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(54) Title: A COOLING APPARATUS FOR REGULATING TEMPERATURE OF AN ELECTRONIC COMPONENT ENCLOSURE AND A METHOD THEREOF

(57) Abstract: The present disclosure discloses a cooling apparatus (100) for regulating temperature of an electronic component enclosure (12) and a method (300) thereof. The at least one actuator (4) is configured to direct ambient air into a first chamber (2) defined with a heat exchanger (5) and a second chamber (3) defined with an evaporator (6) simultaneously for cooling. The control unit (11) determines condition for cooling of the electronic component enclosure (12) based on comparing at least one cooling parameter from one or more sensors (10) with a predetermined set of values. The control unit (11) is configured to regulate the pump (9) and at least one actuator (4) of the cooling apparatus (100) to direct the ambient air towards the electronic component enclosure (12). With such configuration, the cooling apparatus (100) may be cost-effective and may eliminate or reduce damage to the electronic component due to evaporative cooling.

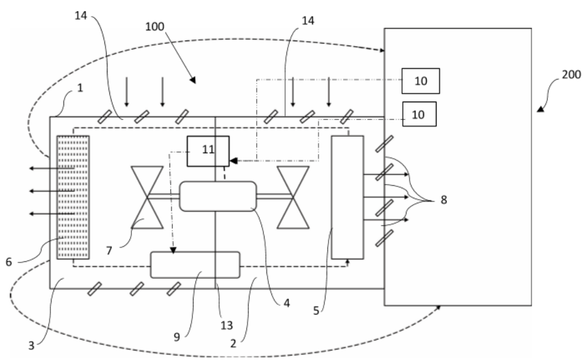

Figure 1

FORM 2

THE PATENTS ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003

Complete Specification

(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

A COOLING APPARATUS FOR REGULATING TEMPERATURE OF AN ELECTRONIC COMPONENT ENCLOSURE AND A METHOD THEREOF

2. APPLICANT(S)

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification describes the invention and the manner in which it is to be performed

TECHNICAL FIELD

[0001] Present disclosure, in general, relates to the field of mechanical engineering. Particularly, but not exclusively, the present disclosure relates to a cooling system. Further, embodiments of the present disclosure disclose a cooling apparatus to regulate temperature of an electronic component enclosure and a method thereof.

BACKGROUND OF THE DISCLOSURE

[0002] Electronic components are building blocks of an electronic circuit, an electronic system or an electronic device. Electronic components generally have two or more terminals and dissipate heat during operation, which are to be regulated for smooth and efficient operation of the electronic circuit, the electronic system and/or the electronic device. In the electronic system/device, multiple electronic components may be simultaneously operated, where such operation of multiple electronic components without adequate cooling may lead to be damage or low durability.

[0003] Generally, portable electronic devices such as laptops and the like are, in general, provided with a cooling fan for cooling. Whereas non-portable electronic components such as a server or a server room are provided with dedicated and/or distributed cooling systems such as a heat exchanger or an air conditioner. Such cooling systems compensate for the heat generated and maintain a specific temperature for smooth operation of the electronic components. For example, electronic components such as a server room generate a large quantity of heat which requires expensive cooling systems for adequate cooling.

[0004] With advent of technology, various attempts have been made to develop a system that provides adequate cooling for electronic components, such as servers. One such cooling system includes evaporative cooling device which isn intended to cool the electronic components with humid air. The evaporative cooling device directs cold air towards the electronic component to absorb heat generated by the electronic component. However, such cooling systems contain humid air which may deposit on the electronic components that may cause incidence such as short circuit, which inherently results in damaging or failure of the electronic devices/systems. On the other hand, conventional cooling systems which do not use humid air for cooling of the electronic components are expensive and may not be economically viable.

[0005] The present disclosure is directed to overcome one or more limitations stated above or any other limitations associated with the conventional mechanisms.

SUMMARY OF THE DISCLOSURE

[0006] One or more shortcomings of the prior art are overcome by a method and a system as claimed and additional advantages are provided through the method and the system as claimed in the present disclosure. Additional features and advantages are realized through the techniques of the present disclosure. Other embodiments and aspects of the disclosure are described in detail herein and are considered a part of the claimed disclosure.

[0007] In one non-limiting embodiment of the present disclosure a cooling apparatus for regulating temperature of an electronic component enclosure is disclosed. The cooling apparatus comprises a housing, at least one actuator, a heat exchanger, an evaporator, one or more sensors, and a control unit. The housing is defined with a first chamber and a second chamber and is connectable to a portion of the electronic component enclosure. The at least one actuator is disposable in the housing and is configured to direct ambient air into the first chamber and the second chamber simultaneously. The heat exchanger is disposable in the first chamber and is configured to cool the ambient air. The heat exchanger is positioned proximal to and in fluid communication with the electronic component enclosure. The evaporator is disposable in the second chamber and is in fluid communication with the heat exchanger to receive a cooling fluid pumped by a pump disposed in the housing. The one or more sensors are disposable in at least one of the electronic component enclosure and the housing and are configured to sense and transmit at least one signal corresponding to at least one cooling parameter associated with one of the electronic component enclosure and the cooling apparatus. The control unit is communicatively coupled to the at least one actuator, the pump and the one or more sensors. The control unit is configured to receive the at least one signal from the one or more sensors associated with at least one of the electronic component enclosure and the cooling apparatus. The control unit determines condition for cooling of the electronic component enclosure based on comparing the at least one cooling parameter from the at least one signal transmitted by the one or more sensors with a predetermined set of values corresponding to the at least one cooling parameter. The control unit is configured to regulate the pump to circulate the cooling fluid between the heat exchanger and the evaporator. The control unit is configured to regulate the at least one actuator of the cooling apparatus to direct the ambient air towards the electronic component enclosure, wherein the ambient air is adaptably cooled by the cooling fluid in the heat exchanger.

[0008] In an embodiment, the at least one actuator is a dual shaft motor disposable between the first chamber and the second chamber, wherein the at least one actuator is defined with at least one fan on each side.

[0009] In an embodiment, the electronic component enclosure is a server case.

[0010] In an embodiment, the at least one actuator is configured to direct the ambient air towards the heat exchanger and is configured to direct the ambient air towards the evaporator.

[0011] In an embodiment, the control unit is configured to determine condition for cooling of the electronic component enclosure based on comparison of humidity of the ambient air from the at least one signal transmitted by the one or more sensors with a predetermined humidity value, to regulate the at least one actuator and direct the ambient air towards the evaporator.

[0012] In an embodiment, the control unit is configured to determine condition for cooling of the electronic component enclosure based on comparison of temperature of the electronic component enclosure from the at least one signal transmitted by the one or more sensors with a predetermined temperature value, to regulate the at least one actuator and direct the ambient air toward the heat exchanger.

[0013] In another non-limiting embodiment of the present disclosure a method for regulating temperature of an electronic component enclosure is disclosed. The method includes steps of receiving, by a control unit, at least one signal from one or more sensors associated with at least one of the electronic component enclosure and a cooling apparatus, wherein the at least one signal corresponds to at least one cooling parameter associated with at least one of the electronic component enclosure and the cooling apparatus. Further, the control unit is configured to determine a condition for cooling of the electronic component enclosure based on comparing the at least one cooling parameter from the at least one signal transmitted by the one or more sensors with a predetermined set of values corresponding to the at least one cooling parameter. The control unit then regulates a pump of the cooling apparatus to circulate a cooling fluid, wherein the pump is fluidly connectable between a heat exchanger disposable in a first chamber and an evaporator disposable in a second chamber of a housing of the cooling apparatus, and that the heat exchanger is positioned proximal to and in fluid communication with the electronic component enclosure. The control unit then regulates at least one actuator of the cooling apparatus to direct ambient air towards the electronic component enclosure, wherein the ambient air is adaptably cooled by the cooling fluid in the heat exchanger.

[0014] In an embodiment, regulating, by the control unit, the at least one actuator comprises rotating at least one fan connectable on each side of the at least one actuator to direct the ambient air towards the heat exchanger and direct the ambient air towards the evaporator.

[0015] In an embodiment, the method comprises determining, by the control unit, condition for cooling of the electronic component enclosure based on comparison of humidity of the ambient air from the at least one signal transmitted by the one or more sensors with a predetermined humidity value, to regulate the at least one actuator and direct the ambient air towards the evaporator.

[0016] In an embodiment, the method comprises determining, by the control unit, condition for cooling of the electronic component enclosure based on comparison of temperature of the electronic component enclosure from the at least one signal transmitted by the one or more sensors with a predetermined temperature value, to regulate the at least one actuator and direct the ambient air toward the heat exchanger.

[0017] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

[0018] The novel features and characteristic of the disclosure are set forth in the appended claims. The disclosure itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying figures. One or more embodiments are now described, by way of example only, with reference to the accompanying figures wherein like reference numerals represent like elements and in which:

[0019] Figure 1 is a schematic view of a cooling apparatus for regulating temperature of an electronic component enclosure, in accordance with an embodiment of the present disclosure.

[0020] Figure 2 is a flow chart illustrating a method for regulating temperature of an electronic component enclosure by the cooling apparatus of Figure 1, in accordance with an embodiment of the present disclosure.

[0021] The figures depict embodiments of the disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the system and method illustrated herein may be employed without departing from the principles of the disclosure described herein.

DETAILED DESCRIPTION

[0022] While the embodiments in the disclosure are subject to various modifications and alternative forms, specific embodiment thereof has been shown by way of example in the figures and will be described below. It should be understood, however, that it is not intended to limit the disclosure to the particular forms disclosed, but on the contrary, the disclosure is to cover all modifications, equivalents, and alternative falling within the scope of the disclosure.

[0023] The terms “comprises”, “comprising”, or any other variations thereof used in the disclosure, are intended to cover a non-exclusive inclusion, such that an apparatus, system, method that comprises a list of components does not include only those components but may include other components not expressly listed or inherent to such system, or assembly, or device. In other words, one or more elements in a system proceeded by “comprises… a” does not, without more constraints, preclude the existence of other elements or additional elements in the system or method.

[0024] Embodiments of the present disclosure discloses a cooling apparatus for regulating temperature of an electronic component enclosure. The cooling apparatus comprises a housing, at least one actuator, a heat exchanger, an evaporator, one or more sensors, and a control unit. The housing is defined with a first chamber and a second chamber and is connectable to a portion of the electronic component enclosure. The at least one actuator is disposable in the housing and is configured to direct ambient air into the first chamber and the second chamber simultaneously. The heat exchanger is disposable in the first chamber and is configured to cool the ambient air. The heat exchanger is positioned proximal to and in fluid communication with the electronic component enclosure. The evaporator is disposable in the second chamber and is in fluid communication with the heat exchanger to receive a cooling fluid pumped by a pump disposed in the housing. The one or more sensors are disposable in at least one of the electronic component enclosure and the housing and are configured to sense and transmit at least one signal corresponding to at least one cooling parameter associated with one of the electronic component enclosure and the cooling apparatus. The control unit is communicatively coupled to the at least one actuator, the pump and the one or more sensors. The control unit is configured to receive the at least one signal from the one or more sensors associated with at least one of the electronic component enclosure and the cooling apparatus. The control unit determines condition for cooling of the electronic component enclosure based on comparing the at least one cooling parameter from the at least one signal transmitted by the one or more sensors with a predetermined set of values corresponding to the at least one cooling parameter. The control unit is configured to regulate the pump to circulate the cooling fluid between the heat exchanger and the evaporator. The control unit is configured to regulate the at least one actuator of the cooling apparatus to direct the ambient air towards the electronic component enclosure, wherein the ambient air is adaptably cooled by the cooling fluid in the heat exchanger. With such configuration, the cooling apparatus may efficiently cool the electronic component enclosure which is cost-effective and the cooling apparatus may eliminate or reduce damage to the electronic component due to evaporative cooling.

[0025] The disclosure is described in the following paragraphs with reference to Figures 1 to 2. In the figures, the same element or elements which have same functions are indicated by the same reference signs. One skilled in the art would appreciate that the apparatus and the method as disclosed in the present disclosure may be used in any vehicle including but not liming to server boxes, server rooms and the like. The cooling apparatus and the method of the present disclosure may also be implemented in electronic component enclosures having one or more electronic components within and the one or more electronic components emitting heat during operation without deviating from the principles of the present disclosure.

[0026] Figure 1 is an exemplary embodiment of the present disclosure which illustrates a cooling apparatus (100) for regulating temperature of an electronic component enclosure (12). The cooling apparatus (100) comprises a housing (1), at least one actuator (4), a heat exchanger (5), an evaporator (6), one or more sensors (10), and a control unit (11). Here, the electronic component enclosure (12) is a server case or at least a portion of the server case. Alternatively, electronic component enclosure (12) may be any enclosure or cover of an electronic component that may be adapted to dissipate heat during operation. In an embodiment, the one or more sensors (10) may be at least a temperature sensor, a humidity sensor among other sensors (10), that may be disposable in at least one of the housing (1), the electronic component enclosure (12), a room or a building comprising the electronic component enclosure (12) for sensing at least one cooling parameter associate with one of the electronic component enclosure (12) and the cooling apparatus (100).

[0027] The housing (1) may be defined with a first chamber (2) and a second chamber (3) and is fluidly connectable to a portion of the electronic component enclosure (12). The housing (1) may be connectable to the electronic component enclosure (12), where the housing (1) and the electronic component enclosure (12) may be in fluid communication. The housing (1) and the electronic component enclosure (12) may be defined with a plurality of apertures (8) for fluid communication between the housing (1) and the electronic component enclosure (12) as can be clearly seen in Figure 1. In an embodiment, the plurality of apertures (8) may be defined by a plurality of through holes extending from the housing (1) to the electronic component enclosure (12) to allow flow of air from the housing (1) to the electronic component enclosure (12). The housing (1) may be detachably connectable to the electronic component enclosure (12) or may be integrally defined on a portion of the electronic component enclosure (12). In an embodiment, the housing (1) may be connected to the electronic component enclosure (12) by one of welding, brazing, plurality of fasteners, snug fit and the like. The housing (1) may be defined with a first chamber (2) and a second chamber (3). In an embodiment, the first chamber (2) and the second chamber (3) may be defined in the housing (1) by a partition member (13) defined across the housing (1) as can be seen in Figure 1. In the illustrative embodiment, the first chamber (2) is connected to and is in fluid communication with the electronic component enclosure (12) for cooling an electronic component within the electronic component enclosure (12) as can be seen in Figure 1**.** A portion of the first chamber (2) and the second chamber (3) may be defined with a plurality of openings (14) to receive ambient air in a downward direction for cooling and directing the cooled ambient air toward the electronic component enclosure (12). In the illustrative embodiment, the plurality of openings (14) is depicted at top end of the first chamber (2) and the second chamber (3) for easy reception of ambient air.

[0028] Referring again to Figure 1, the first chamber (2) may be configured to receive a heat exchanger (5) disposed proximal to the electronic component enclosure (12). The heat exchanger (5) may be configured to cool the ambient air. The heat exchanger (5) may be positioned proximal to and in fluid communication with the electronic component enclosure (12). In the illustrative embodiment, the heat exchanger (5) is disposed proximal to and between the plurality of opening and the plurality of apertures (8). In an embodiment, the second chamber (3) may be configured to receive the evaporator (6). The evaporator (6) may be in fluid communication with the heat exchanger (5) to receive a cooling fluid to cool the ambient air. In the illustrative embodiment, the cooling fluid is water. The evaporator (6) may be disposed away from the heat exchanger (5) and may be configured to cool the ambient air. In the illustrative embodiment, the evaporator (6) is disposed proximal to and between the plurality of apertures (8) and the plurality of openings (14) of the second chamber (3) as can be seen in Figure 1 to cool the ambient air. The heat exchanger (5) may reduce humidity of the cooled ambient air from the first chamber (2) and may avoid damage to the electronic component. In an embodiment, the partition member (13) may be defined between the heat exchanger (5) and the evaporator (6) to avoid fluid communication between the first chamber (2) and the second chamber (3). The cooling apparatus (100) may include a pump (9) disposable in a portion of the housing (1) and fluidly connected between the heat exchanger (5) and the evaporator (6) to pump (9) the cooling fluid between the heat exchanger (5) and the evaporator (6) to cool the ambient air.

[0029] Further, the at least one actuator (4) may be disposable in the housing (1) and may be defined with at least one fan (7) on each side. The at least one actuator (4) may be configured to draw and direct ambient air into the first chamber (2) and the second chamber (3) simultaneously by the at least one fan (7). The at least one actuator (4) may include a dual shaft motor, a plurality of single shaft motors, and the like. In the illustrative embodiment, the at least one actuator (4) is depicted as a dual shaft motor defined with one fan (7) on each side to simultaneously cool the ambient air and also make the electronic component enclosure (12) compact.. The at least one fan (7) may be configured to direct ambient air drawn via the plurality of openings (14) toward the heat exchanger (5) and the evaporator (6). The at least one actuator (4) may direct the ambient air in the first chamber (2) drawn via the plurality of openings (14) toward the electronic component enclosure (12) through the heat exchanger (5) and the plurality of apertures (8) to cool the electronic component within the electronic component enclosure (12). The at least one actuator (4) may direct the ambient air in the second chamber (3) drawn via the plurality of openings (14) toward the electronic component enclosure (12) through the evaporator (6) and the plurality of apertures (8) to cool the electronic component enclosure (12). In an embodiment, the cooled ambient air from the first chamber (2) may have low humidity level, whereas the cooled ambient air from the second chamber (3) may have high humidity level. For example, the cooled ambient air from the first chamber (2) directed into the electronic component enclosure (12) may have a relative humidity in a range of 30 to 40% and a temperature in a range of 35 to 45˚C, whereas the cooled ambient air from the second chamber (3) directed towards the electronic component enclosure (12) may have a relative humidity greater than 80% and a temperature in the range of wet bulb temperature of the cooling fluid such as in a range of 30 to 35˚C for water, while the ambient temperature may be in a range of 50˚C. In the illustrative embodiment, the at least one actuator (4) is configured to direct the cooled ambient air from the first chamber (2) into the electronic enclosure for internal cooling and is configured to direct the cooled ambient air from the second chamber (3) towards the electronic component enclosure (12) for external cooling as can be clearly seen in Figure 1. Such flow of the cooled ambient air from the first chamber (2) and the second chamber (3) may avoid failure and/or damage to the electronic component within the electronic component enclosure (12).

[0030] Further, the one or more sensors (10) may be disposable in at least one of the electronic component enclosure (12) and the housing (1). In the illustrative embodiment, the one or more sensors (10) are disposed in the electronic component enclosure (12) as can be seen in Figure 1 to sense at least one cooling parameter of the electronic component enclosure (12). The at least one cooling parameter includes temperature and relative humidity and the like of the electronic component enclosure (12). In an embodiment, the one or more sensors (10) may be disposed on a portion of the electronic component enclosure (12) and proximal to the electronic component within the electronic component enclosure (12) to sense the at least one cooling parameter. The one or more sensors (10) may be configured to sense and transmit at least one signal corresponding to the at least one cooling parameter associated with one of the electronic component enclosure (12) and the cooling apparatus (100). In an embodiment, the one or more sensors (10) may be configured to sense temperature and relative humidity of the electronic component enclosure (12) and the housing (1) and transmit corresponding signals.

[0031] Referring again to Figure 1, the control unit (11) may be communicatively coupled to the at least one actuator (4), the pump (9) and the one or more sensors (10). The control unit (11) may be configured to receive the at least one signal from the one or more sensors (10) associated with at least one of the electronic component enclosure (12) and the cooling apparatus (100). The control unit (11) may determine condition for cooling of the electronic component enclosure (12) based on comparing the at least one cooling parameter from the at least one signal with a predetermined set of values corresponding to the at least one cooling parameter. The control unit (11) may determine condition for cooling of the electronic component enclosure (12) as a function of the at least one cooling parameter. The control unit (11) may be configured to determine condition for cooling of the electronic component enclosure (12) based on comparison of humidity of the ambient air from the at least one signal transmitted by the one or more sensors (10) with a predetermined humidity value.

[0032] The control unit (11) may be configured to determine condition for cooling of the electronic component enclosure (12) based on comparison of temperature of the electronic component enclosure (12) from the at least one signal transmitted by the one or more sensors (10) with a predetermined temperature value. For example, the control unit (11) may determine the condition for cooling to be optimal when the temperature of the electronic component enclosure (12) is equal to or greater than a predetermined temperature value from the predetermined set of values. In an embodiment, the control unit (11) may determine the condition for cooling of the electronic component enclosure (12) to be non-optimal when the temperature of the electronic component enclosure (12) is less than the predetermined temperature value. The control unit (11) is configured to regulate the pump (9) to circulate the cooling fluid between the heat exchanger (5) and the evaporator (6) based on determined condition for cooling of the electronic component enclosure (12). The control unit (11) may regulate the pump (9) to vary rate of cooling the ambient air by the heat exchanger (5) and the evaporator (6). In an embodiment, the control unit (11) may be configured to vary operational parameters of the pump (9) to vary the rate of cooling the ambient air. The operational parameters of the pump (9) may include speed, volume flow rate, pressure of flow of the cooling fluid and the like. For example, the control unit (11) may increase the speed of the pump (9) when the condition for cooling may be determined to be optimal for cooling the electronic component enclosure (12). Similarly, the control unit (11) may decrease the speed of the pump (9) when the condition for cooling may be determined to be non-optimal for cooling the electronic component enclosure (12). In an embodiment, the control unit (11) may vary at least one of the operational parameters of the pump (9) based on the determined condition for cooling of the electronic component enclosure (12).

[0033] Further, the control unit (11) may be configured to regulate the at least one actuator (4) to direct the ambient air from the first chamber (2) and the second chamber (3) towards the electronic component enclosure (12) based on the determined condition for cooling of the electronic component enclosure (12). The ambient air is adaptably cooled by the cooling fluid in the heat exchanger (5). For example, the control unit (11) may determine the condition for cooling to be optimal when the temperature of the electronic component enclosure (12) is equal to or greater than a predetermined temperature value from the predetermined set of values. In an embodiment, the control unit (11) may determine the condition for cooling of the electronic component enclosure (12) to be non-optimal when the temperature of the electronic component enclosure (12) is less than the predetermined temperature value. The control unit (11) may be configured to regulate the at least one actuator (4) to draw and direct the ambient air in the first chamber (2) toward the heat exchanger (5) and to draw and direct the ambient air in the second chamber (3) towards the evaporator (6) based on the determined condition for cooling of the electronic component enclosure (12).

[0034] The control unit (11) may be configured to rotate the at least one fan (7) connectable on each side of the at least one actuator (4) to draw and direct the ambient air towards the heat exchanger (5) and the evaporator (6). The control unit (11) may regulate the at least one actuator (4) to vary rate of cooling the ambient air by the heat exchanger (5) and the evaporator (6). In an embodiment, the control unit (11) may be configured to vary operational parameters of the at least one actuator (4) to vary the rate of cooling the ambient air at the heat exchanger (5) and the evaporator (6). The operational parameters of the at least one actuator (4) may include speed, torque, and the like. For example, the control unit (11) may increase the speed of the at least one actuator (4) when the condition for cooling may be determined to be optimal for cooling the electronic component enclosure (12). Similarly, the control unit (11) may decrease the speed of the at least one actuator (4) when the condition for cooling may be determined to be non-optimal for cooling the electronic component enclosure (12). In an embodiment, the control unit (11) may vary at least one of the operational parameters of the at least one actuator (4) based on the determined condition for cooling of the electronic component enclosure (12).

[0035] In an embodiment, the at least one actuator (4) may include a first motor disposed proximal to the heat exchanger (5) and a second motor disposed proximal to the evaporator (6), where each of the first motor and the second motor may be defined with at least one fan (7) and are communicatively coupled to the control unit (11). The control unit (11) may regulate the first motor and the second motor at different speeds based on the determined condition for cooling of electronic component enclosure (12). For example, the control unit (11) may regulate the first motor at a speed greater than the speed of the second motor when the condition for cooling is determined as optimal for cooling to increase flow of the cooled ambient air into the electronic component enclosure (12) and cool the electronic component quickly. Such operation of the first motor and the second motor may reduce consumption of electricity and may quickly cool the electronic component.

[0036] In an embodiment, the control unit (11) may be comprised of a processing unit. The processing unit may comprise at least one data processor for executing program components for executing user- or system-generated requests. The processing unit may be a specialized processing unit such as integrated system controllers, memory management control units, floating point units, graphics processing units, digital signal processing units, etc. The processing unit may include a microprocessor, such as AMD Athlon, Duron or Opteron, ARM's application, embedded or secure processors, IBM PowerPC, Intel's Core, Itanium, Xeon, Celeron or other line of processors, etc. The processing unit may be implemented using a mainframe, distributed processor, multi-core, parallel, grid, or other architectures. Some embodiments may utilize embedded technologies like application-specific integrated circuits, digital signal processors, Field Programmable Gate Arrays, etc.

[0037] The control unit (11) may be disposed in communication with one or more memory devices via a storage interface. The storage interface may connect to memory devices including, without limitation, memory drives, removable disc drives, etc., employing connection protocols such as serial advanced technology attachment, integrated drive electronics, IEEE-1394, universal serial bus, fiber channel, small computing system interface, etc. The memory drives may further include a drum, magnetic disc drive, magneto-optical drive, optical drive, redundant array of independent discs, solid-state memory devices, solid-state drives, etc.

[0038] Referring now to Figure 2 which is an exemplary embodiment of the present disclosure illustrating a method (300) for regulating temperature of the electronic component enclosure (12). In an embodiment, the method (300) may be implemented in any electronic enclosure including, but not limited to, a server case, a network attached storage and the like.

[0039] The method (300) may describe in the general context of processor executable instructions in the control unit (11). Generally, the executable instructions may include routines, programs, objects, components, data structures, procedures, modules, and functions, which perform particular functions or implement particular abstract data types.

[0040] The order in which the method (300) is described is not intended to be construed as a limitation, and any number of the described method (300) blocks may be combined in any order to implement the method (300). Additionally, individual blocks may be deleted from the methods without departing from the scope of the subject matter described herein. Furthermore, the method (300) can be implemented in any suitable hardware, software, firmware, or combination thereof.

[0041] At block 201, the control unit (11) which is communicatively coupled to the one or more sensors (10) disposed on at least one of the electronic component enclosure (12) and the cooling apparatus (100), may be configured to receive the at least one signal from the one or more sensors (10). The control unit (11) may be configured to process and determine real-time values of the at least one cooling parameter upon receiving the at least one signal.

[0042] At block 202, the control unit (11) may determine condition for cooling of the electronic component enclosure (12) based on comparing the at least one cooling parameter from the at least one signal with a predetermined set of values corresponding to the at least one cooling parameter. The control unit (11) may be configured to determine condition for cooling of the electronic component enclosure (12) based on comparison of humidity of the ambient air from the at least one signal transmitted by the one or more sensors (10) with a predetermined humidity value. The control unit (11) may be configured to determine condition for cooling of the electronic component enclosure (12) based on comparison of temperature of the electronic component enclosure (12) from the at least one signal transmitted by the one or more sensors (10) with a predetermined temperature value. The control unit (11) may determine condition for cooling of the electronic component enclosure (12) as a function of the at least one cooling parameter. For example, the control unit (11) may determine the condition for cooling to be optimal when the temperature of the electronic component enclosure (12) is equal to or greater than a predetermined temperature value from the predetermined set of values. In an embodiment, the control unit (11) may determine the condition for cooling of the electronic component enclosure (12) to be non-optimal when the temperature of the electronic component enclosure (12) is less than the predetermined temperature value.

[0043] At block 203, the control unit (11) is configured to regulate the pump (9) to circulate the cooling fluid between the heat exchanger (5) and the evaporator (6) based on determined condition for cooling of the electronic component enclosure (12). The control unit (11) may regulate the pump (9) to vary rate of cooling the ambient air by the heat exchanger (5) and the evaporator (6). In an embodiment, the control unit (11) may be configured to vary operational parameters of the pump (9) to vary the rate of cooling the ambient air. The operational parameters of the pump (9) may include speed, volume flow rate, pressure of flow of the cooling fluid and the like. For example, the control unit (11) may increase the speed of the pump (9) when the condition for cooling may be determined to be optimal for cooling the electronic component enclosure (12). Similarly, the control unit (11) may decrease the speed of the pump (9) when the condition for cooling may be determined to be non-optimal for cooling the electronic component enclosure (12). In an embodiment, the control unit (11) may vary at least one of the operational parameters of the pump (9) based on the determined condition for cooling of the electronic component enclosure (12).

[0044] At block 204, the control unit (11) may be configured to regulate the at least one actuator (4) to draw and direct the ambient air from the first chamber (2) and the second chamber (3) towards the electronic component enclosure (12) based on the determined condition for cooling of the electronic component enclosure (12). The ambient air is adaptably cooled by the cooling fluid in the heat exchanger (5). For example, the control unit (11) may determine the condition for cooling to be optimal when the temperature of the electronic component enclosure (12) is equal to or greater than a predetermined temperature value from the predetermined set of values. In an embodiment, the control unit (11) may determine the condition for cooling of the electronic component enclosure (12) to be non-optimal when the temperature of the electronic component enclosure (12) is less than the predetermined temperature value. The control unit (11) may be configured to regulate the at least one actuator (4) to direct the ambient air in the first chamber (2) toward the heat exchanger (5) and to draw and direct the ambient air in the second chamber (3) towards the evaporator (6) based on the determined condition for cooling of the electronic component enclosure (12). The control unit (11) may regulate the at least one actuator (4) to vary rate of cooling the ambient air by the heat exchanger (5) and the evaporator (6). In an embodiment, the control unit (11) may be configured to vary operational parameters of the at least one actuator (4) to vary the rate of cooling the ambient air at the heat exchanger (5) and the evaporator (6). The operational parameters of the at least one actuator (4) may include speed, torque, and the like. For example, the control unit (11) may increase the speed of the at least one actuator (4) when the condition for cooling may be determined to be optimal for cooling the electronic component enclosure (12). Similarly, the control unit (11) may decrease the speed of the at least one actuator (4) when the condition for cooling may be determined to be non-optimal for cooling the electronic component enclosure (12). In an embodiment, the control unit (11) may vary at least one of the operational parameters of the pump (9) based on the determined condition for cooling of the electronic component enclosure (12).

[0045] In an embodiment, the method (300) may automatically cool the electronic component enclosure (12) which is cost-effective and the method (300) may eliminate or reduce damage to the electronic component due to evaporative cooling.

[0046] In an embodiment, the cooling apparatus (100) and the method (300) may be applied to other enclosures across various applications including, but not limited to, agriculture, poultry, dairy, chemical processing centres and the like.

EQUIVALENTS

[0047] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0048] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims are generally intended as "open" terms. It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an"; the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation *is* explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean *at least* the recited number. Furthermore, in those instances where a convention analogous to “at least one of A, B, and C, etc.” is used, in general such a construction is intended in the sense one having skill in the art would understand the convention having at least one of A, B, and C” would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to “at least one of A, B, or C, etc.” is used, in general such a construction is intended in the sense one having skill in the art would understand the convention having at least one of A, B, or C” would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase “A or B” will be understood to include the possibilities of “A” or “B” or “A and B.”

[0049] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0050] While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

Reference numerals:

Component	**Reference numeral**
Cooling apparatus	100
Housing	1
First chamber	2
Second chamber	3
At least one actuator	4
Heat exchanger	5

Evaporator	6
Fan	7
Plurality of apertures	8
Pump	9
Sensors	10
Control unit	11
Electronic component enclosure	12
Partition member	13
Plurality of openings	14
Method	300

WE CLAIM:

1. A cooling apparatus (100) for regulating temperature of an electronic component enclosure (12), comprising:

a housing (1) defined with a first chamber (2) and a second chamber (3), the housing (1) is connectable to a portion of the electronic component enclosure (12);

at least one actuator (4) disposable in the housing (1), the at least one actuator (4) being configured to direct ambient air into the first chamber (2) and the second chamber (3) simultaneously;

a heat exchanger (5) disposable in the first chamber (2), the heat exchanger (5) being configured to cool the ambient air, wherein the heat exchanger (5) is positioned proximal to and in fluid communication with the electronic component enclosure (12);

an evaporator (6) disposable in the second chamber (3), the evaporator (6) being in fluid communication with the heat exchanger (5) to receive a cooling fluid pumped by a pump (9) disposed in the housing (1);

one or more sensors (10) disposable in at least one of the electronic component enclosure (12) and the housing (1), the one or more sensors (10) configured to sense and transmit at least one signal corresponding to at least one cooling parameter associated with one of the electronic component enclosure (12) and the cooling apparatus (100);

a control unit (11) communicatively coupled to the at least one actuator (4), the pump (9) and the one or more sensors (10), wherein the control unit (11) is configured to:

receive the at least one signal from the one or more sensors (10) associated with at least one of the electronic component enclosure (12) and the cooling apparatus (100);

determine condition for cooling of the electronic component enclosure (12) based on comparing the at least one cooling parameter from the at least one signal transmitted by the one or more sensors (10) with a predetermined set of values corresponding to the at least one cooling parameter;

regulate the pump (9) to circulate the cooling fluid between the heat exchanger (5) and the evaporator (6); and

regulate the at least one actuator (4) of the cooling apparatus (100) to direct the ambient air towards the electronic component enclosure (12), wherein the ambient air is adaptably cooled by the cooling fluid in the heat exchanger (5).

2. The cooling apparatus (100) as claimed in claim 1, wherein the at least one actuator (4) is a dual shaft motor disposable between the first chamber (2) and the second chamber (3), wherein the at least one actuator (4) is defined with at least one fan (7) on each side.

3. The cooling apparatus (100) as claimed in claim 1, wherein the electronic component enclosure (12) is a server case.

4. The cooling apparatus (100) as claimed in claim 1, wherein the at least one actuator (4) is configured to direct the ambient air towards the heat exchanger (5) and is configured to direct the ambient air towards the evaporator (6).

5. The cooling apparatus (100) as claimed in claim 1, wherein the control unit (11) is configured to determine condition for cooling of the electronic component enclosure (12) based on comparison of humidity of the ambient air from the at least one signal transmitted by the one or more sensors (10) with a predetermined humidity value, to regulate the at least one actuator (4) and direct the ambient air towards the evaporator (6).

6. The cooling apparatus (100) as claimed in claim 1, wherein the control unit (11) is configured to determine condition for cooling of the electronic component enclosure (12) based on comparison of temperature of the electronic component enclosure (12) from the at least one signal transmitted by the one or more sensors (10) with a predetermined temperature value, to regulate the at least one actuator (4) and direct the ambient air toward the heat exchanger (5).

7. A method (300) for regulating temperature of an electronic component enclosure (12), the method (300) comprising:

receiving, by a control unit (11), at least one signal from one or more sensors (10) associated with at least one of the electronic component enclosure (12) and a cooling apparatus (100), wherein the at least one signal corresponds to at least one cooling parameter associated with at least one of the electronic component enclosure (12) and the cooling apparatus (100);

determining, by the control unit (11), condition for cooling of the electronic component enclosure (12) based on comparing the at least one cooling parameter from the at least one signal transmitted by the one or more sensors (10) with a predetermined set of values corresponding to the at least one cooling parameter;

regulating, by the control unit (11), a pump (9) of the cooling apparatus (100) to circulate a cooling fluid, wherein the pump (9) is fluidly connectable between a heat exchanger (5) disposable in a first chamber (2) and an evaporator (6) disposable in a second chamber (3) of a housing (1) of the cooling apparatus (100), and that the heat exchanger (5) is positioned proximal to and in fluid communication with the electronic component enclosure (12); and

regulating, by the control unit (11), at least one actuator (4) of the cooling apparatus (100) to direct ambient air towards the electronic component enclosure (12), wherein the ambient air is adaptably cooled by the cooling fluid in the heat exchanger (5).

8. The method (300) as claimed in claim 7, wherein regulating, by the control unit (11), the at least one actuator (4) comprises rotating at least one fan (7) connectable on each side of the at least one actuator (4) to direct the ambient air towards the heat exchanger (5) and direct the ambient air towards the evaporator (6).

9. The method (300) as claimed in claim 7, comprising determining, by the control unit (11), condition for cooling of the electronic component enclosure (12) based on comparison of humidity of the ambient air from the at least one signal transmitted by the one or more sensors (10) with a predetermined humidity value, to regulate the at least one actuator (4) and direct the ambient air towards the evaporator (6).

10. The method (300) as claimed in claim 7, comprising determining, by the control unit (11), condition for cooling of the electronic component enclosure (12) based on comparison of temperature of the electronic component enclosure (12) from the at least one signal transmitted by the one or more sensors (10) with a predetermined temperature value, to regulate the at least one actuator (4) and direct the ambient air toward the heat exchanger (5).

Dated this 07th day of September 2023

-- Digitally Signed--
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ABSTRACT

A COOLING APPARATUS FOR REGULATING TEMPERATURE OF AN ELECTRONIC COMPONENT ENCLOSURE AND A METHOD THEREOF

The present disclosure discloses a cooling apparatus (100) for regulating temperature of an electronic component enclosure (12) and a method (300) thereof. The at least one actuator (4) is configured to direct ambient air into a first chamber (2) defined with a heat exchanger (5) and a second chamber (3) defined with an evaporator (6) simultaneously for cooling. The control unit (11) determines condition for cooling of the electronic component enclosure (12) based on comparing at least one cooling parameter from one or more sensors (10) with a predetermined set of values. The control unit (11) is configured to regulate the pump (9) and at least one actuator (4) of the cooling apparatus (100) to direct the ambient air towards the electronic component enclosure (12). With such configuration, the cooling apparatus (100) may be cost-effective and may eliminate or reduce damage to the electronic component due to evaporative cooling.

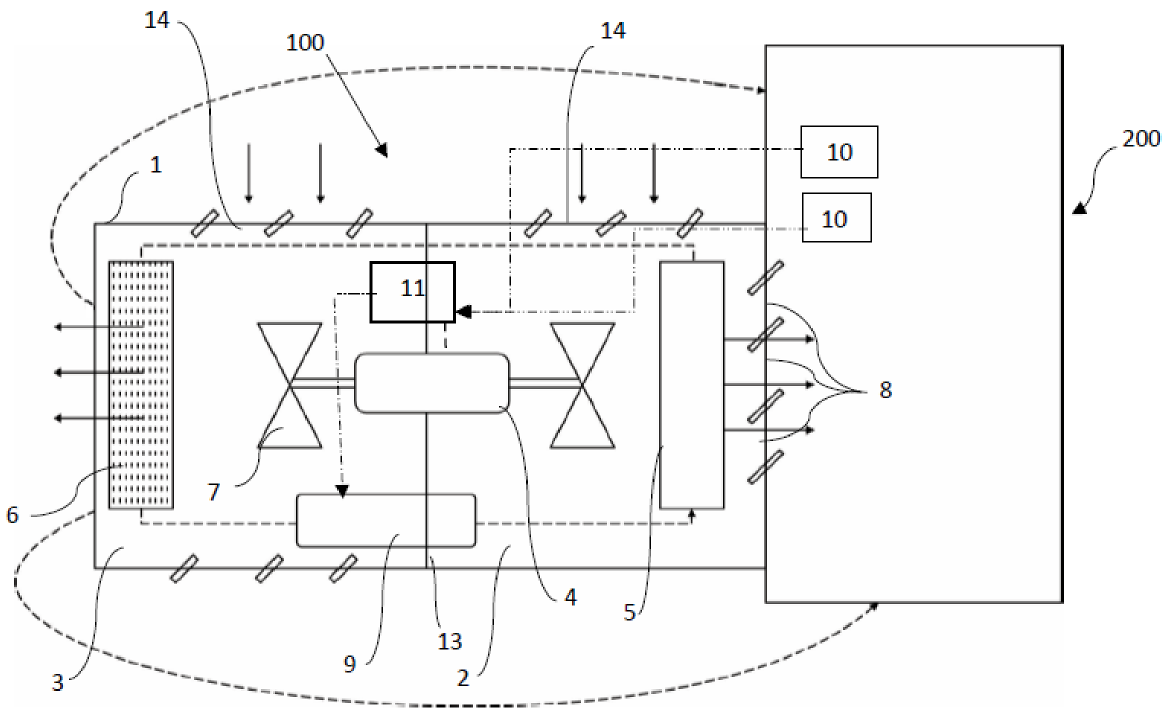

Figure 1

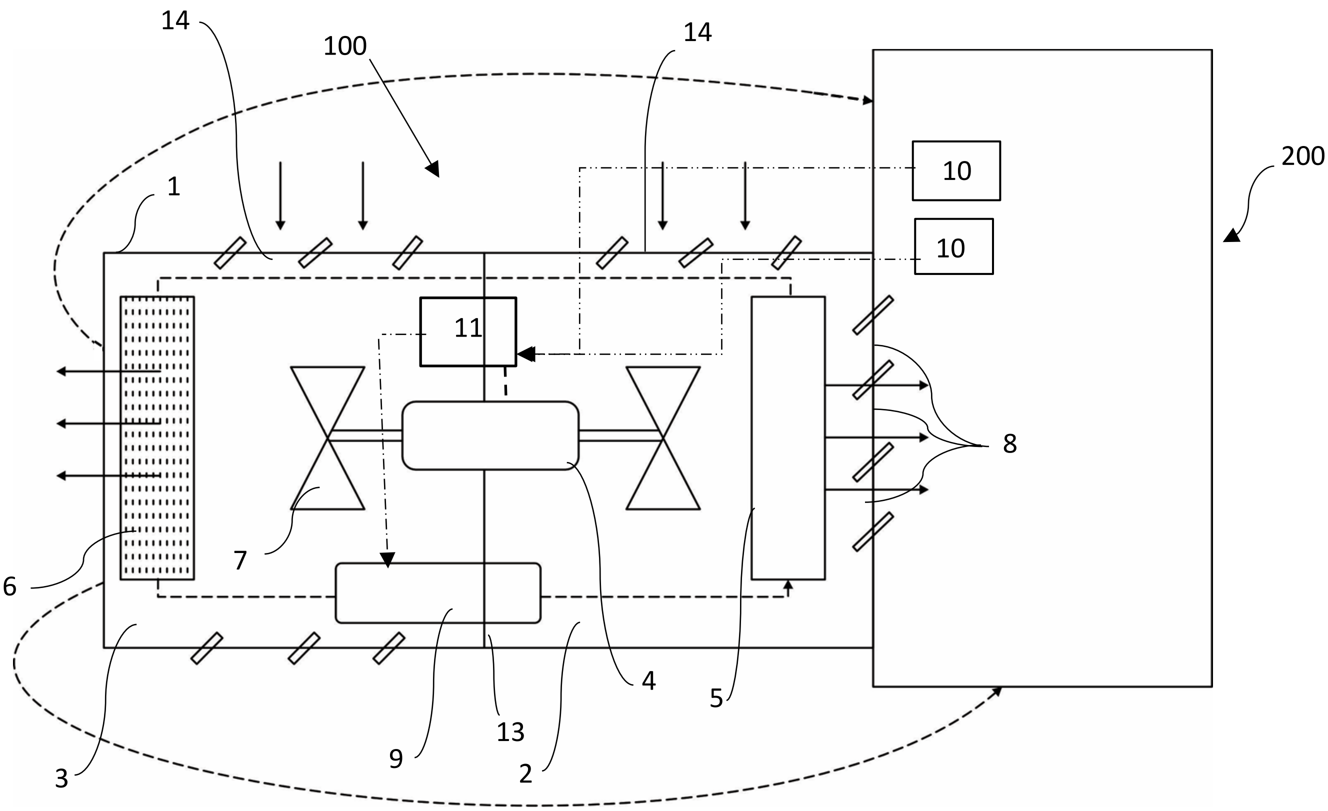

Figure 1

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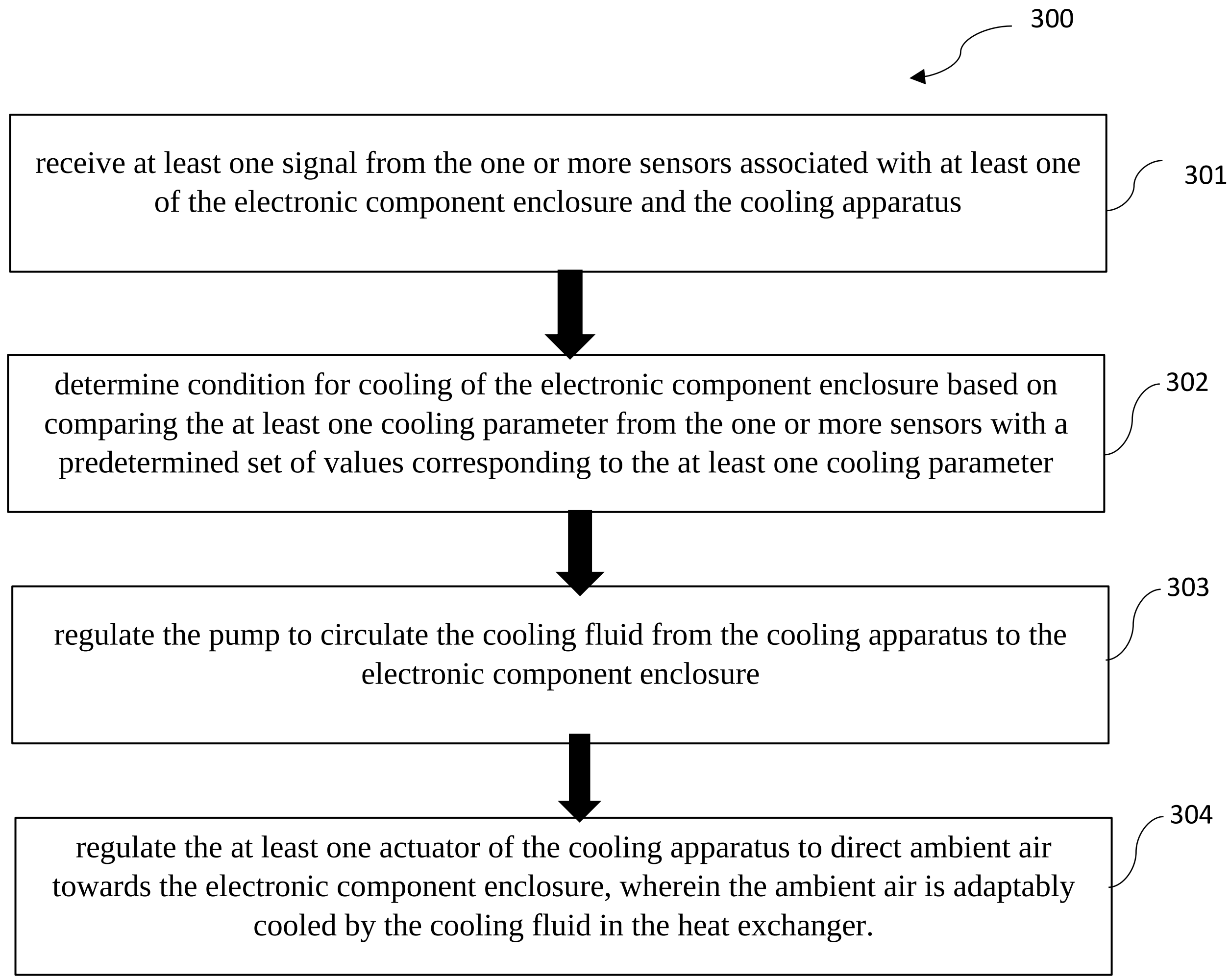

Figure 2

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