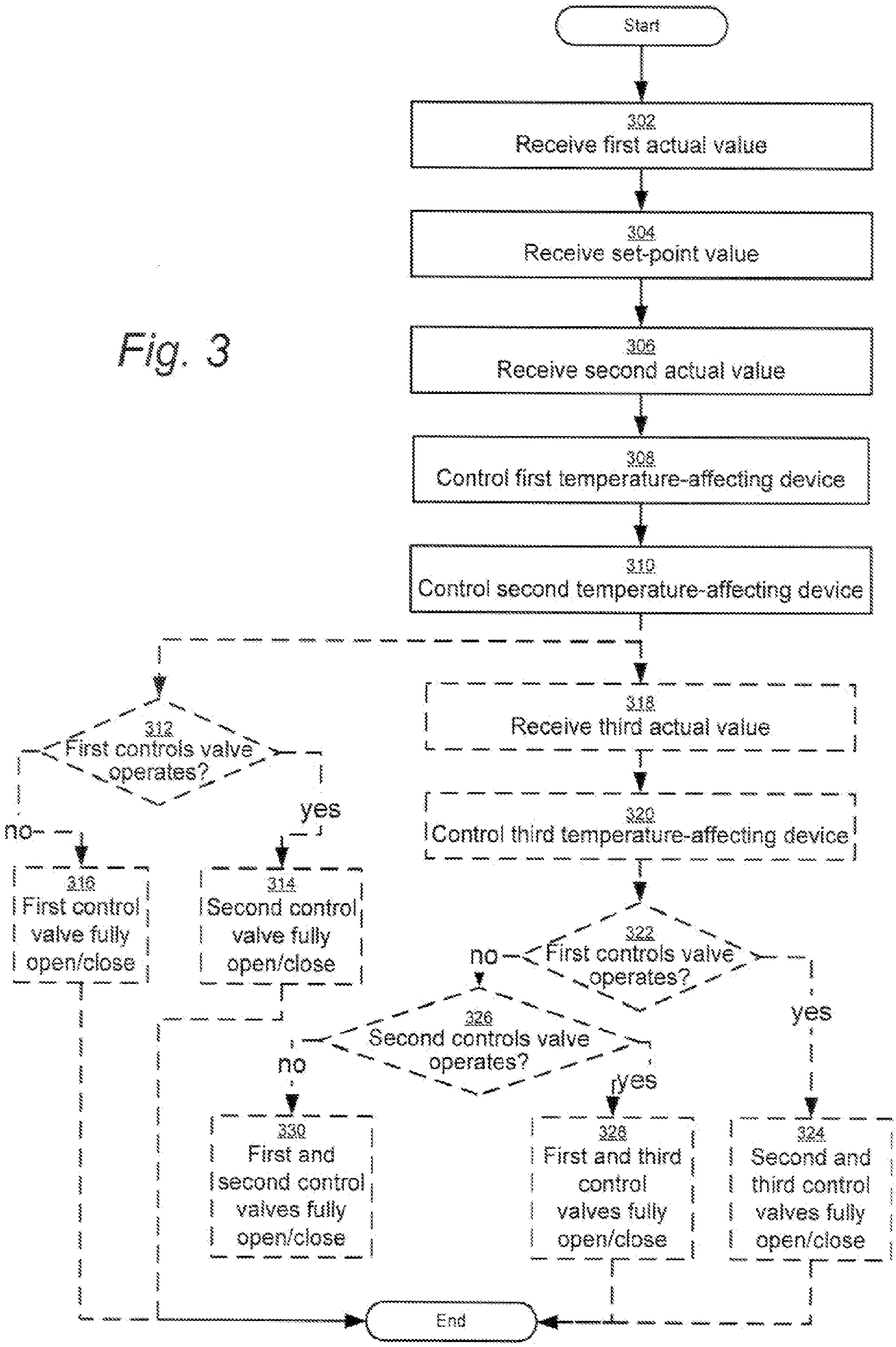

Start
202
Receive first actual value
204
Receive set-point value
206
Receive second actual value
208
Control first temperature-affecting device
210
Control second temperature-affecting device
End

Fig. 2

Fig. 3


Start
302
Receive first actual value
304
Receive set-point value
306
Receive second actual value
308
Control first temperature-affecting device
310
Control second temperature-affecting device
312
First controls valve operates?
no
yes
316
First control valve fully open/close
314
Second control valve fully open/close
318
Receive third actual value
320
Control third temperature-affecting device
322
First controls valve operates?
no
yes
326
Second controls valve operates?
no
yes
330
First and second control valves fully open/close
328
First and third control valves fully open/close
324
Second and third control valves fully open/close
End

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 08 15 9497

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 01 070633 A (FUJI ELECTRIC CO LTD) 16 March 1989 (1989-03-16) * abstract; figure 1 *	1-15	INV. F24F11/00
X	EP 0 102 397 A (HITACHI LTD [JP]; HITACHI AUTOMOTIVE ENG [JP]) 14 March 1984 (1984-03-14) * page 5, paragraph 2 - page 13, paragraph 2; figures 2a,2b,2c *	1-15	
X	JP 2007 309572 A (KANTO DENKI KOJI; NIPPON DENGI KK) 29 November 2007 (2007-11-29) * paragraph [0003] - paragraph [0009]; figures 9-11 * * paragraph [0027] - paragraph [0030]; figure 1 *	1-15	
A	JP 60 066038 A (TOKYO SHIBAURA ELECTRIC CO) 16 April 1985 (1985-04-16) * the whole document *	1,12	
A	US 4 375 754 A (OKURA EIJI [JP]) 8 March 1983 (1983-03-08) * the whole document *	1,12	TECHNICAL FIELDS SEARCHED (IPC): B60H G05D F24F
A,D	US 5 350 113 A (COOGAN JAMES J [US]) 27 September 1994 (1994-09-27) * the whole document *	1,12	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 November 2008	González-Granda, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

4
EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 15 9497

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.

17-11-2008

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
JP 1070633	A	16-03-1989	NONE		
EP 0102397	A	14-03-1984	JP	58156410 A	17-09-1983
			WO	8303229 A1	29-09-1983
JP 2007309572	A	29-11-2007	NONE		
JP 60066038	A	16-04-1985	NONE		
US 4375754	A	08-03-1983	JP	57018515 A	30-01-1982
US 5350113	A	27-09-1994	NONE		

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5350113 A **[0006]**

Non-patent literature cited in the description

- **J. G. Ziegler ; N. B. Nichols.** Optimum settings for automatic controllers. *ASME Transactions,* 1942, vol. 64, 759-768 **[0043]**