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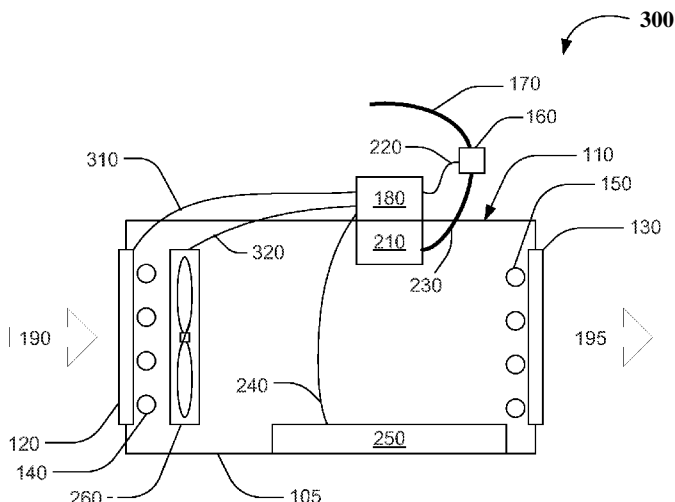


FIG. 3

(57) **Abstract:** Flow measurement systems and methods are provided. A flow measurement system can include at least one heat-producing computing device (160) having at least one fluid inlet (120) and one fluid outlet (130). The system can further include at least one inlet fluid inlet temperature sensor (140) and at least one outlet fluid temperature sensor (150). At least one current sensor (160) measuring the current supplied to at least a portion of the at least one heat-producing computing device (110) can also be included with the system (100). The system can also include at least one calculating device (180) adapted to calculate the inlet fluid flow rate based at least in part upon the sensed inlet fluid temperature, the sensed outlet fluid temperature, and the sensed current flow.



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FLOW MEASUREMENT SYSTEM AND METHODS

BACKGROUND OF THE INVENTION

Description of the Related Art

[0001] Thermal management presents considerable challenges within a computing environment. Controlling cooling fluid flow to the various components disposed within a computing environment often requires rather precise knowledge of the heat being generated by the device in order to properly match the cooling system to the specific demands presented by the component. Balancing cost efficient, environmentally friendly operation of the cooling equipment against the very specific cooling requirements of the various components found within the computing environment is frequently of paramount importance to manufacturers, owners, and operators of the computing environment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Advantages of one or more disclosed embodiments may become apparent upon reading the following detailed description and upon reference to the drawings in which:

[0003] Fig. 1 is a schematic depicting an embodiment of an illustrative flow measurement system, according to one or more embodiments described herein;

[0004] Fig. 2 is a schematic depicting an embodiment of another illustrative flow measurement system, according to one or more embodiments described herein;

[0005] Fig. 3 is a schematic depicting an embodiment of yet another illustrative flow measurement system, according to one or more embodiments described herein;

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[0006] Fig. 4 is a flow diagram depicting an embodiment of an illustrative flow measurement method, according to one or more embodiments described herein; and

[0007] Fig. 5 is a flow diagram depicting an embodiment of another illustrative flow measurement method, according to one or more embodiments described herein.

DETAILED DESCRIPTION

[0008] The accurate measurement of fluid flow about computing devices is frequently of great importance, particularly in computing intensive environments such as those found in server rooms and data centers. Balancing fluid flow amongst a myriad of computing devices is often performed based upon the heat generated by the computing device and the overall flow of fluid through the computing device.

[0009] At least one flow measurement system is therefore provided. A flow measurement system can include at least one heat-producing computing device having at least one fluid inlet and one fluid outlet. The system can further include at least one fluid inlet temperature sensor and at least one fluid outlet temperature sensor. At least one current sensor measuring the current supplied to at least a portion of the at least one heat-producing computing device can also be included with the system. The system can also include at least one calculating device adapted to calculate the inlet fluid flow rate based at least in part upon the sensed fluid inlet temperature, the sensed fluid outlet temperature, and the sensed current flow.

[0010] At least one flow measurement method is also provided. The method can include measuring a fluid inlet temperature to at least one heat-producing computing device using at least one fluid inlet temperature sensor. The method can further include measuring the input current to at least one heat-producing computing device disposed at least partially within the enclosure using at least one current sensor. The method can include measuring a fluid outlet

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temperature from the at least one heat-producing computing device using at least one fluid outlet temperature sensor. The method can further include calculating the heat generated by the heat-producing computing device based upon the input current using at least one calculating device. The method can also include calculating the differential temperature by subtracting the fluid inlet temperature from the fluid outlet temperature using the at least one calculating device. The method can further include calculating the fluid flow rate to the heat-producing computing device based upon the heat generated and the differential temperature using the at least one calculating device.

[001 1] Fig. 1 is a schematic depicting an embodiment of an illustrative flow measurement system 100, according to one or more embodiments. In at least some embodiments, the system 100 can include at least one heat-generating computing device 110 having at least one fluid inlet 120 and one fluid outlet 130. The device can further include at least one fluid inlet temperature sensor 140 and at least one fluid outlet temperature sensor 150. The system can include at least one current sensor 160 measuring the current supplied to at least a portion of the heat-producing computing device 110. At least one calculating device 165 can be adapted to calculate the inlet fluid flow rate based at least in part upon the sensed inlet fluid temperature, the sensed outlet fluid temperature, and the sensed current flow.

[001 2] In at least some embodiments, the heat-generating computing device 110 can include any number of heat-generating devices, systems, or combination of systems and devices 115 capable of providing, producing, or otherwise generating heat. In at least some embodiments, the heat-generating computing device 110 can include any number of housings or enclosures 105. In at least some embodiments, the heat-generating computing device 110 can include one or more heat-generating devices, systems, or combination of systems and devices 115 disposed partially or completely within any number of housings or enclosures 105. In at least some embodiments, the heat-generating computing device 110 can include one or more board mounted

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electronic components 115 disposed at least partially within the enclosure or housing 105.

[0013] In at least some embodiments, at least one fluid inlet 120 and at least one fluid outlet 130 can be disposed in, on, or about the heat-producing computing device 110. The fluid inlet 120 and the fluid outlet 130 can provide the entry and exit points, respectively, for the flow of one or more fluids in, around, through, or about the heat-generating computing device 110. The one or more fluids can include one or more liquids or gasses suitable for transporting heat or thermal energy from the heat-producing computing device 110. Illustrative, non-limiting, liquids can include water, glycol solutions, and the like. Illustrative, non-limiting, gases can include ambient or conditioned air, or similar non-condensing gases or gas mixtures.

[0014] Physically, the at least one fluid inlet 120 and the at least one fluid outlet 130 can be of equal or differing shapes, sizes, geometries, or cross-sectional areas. Either one or both of the at least one fluid inlet 120 and the at least one fluid outlet 130 can include or otherwise incorporate one or more flow control devices, for example, one or more variable position flow control valves, dampers, or the like, to control, restrict, impede, alter, or otherwise limit the fluid flow through the heat-generating computing device 110.

[0015] The at least one fluid inlet temperature sensor ("inlet sensor") 140 and the at least one fluid outlet temperature sensor ("outlet sensor") 150 can include any number of systems, devices, or any combination of systems and devices adapted to measure and transmit a signal proportionate to the temperature of the fluid flowing about the inlet sensor 140 and the outlet sensor 150. The at least one inlet sensor 140 can be used to measure the temperature of all or a portion of an inlet fluid 190 entering the heat-generating computing device 110. The at least one outlet sensor 150 can be used to measure the temperature of all or a portion of an outlet fluid 195 exiting the heat-generating computing device 110. The at least one inlet sensor 140 and the at least one outlet sensor 150 can include thermocouples, resistive thermal devices ("RTDs"), chip

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mounted temperature sensors, or any combination thereof. In at least some embodiments, all or a portion of the inlet sensors 140 and the outlet sensors 150 can be communicatively coupled to the calculating device 180.

[0016] As used herein, the term "communicative coupling", or a connection by which entities are "communicatively coupled", is one by which electromagnetic signals, physical communications, and/or logical communications may be sent and/or received. Typically, a communicative coupling includes a physical interface, an electrical interface, and/or a data interface, but it is to be noted that a communicative coupling may include differing combinations of these or other types of connections sufficient to allow intermittent or continuous communication or control. For example, two entities can be communicatively coupled by being able to communicate signals to each other directly or through one or more intermediate entities like a processor, operating system, a logic device, software, or other entity. Logical and/or physical communication channels can be used to create a communicative coupling.

[0017] At least one current sensor 160 can be used to monitor the electrical current flow to the heat-generating computing device 110. In at least some embodiments, the at least one current sensor 160 can be disposed in, on, or about the heat-generating computing device 110 power feed 170. In at least some embodiments, the at least one current sensor 160 can include one or more electrical current sensors, one or more voltage sensors, one or more power factor sensors, one or more power sensors, or any combination or multiples thereof. The at least one current sensor 160 can be a single phase or multi-phase sensor, for example a one, two or three phase sensor.

[0018] The calculating device 180 can include any number of systems, devices, or any combination of systems and devices suitable for receiving at least one signal input and performing at least one calculation involving the one or more inputs. In at least some embodiments, the calculating device 180 can generate one or more outputs, for example one or more control outputs, one or more display outputs, or any combination or multiples thereof. In at least some

embodiments, the calculating device 180 can be disposed externally or remotely from the heat-generating computing device 110. The calculating device 180 can be a discrete device, for example a dedicated board mount integrated circuit, or a smaller portion of a larger computing device, for example a co-processor housed within a computer central processing unit ("CPU"). In at least some embodiments, the calculating device 180 can be disposed proximate or internal to the heat-generating computing device 110. In at least some embodiments, the calculating device can be at least a portion of the heat-generating computing device 110.

[0019] Fig. 2 is a schematic depicting an embodiment of another illustrative flow measurement system 200. In at least some embodiments, the heat-producing computing device 110 disposed within the system 200 can include one or more blade computing devices 210. In at least some embodiments, the enclosure 105 can include one or more rack enclosures that partially or completely enclose the one or more blade computing devices 210.

[0020] In at least some embodiments, the power 230 required by the one or more blade computing devices 210 can be supplied via the power feed 170. In at least some embodiments, the power supplied to the one or more blade computing devices 210 can be measured using the at least one current sensor 160. The current sensor can be communicatively coupled 220 to the calculating device 180. In at least some embodiments, the heat-producing computing device 110 can include at least one display device 250. In at least some embodiments, the heat-producing computing device 110 can include at least one fluid mover 260.

[0021] The one or more blade computing devices 210 can include any number of systems, devices, or any combination of systems and devices suitable for performing one or more functions while mounted in a rack based enclosure 105. The one or more blade computing devices 210 can include, but are not limited to, one or more blade computing devices adapted to provide switching, routing, storage, SAN and fiber-channel access, or any combination thereof. In at least

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some embodiments, the one or more blade computing devices 210 can include at least one blade mounted server. In at least some embodiments, the one or more calculating devices 180 can be disposed or otherwise incorporated partially or completely within the one or more blade computing devices 210.

[0022] The power feed 170 can be coupled to the one or more blade computing devices 210 via one or more power feeds 230. In at least some embodiments, the one or more power feeds 230 can include one or more power supplies (not shown in Fig. 2) disposed internally within the heat-producing computing device. In at least some embodiments, the at least one current sensor 160 can transmit a signal proportional to the current flow through the power feed 170 to the calculating device 180 via the communicative coupling 220.

[0023] As used herein, the term "couple" or "coupled" can refer to any form of direct, indirect, optical or wireless electrical connection. The electrical connection can, in one or more embodiments, include, but is not limited to any electrically conductive or magnetically inductive connection linking two or more devices. The connection can be electrically conductive, for example using one or more conductors such as copper or aluminum wire, conductive strips on a printed circuit board, or the like to connect two or more components. The connection can be magnetically inductive, for example, stimulating the flow of current from a transformer secondary coil by passing a current through a primary coil inductively coupled to the secondary coil. The connection can be electro-magnetic, for example by controlling current flow through a relay contact via an independent relay coil such that passage of a current through the relay coil can magnetically open and close the relay contact.

[0024] In at least some embodiments, the calculating device can be coupled 240 to at least one display device 250. The at least one display device 250 can include any number of systems, devices, or any combination of systems and devices suitable for visually or audibly displaying data. Illustrative display devices can include single element light emitting diodes ("LEDs"), a multi-element LED display, a liquid crystal display ("LCD"), a cathode ray tube

("CRT") display, and the like. In some embodiments, the at least one display device 250 can display information related to the at least one heat-producing computing device 110, for example the inlet temperature, outlet temperature, or the current flow. In some embodiments, the at least one display device 250 can display measured information related to the heat-producing computing device 110, for example the inlet temperature, outlet temperature, or the current flow. In some embodiments, the at least one display device can display fluid flow rate through the heat-producing computing device 110.

[0025] In at least some embodiments, the fluid flow about the at least one heat-producing computing device 110 can be provided at least in part by at least one fluid mover 260. The fluid mover 260 can include any number of systems, devices, or any combination of systems and devices suitable for initiate, impart, enhance or promote fluid flow in, through, around, or about the at least one heat-producing computing device 110. Illustrative gaseous fluid movers 260 can include one or more centrifugal or axial flow fans. Illustrative liquid fluid movers 260 can include one or more pumps. In at least some embodiments, all or a portion of the power required to operate the at least one fluid mover 260 can be supplied via the power feed 170.

[0026] Fig. 3 is a schematic depicting yet another embodiment of an illustrative flow measurement system 300, according to one or more embodiments. In the system 300, the calculating device 180 can be coupled to at least a portion of the fluid inlet 120. In the system 300, the calculating device 180 can be coupled to the fluid mover 260. In at least some embodiments, the calculating device 180 can control or limit the flow of fluid in, around, through, or about the heat-producing computing device 110 by modulating the cross sectional area of the fluid inlet 120. In at least some embodiments, the calculating device 180 can control or limit the flow of fluid in, around, through, or about the heat-producing computing device 110 by modulating the pumping rate of the fluid mover 260.

[0027] Fig. 4 is a flow diagram depicting an embodiment of an illustrative flow measurement method 400, according to one or more embodiments. In at least

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some embodiments, the method 400 can include measuring the fluid inlet temperature (T_i) at 410, using the at least one inlet sensor 140. The temperature measured using the at least one inlet sensor 140 can be transmitted to the coupled calculating device 180. The method 400 can further include measuring the fluid outlet temperature (T_o) at 420, using the at least one inlet sensor 150. The temperature measured using the at least one outlet sensor 150 can be transmitted to the coupled calculating device 180.

[0028] At 430, the electrical current supplied (I_s) to the heat producing computing device 110 can be measured using the at least one current sensor 160. The current measured using the at least one current sensor 160 can be transmitted to the coupled 220 calculating device 180. At 440, the computing device 180 can calculate the heat ("q") produced by the heat-producing computing device 110. In at least some embodiments, at 440, the calculating device 180 can use the following formulas to calculate the heat generated by the heat-producing computing device 110 when supplied 270 with single or three phase alternating current power supplied at a source voltage of V_s :

$$\text{Single Phase (kW):} \quad q = (I_s \times V_s \times \text{PF}) / 1000$$

$$\text{Three Phase (kW):} \quad q = (I_s \times V_s \times \text{PF} \times 1.73) / 1000$$

[0029] Using an average power factor of 0.7, the formulas can be simplified in this example to the following:

$$\text{Single Phase (BTU/min):} \quad q = I_s \times V_s \times 0.040$$

$$\text{Single Phase (kJ/min):} \quad q = I_s \times V_s \times 0.042$$

$$\text{Three Phase (BTU/min):} \quad q = I_s \times V_s \times 0.069$$

$$\text{Three Phase (kJ/min):} \quad q = I_s \times V_s \times 0.073$$

[0030] At 450, the calculating device 180 can calculate the temperature differential (" ΔT ") between the fluid inlet temperature (" T_i ") and the fluid outlet temperature (" T_o "). The temperature differential can be calculated in degrees

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Fahrenheit (°F) or in degrees Celsius (°C). In at least some embodiments, at 450 the computing device 180 can calculate the fluid mass flow rate through the heat-producing computing device 110 using the following formula based upon the specific heat ("c_p") of the fluid:

$$\text{Mass flow rate: } m = q / (c_p \times \Delta T)$$

[0031] Other formulas can also be used by the calculating device to provide the mass flow rate. In some embodiments, the specific heat of the fluid can be manually entered or programmed into the calculating device 180. Where the specific heat of the fluid displays a temperature dependency, the fluid inlet temperature, fluid outlet temperature, or fluid average temperature can be used by the calculating device 180 to determine the correct specific heat. Using air (c_p = 1.00 kJ/kg-K or 0.24 BTU/lb-°F) as a non-exclusive illustrative example, the fluid mass flow rate can be determined using the following formulas:

$$\text{Mass Flow (lb/min): } m = 4.2 \times (q \text{ (in BTU/min)} / \Delta T \text{ (in } ^\circ\text{F)})$$

$$\text{Mass Flow (kg/min): } m = 1.0 \times (q \text{ (in kJ/min)} / \Delta T \text{ (in } ^\circ\text{C)})$$

[0032] At 460 the calculating device can convert the calculated fluid mass flow rate to a volumetric flow rate using the density ("p") of the fluid. Since density displays a temperature dependency, the fluid inlet temperature, fluid outlet temperature, or fluid average temperature can be used by the calculating device 180 to determine the density of the fluid. In at least some embodiments, the calculating device 180 can use the following formula to calculate the volumetric flow rate through the heat-producing computing device 110:

$$\text{Volumetric flow rate: } V = m / p$$

[0033] Once again using air (p = 1.184 kg/m³ or 0.074 lb/ft³) as a non-exclusive illustrative example, the fluid volumetric flow rate can be determined using the following formulas:

$$\text{Volumetric flow rate (ft}^3\text{/min): } V = 13.5 \times m \text{ (in lb/min)}$$

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Volumetric flow rate (m³/min): $V = 0.84 \times m$ (in kg/min)

[0034] The use of observed parameters such as fluid inlet and outlet temperatures and current can permit an accurate determination of fluid flow rate in 460 regardless of the internal configuration of the at least one heat-producing computing device 110. Systems relying instead on estimating the fluid flow rate through at least one heat-producing computing device 110 based wholly or partially upon one or more fluid mover 260 performance characteristics, such as current draw or speed, may provide an erroneous fluid flow rate when internal components within the at least one heat-producing computing device 110 are added, removed, or reconfigured.

[0035] Fig. 5 is a flow diagram depicting an embodiment of another illustrative flow measurement method 500. In at least some embodiments, the fluid flow through the heat-producing computing device 110 can be controlled or modulated based upon one or more predetermined parameters. For example, in some embodiments, in 510 a predetermined volumetric fluid flow rate setpoint can be entered into the calculating device 180. After the calculating device 180 determines the volumetric flow rate, using for example the method in 410 through 460, and described in detail with regards to Fig. 4, the fluid flow rate can be displayed, for example using the at least one display device 250 in 520.

[0036] In at least some embodiments, the inlet fluid temperature, the outlet fluid temperature, the current flow, the fluid flow rate, or any combination thereof can be transmitted to one or more external systems, for example an environmental control system adapted to control or adjust one or more environmental control system parameters in response to sensed or measured conditions. Illustrative, non-limiting environmental control system parameters can include environmental control system heat output, environmental control system cooling output, wet bulb temperature, dry bulb temperature, ambient temperature, and relative humidity.

[0037] At 530 the calculating device 180 can determine whether the fluid flow rate is within an acceptable range of the setpoint entered in 510. If the fluid flow

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rate is within an acceptable range of the setpoint entered in 510, the calculating device 180 can delay for one time constant in 540 before again calculating the fluid flow rate (in 410 through 460) and comparing the actual flow rate to the setpoint in 530.

[0038] If the fluid flow rate is not within an acceptable range of the setpoint entered in 510, the calculating device 180 can adjust the fluid flow rate in 550. In at least some embodiments, the calculating device 180 can adjust the fluid flow rate by altering the cross sectional area of the fluid inlet 120. In at least some embodiments, the calculating device 180 can adjust the fluid flow rate by altering the cross sectional area of the fluid outlet 130. In at least some embodiments, the calculating device 180 can adjust the fluid flow rate by altering the capacity of the fluid mover 260.

[0039] Though depicted sequential for convenience, discussion and readability, at least some of the actions, steps, or sequences shown in Figs. 4 and 5 can be performed in a different order and/or in parallel. Additionally, one or more specific embodiments may perform only a limited number of the actions, steps, or sequences shown in Figs. 4 and 5. Additionally, one or more actions, steps, or sequences can be performed using a second calculating device disposed proximate or remote from the calculating device 180 executing all or a portion of the one or more actions, steps, or sequences depicted in Figs. 4 and 5.

[0040] Certain embodiments and features have been described using a set of numerical upper limits and a set of numerical lower limits. It should be appreciated that ranges from any lower limit to any upper limit are contemplated unless otherwise indicated. Certain lower limits, upper limits and ranges appear in one or more claims below. All numerical values are "about" or "approximately" the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

[0041] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without

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departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

CLAIMS:

What is claimed is:

1. A flow measurement system, comprising:
 - at least one heat-producing computing device (160) comprising at least one fluid inlet (170) and one fluid outlet (180);
 - at least one inlet fluid inlet temperature sensor (120) and at least one outlet fluid temperature sensor (130);
 - at least one current sensor (140) measuring the current supplied to at least a portion of the at least one heat-producing computing device (160); and
 - at least one calculating device (180) adapted to calculate the inlet fluid flow rate based at least in part on the sensed inlet fluid temperature, the sensed outlet fluid temperature, and the sensed current flow.
2. The system of claim 1, wherein the at least one heat-producing computing device (160) comprises a rack and a blade mount server (210) disposed at least partially within the rack.
3. The system of claim 1, wherein the calculating device (180) is further adapted to:
 - accept the input of an inlet fluid flow rate setpoint;
 - calculate the actual inlet fluid flow rate;
 - compare the actual inlet fluid flow rate to the setpoint; and
 - generate a control output (310) based upon the deviation of the actual inlet fluid flow rate from the setpoint.
4. The system of claim 3, wherein the control output (310) is operably connected to the at least one fluid inlet (120) and wherein the open cross sectional area of the fluid inlet (120) is adjustable in response to the control output.

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5. The system of claim 3, further comprising at least one fluid mover (260);
wherein the control output (320) is coupled to the at least one fluid mover; and
wherein the capacity of the fluid pumping device is adjustable in response to the control output.
6. The system of claim 1, further comprising at least one display device (250) coupled (240) to the calculating device (180); the display device adapted to display the calculated fluid flow rate.
7. A flow measurement method, comprising:
measuring (410) an inlet fluid (175) temperature to at least one heat-producing computing device (160) using at least one inlet temperature sensor (120);
measuring (420) the input current to at least one heat-producing computing device (160) disposed at least partially within the enclosure using at least one current sensor (140);
measuring (430) a discharge fluid (185) temperature from the at least one heat-producing computing device (160) using at least one outlet temperature sensor (130);
calculating (440) the heat generated by the heat-producing computing device based upon the input current using at least one calculating device (165);
calculating (450) the differential temperature by subtracting the inlet temperature from the outlet temperature using the at least one calculating device (165); and
calculating (460) the inlet fluid flow rate through the enclosure based upon the heat generated and the differential temperature using the at least one calculating device (165).

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8. The method of claim 7 further comprising,
 - displaying (520) the inlet fluid flow rate on at least one display device (220); and
 - transmitting the inlet fluid flow rate to an environmental control system.

9. The method of claims 7 or 8, further comprising:
 - entering an inlet fluid flow rate setpoint (510);
 - comparing the inlet fluid flow rate through the enclosure to the setpoint (530); and
 - adjusting the inlet fluid flow rate through the heat-producing computing device (110) based upon the deviation from the entered inlet fluid flow rate setpoint.

10. The method of claim 9, wherein adjusting the inlet fluid flow rate comprises altering the cross sectional area of the fluid inlet (120).

11. The method of claim 9, wherein adjusting the inlet fluid flow rate comprises altering the pumping rate of the fluid mover (260).

12. The method of claims 7 through 11, wherein the fluid is air.

13. The method of claims 7 through 12, wherein the at least one heat-producing computing device (110) comprises a rack and a computing device disposed at least partially within the rack.

14. The method of claim 8, further comprising adjusting at least one environmental control system parameter, wherein the at least one parameter is selected from the group of parameters consisting of: environmental control system heat output, environmental control system cooling output, wet bulb

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temperature, dry bulb temperature, ambient temperature, and relative humidity.

15. The method of claim 13, wherein at least a portion of the at least one heat-producing computing device (110) comprises the calculating device (180).

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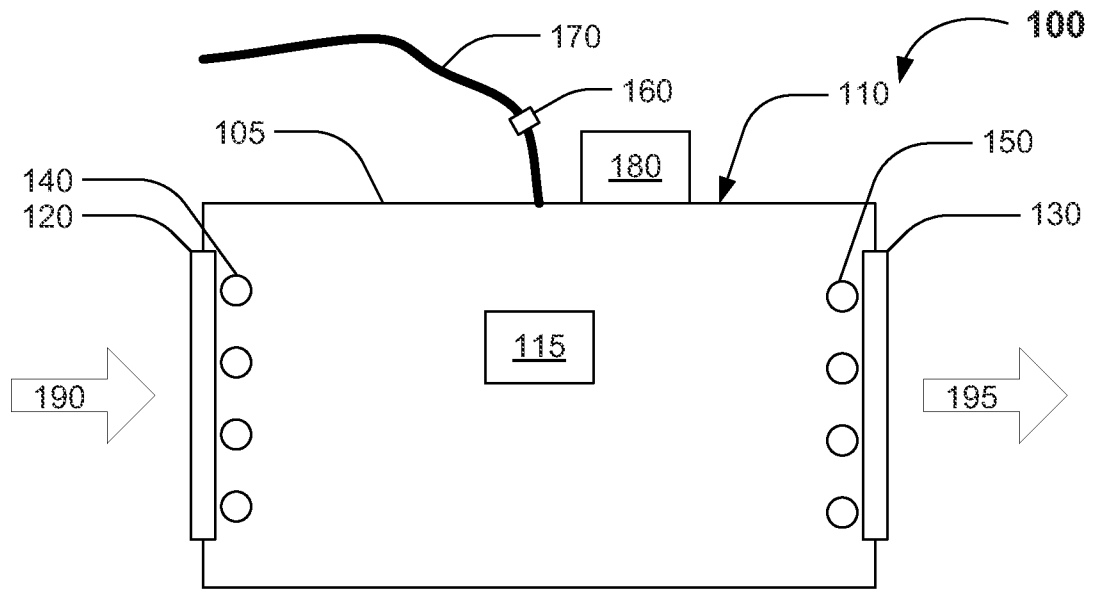


FIG. 1

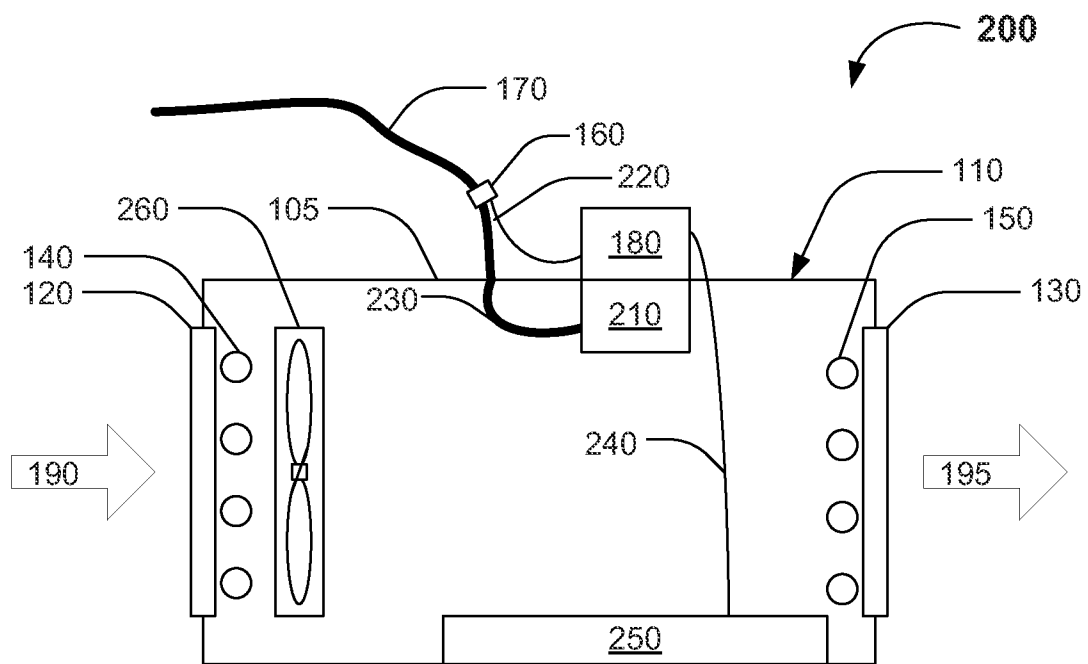


FIG. 2

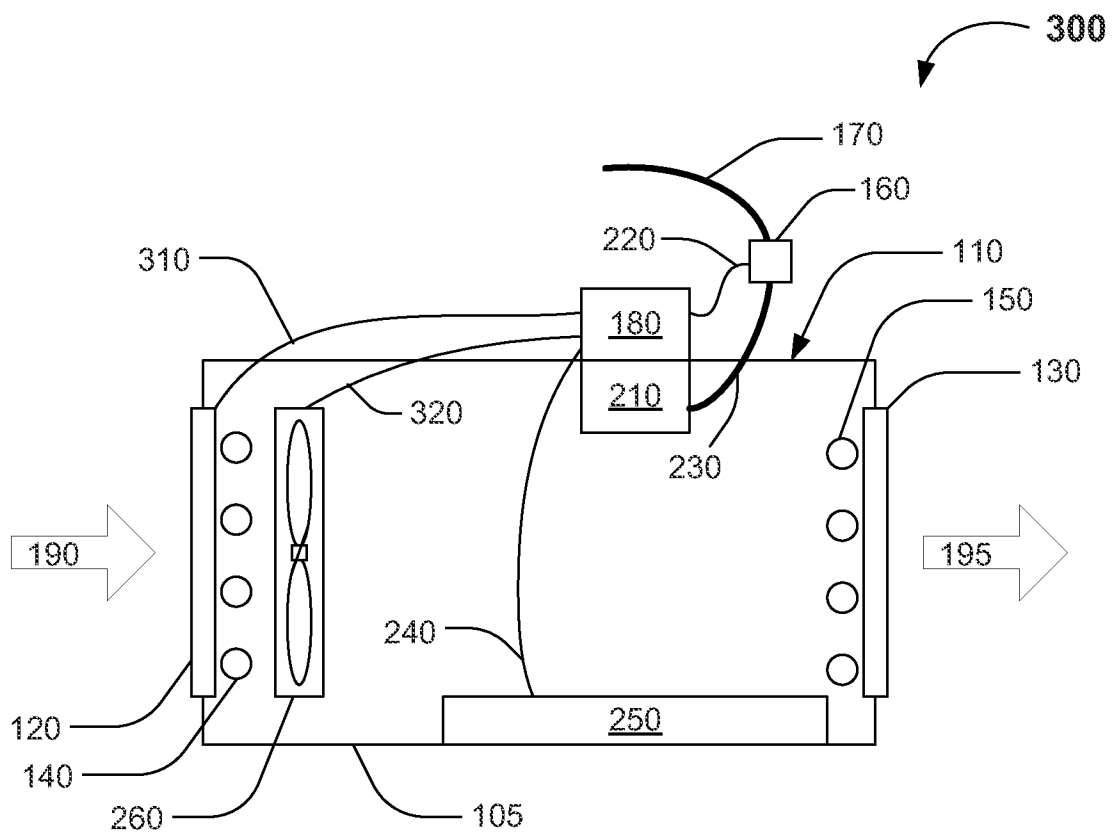


FIG. 3

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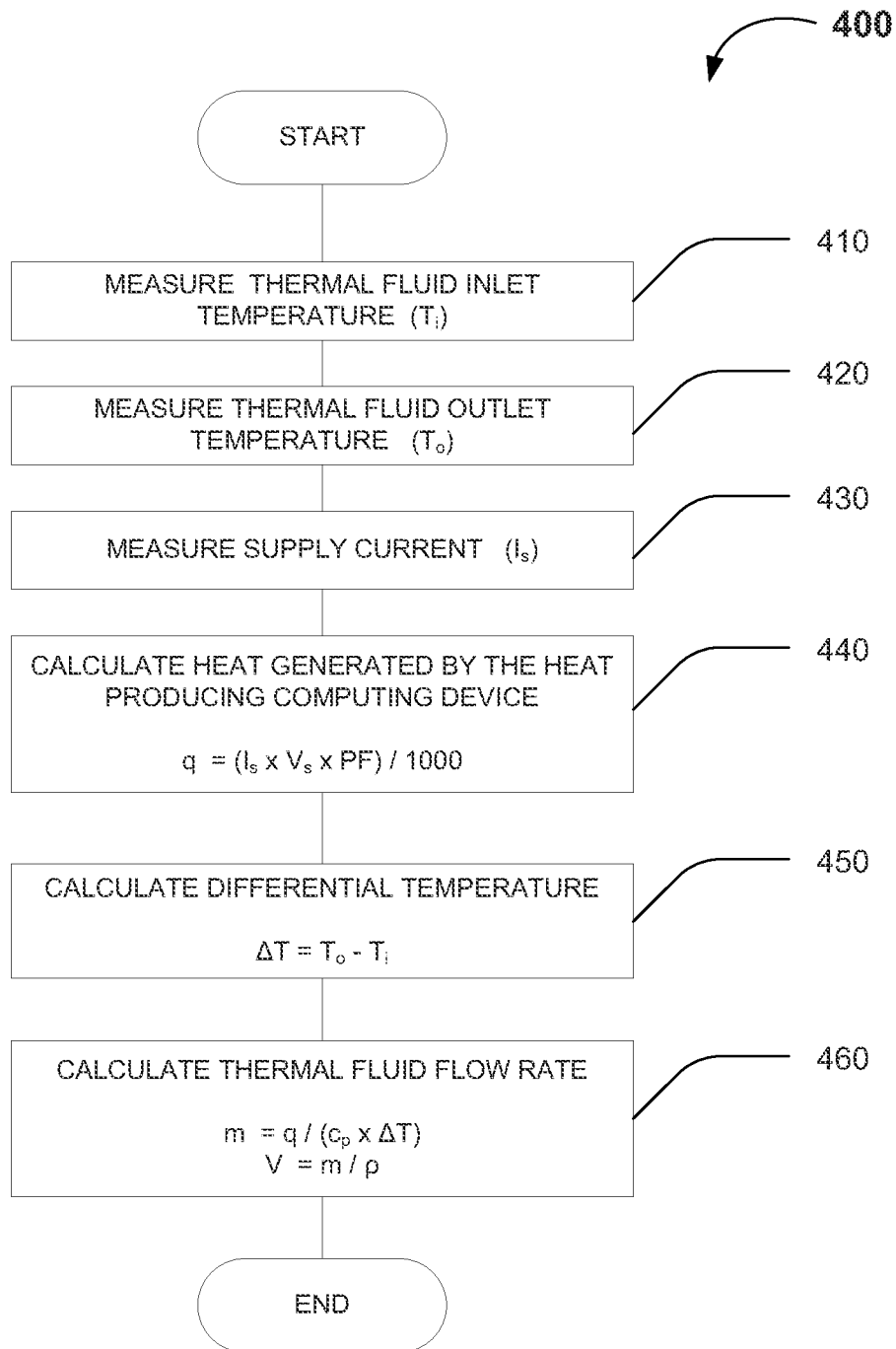


FIG. 4

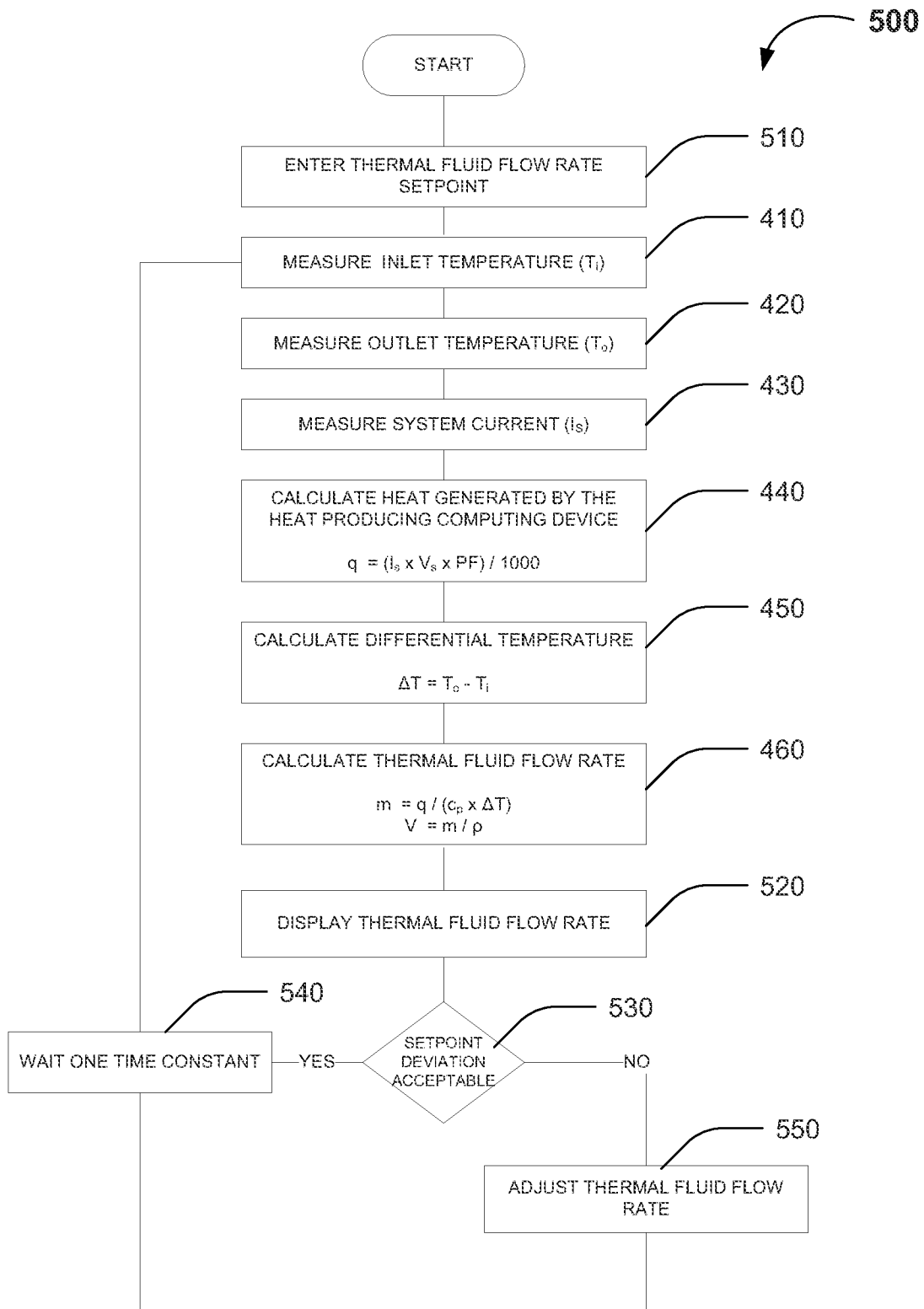




FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US20 10/025695

A. CLASSIFICATION OF SUBJECT MATTER		
<i>G06F 1/20(2006.01)i, H05K 7/20(2006.01)I</i>		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) G06F 1/20; G01K 15/00; G01K 13/00; G01K 1/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models Japanese utility models and applications for utility models		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS(KIPO internal) & Keywords: flow, temperature, sensor		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2009-0192748 A1 (TIM PALMER, PAUL WINTER) 30 July 2009 See [0003] - [0072].	1,7 2-6,8-15
X Y	US 2006-0162351 A1 (MOHAMED BEN YAHIA) 27 July 2006 See [0013] - [0113].	1,7 2-6,8-15
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
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Date of the actual completion of the international search 29 NOVEMBER 2010 (29.11.2010)		Date of mailing of the international search report 30 NOVEMBER 2010 (30.11.2010)
Name and mailing address of the ISA/KR  Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140		Authorized officer KWON, Oh Seong Telephone No. 82-42-481-8526 

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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