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(54) **Title:** BATTERY TEST AND CONDENSATION PREVENTION METHOD, SYSTEM AND APPARATUS

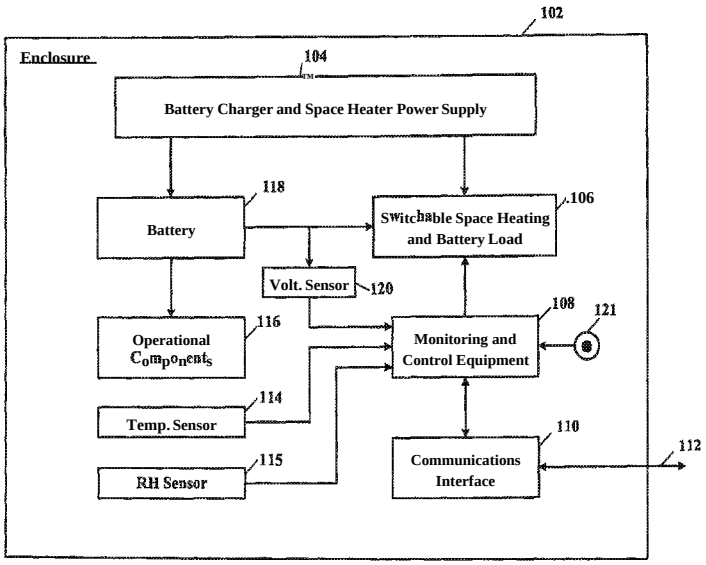

FIGURE 1

(57) **Abstract:** A single common load is provided for both space heating of the interior of an enclosure and for testing of a back-up battery therewith. The common load is coupled to either the battery for momentary load testing thereof, or to a power supply when heat is to be generated by the load for space heating of an interior of an enclosure. Providing only a single load for both space heating and battery testing results in reduced component costs, space savings and simplification of connections and wiring harnesses required. Power resistors, active components such as transistors or MOSFETs, and/or resistive heat tracing may be used as the common load, and deposed within the interior of the enclosure.

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BATTERY TEST AND CONDENSATION PREVENTION METHOD, SYSTEM AND APPARATUS

TECHNICAL FIELD

[0001] The present disclosure relates generally to battery testing and prevention of condensation conditions inside of an enclosure, and more particularly, to an apparatus for providing both.

BACKGROUND

[0002] Operation of switches, protective devices *(e.g.,* circuit breakers, fuses, electromechanical and solid state relays), contactors, motor overload circuits, and electronic monitoring and control devices *(e.g.,* microcontrollers, data acquisition and control systems) (hereinafter "components") can be affected by changes in the surrounding environment in which these components are disposed. For example, if the components are disposed in an enclosure and the relative humidity of the components' surrounding environment increases and/or interior temperature decreases beyond a certain threshold, thereby causing water condensation thereon, the components may not operate as intended and/or an arc fault condition may occur. Typically, the conditions of the components' surrounding environment are usually apparent when a person opens the enclosure to observe its inside. However, these conditions are not noticed until the enclosure is opened and the components' surrounding environment can be observed. While the components operate to prevent potentially harmful situations, the failure to acknowledge and adjust the components' surrounding environment can lead to other hazardous consequences, such as harm to equipment and/or personnel. Many of these components can be expensive and/or critical to commercial/industrial plant operation and/or personnel safety. If the change in the components' surrounding environment is not properly monitored and controlled, then the expensive and/or critical components can become damaged and/or not operate as intended when the surrounding environment is outside of acceptable operating conditions. Expensive and/or critical equipment that the expensive and/or critical components protect also can become damaged. In addition, replacement of the environmentally damaged expensive and/or critical components can be expensive and time consuming. Generally a heating element is provided in the enclosure that is activated when an interior temperature falls below a temperature set point and/or relative humidity exceeds a relative humidity set point.

[0003] Back-up battery operation of the aforementioned electronic monitoring and control devices, and critical interfaces whose states must be maintained during power

interruption may also be included in the enclosure. Provision for charging and testing of the back-up battery must also be provided with the control. A battery charger for charging the battery and a resistive load for testing the load capabilities of the battery, *e.g.,* voltage drop under load conditions, are provided in the control enclosure and/or external to the control enclosure.

[0004] Providing separate devices for space heating and battery load testing require expensive and space consuming high power resistance elements, wires within a harness to accommodate the heating elements, and control circuits therefore, and a significant amount of space either inside of the enclosure or in another enclosure adjacent thereto.

SUMMARY

[0005] Therefore, what is needed is a more cost effective and space efficient solution for providing both space heating of the interior of an enclosure and for testing of a back-up battery therewith. A common resistance load is coupled to either the battery for momentary load testing thereof, or to a power supply when heat is to be generated from the resistance load for space heating of an interior of an enclosure. Providing only a single load for both space heating and battery testing results in reduced component costs, space savings and simplification of connections and wiring harnesses required.

[0006] According to a specific example embodiment of this disclosure, an apparatus for testing a battery and space heating an enclosure comprises: at least one switchable resistive or active component(s) that make up a load located in the control; a voltage sensor for measuring voltage of a battery; and monitoring and control equipment coupled to the voltage sensor and controlling the at least one switchable active or passive load; wherein the at least one switchable active or passive load is coupled to a power source when temperature is to be raised in the enclosure; and wherein the monitoring and control equipment couples the at least one switchable active or passive load to the battery when a test thereof is performed.

[0007] According to a specific example embodiment of this disclosure, an apparatus for testing a battery and space heating an enclosure comprises: at least one switchable active or passive load located in an enclosure; a relative humidity sensor for measuring relative humidity within the enclosure; a voltage sensor for measuring voltage of a battery; and monitoring and control equipment coupled to and controlling the at least one switchable active or passive load, and coupled to the relative humidity sensor and the voltage sensor;

wherein the at least one switchable active or passive load is coupled to a power source when the measured relative humidity is greater than a certain relative humidity value, whereby the enclosure temperature increases to prevent moisture condensation therein; and wherein the monitoring and control equipment couples the at least one switchable active or passive load to the battery when a test thereof is performed.

[0008] According to another specific example embodiment of this disclosure, a system for testing a battery and space heating an enclosure comprises: operational electrical components located within an enclosure; at least one active or passive load located within the enclosure; a battery located within the enclosure and coupled to at least one of the operational electrical components; a voltage sensor for measuring voltage of the battery; and monitoring and control equipment coupled to the voltage sensor and controlling the least one switchable active or passive load; wherein the at least one switchable active or passive load is coupled to a power source when temperature is to be raised in the enclosure; and wherein the monitoring and control equipment couples the at least one switchable active or passive load to the battery when a test thereof is performed.

[0009] According to another specific example embodiment of this disclosure, a system for testing a battery and space heating an enclosure comprises: operational electrical components located within an enclosure; at least one switchable active or passive load located within the enclosure; a relative humidity sensor for measuring relative humidity located within the enclosure; a battery located within the enclosure and coupled to at least one of the operational electrical components; a voltage sensor for measuring voltage of the battery; and monitoring and control equipment coupled to and controlling the at least one switchable active or passive load, and coupled to the relative humidity sensor and the voltage sensor; wherein the at least one switchable active or passive load is coupled to a power source when the measured relative humidity is greater than a certain relative humidity value, whereby the enclosure temperature increases to prevent moisture condensation therein; and wherein the monitoring and control equipment couples the at least one switchable active or passive load to the battery when a test thereof is performed.

[0010] According to yet another specific example embodiment of this disclosure, a method for testing a battery and space heating an enclosure comprises the steps of: testing a battery by coupling at least one switchable active or passive load located within an enclosure to the battery and measuring a voltage drop thereof; measuring a relative humidity within the enclosure; determining whether the measured relative humidity within the enclosure is

approaching a specified relative humidity value; connecting the at least one switchable active or passive load to a power source when the measured relative humidity is greater than the specified relative humidity value, thereby increasing temperature and reducing the relative humidity within the enclosure; and returning to the step of measuring the relative humidity within the enclosure.

[001 1] According to still another specific example embodiment of this disclosure, a method for testing a battery and space heating an enclosure comprises the steps of: testing a battery by coupling at least one switchable active or passive load located within an enclosure to the battery and measuring a voltage drop thereof; measuring a temperature within the enclosure; connecting the at least one switchable load to the power source if the measured temperature is less than a specified low temperature value; and returning to the step of measuring the temperature within the enclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description, in conjunction with the accompanying figures briefly described as follows.

[0013] Figure 1 illustrates a schematic block diagram of an enclosure having operational components, monitoring and control equipment, sensors, battery back-up and a communications interface located therein, according to a specific example embodiment of this disclosure;

[0014] Figure 2 illustrates a schematic elevational diagram of the enclosure shown in Figure 1, according a specific example embodiment of this disclosure;

[0015] Figure 3 illustrates a schematic elevational diagram of a heat sink and load resistors attached thereto, according to a specific example embodiment of this disclosure;

[0016] Figure 3A illustrates a schematic elevational diagram of a heat sink and load power transistors attached thereto, according to another specific example embodiment of this disclosure;

[0017] Figure 4 illustrates a schematic elevational diagram of the enclosure using heat tracing as a load resistor, according to another specific example embodiment of this disclosure;

[0018] Figure 4A illustrates a schematic elevational diagram of the enclosure using at least one power load resistor, according to yet another specific example embodiment of this disclosure;

[0019] Figure 5 illustrates a schematic block diagram of the power supply, battery and resistive load shown in Figure 1, according to the specific example embodiments of this disclosure; and

[0020] Figure 5A illustrates a schematic block diagram of the power supply, battery and power transistor load shown in Figure 3A, according to the specific example embodiments of this disclosure; and also using a single voltage reference 576a to regulate the load transistors 440a, 440b, … 440n.

[0021] Figure 6 illustrates a schematic operational process flow diagram for enabling space heating to prevent moisture build up in the enclosure shown in Figure 1, according to specific exemplary embodiments of this disclosure.

[0022] Figure 7 illustrates a circuit board and circuit components coupled to a heat sink according to an exemplary embodiment of this disclosure.

[0023] Figure 8 illustrates a schematic block diagram according to an exemplary embodiment of this disclosure.

[0024] While the present disclosure is susceptible to various modifications and alternative forms, specific example embodiments thereof have been shown in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific example embodiments is not intended to limit the disclosure to the particular forms disclosed herein, but on the contrary, this disclosure is to cover all modifications and equivalents as defined by the appended claims.

DETAILED DESCRIPTION OF SPECIFIC EXAMPLE EMBODIMENTS

[0025] Referring now to the drawings, details of example embodiments of the present invention are schematically illustrated. Like elements in the drawings will be represented by like numbers, and similar elements will be represented by like numbers with a different lower case letter suffix.

[0026] Referring to Figure 1, depicted is a schematic block diagram of an enclosure having operational components, monitoring and control equipment, sensors, battery back-up and a communications interface located therein, according to a specific example embodiment

of this disclosure. An enclosure 102 contains a battery charger and space heater power supply 104, a switchable space heating and battery load 106, monitoring and control equipment 108, a temperature sensor 114, a relative humidity (RH) sensor 115, operational components 116, a battery 118, a battery test push button 121 which may be operated manually, or automatically, and, optionally, a communications interface 110 coupled to an information transmission medium 112.

[0027] The enclosure 102 may be, for example, but is not limited to, explosion proof and non-explosion proof, indoor or outdoor, rain tight, dust tight, metal or non-metal NEMA enclosures, and equivalent international enclosures such as IEC standard enclosures. The operational components 116 may be, for example, but are not limited to, circuit breakers, fuses, motor starters, generator control equipment, programmable logic controllers (PLC), industrial process controllers, radio communications relays and repeaters. The operational components 116 may be any electrical/electronic components or equipment that could be damaged if condensing water vapor is allowed to occur on its surface or internal parts.

[0028] The switchable space heating and battery load 106 may be, for example, but is not limited to, a resistive element, a transistor(s) or MOSFET(s), electric heat tracing, *etc.*, and may be used as an electric space heater and a test load for the battery 118. The switchable space heating and battery load 106 may include switching devices, *e.g.*, electro¬mechanical relays and/or power transistors or MOSFETs, *etc.*, for momentarily connecting the load portion thereof to the battery 118 or for longer term connection to the power supply 104 for enclosure space heating purposes. The monitoring and control equipment 108 may be, for example but is not limited to, relay logic (electro-mechanical and/or solid state), a microcontroller, *etc.* The battery 118 may be any type of rechargeable battery suitable for the operating temperature and load conditions of the environment and equipment, respectively.

[0029] The communications interface 110 may be, for example but is not limited to, a data concentrator having inputs and outputs adapted to interface with the monitoring and control equipment 108, and an interface for the wired or wireless information transmission medium 112. The communications interface 110 can be used with a digital processor based monitoring and control system based upon a microcontroller, data acquisition and control interface such as the input and output modules of a PLC in remote communications with a plant supervisory control and data acquisition (SCADA) system (not shown) over the information transmission medium 112, *e.g.*, wired (Ethernet, Internet, telephone/modem, fiber optic cable, etc.) or wireless (VHF, UHF or microwave telemetry; cell phone, spread

spectrum, radio mesh, WiFi, Zigbee, wireless Ethernet (802.11), *etc.)* The communications interface 110 may also be an integral part of the monitoring and control equipment 108.

[0030] The temperature sensor 114 measures the interior temperature of the enclosure 102. The relative humidity sensor measures the relative humidity inside of the enclosure 102. While shown in the exemplary embodiment illustrated in Figure 1, the relative humidity sensor is not required in alternate embodiments of the disclosure. The voltage sensor 120 can measure the voltage of the battery 118 during operation and testing thereof. For example, during normal operation a determination can be made from the measured battery voltage whether to engage the battery charger portion of the power supply 104 for charging of the battery 118, or maintain a trickle charge thereon. During testing, both no load and load voltages can be measured to determine the charge holding capabilities of the battery 118. The voltage sensor 120 may be an analog or digital voltmeter for local observation during testing of the condition of the battery 118, *e.g.*, by pressing the battery test push button 121; and/or it may be an analog-to-digital converter coupled to the monitoring and control equipment 108. Information from the temperature sensor 114 and/or the relative humidity sensor 115 can be used in determining when power should be applied to the switchable space heating and battery load 106 for space heating purposes to prevent water vapor condensation within the enclosure 102.

[0031] Testing of the battery 118 may be performed locally by pressing the battery test push button 121, or remotely with a battery test command over the information transmission medium 112 and through the communications interface 110. Remote monitoring of the enclosure environment and battery condition may be done through the monitoring and control equipment 108 coupled to the communications interface 110, wherein the communications interface 110 is in communications (wire or wireless) with a remote supervisory and control system (not shown).

[0032] Referring to Figure 2, depicted is a schematic elevational diagram of the enclosure shown in Figure 1, according a specific example embodiment of this disclosure. At least one power resistor 224 (three shown) may be mounted on a heat sink 222 and is in thermal communication therewith. The heat sink 222 may comprise a thermally conductive base 230 and may have thermally conductive fins 228 substantially perpendicular thereto. The thermally conductive base 230 and the fins 228 may be made of copper, aluminum, or any other material that has thermally conductive properties. A fan 226 may be used to blow

inside air across the heat sink fins 228 and for distributing the air warmed thereby throughout the interior of the enclosure 102.

[0033] Referring to Figure 3, depicted is a schematic elevational diagram of a heat sink and load resistors attached thereto, according to a specific example embodiment of this disclosure. At least one solid state power transistor or MOSFET 340 may also be attached to and be in thermal communication with the heat sink 222a so that the heat therefrom may be used in addition to heat from the at least one power resistor 224 for space heating purposes. The at least one power transistor or MOSFET 340 may be used to switch the respective at least one power resistor 224 to the battery 118 for testing purposes thereof, and to the power supply 104 during space heating of the enclosure 102.

[0034] Referring to Figure 3A, depicted is a schematic elevational diagram of a heat sink and load power transistors attached thereto, according to another specific example embodiment of this disclosure. At least one power transistor or MOSFET 440 may be attached to and be in thermal communication with the heat sink 222b so that the heat therefrom may be used for space heating purposes. One or more of the power transistors or MOSFETs 440 can be configured to operate at a constant current, and the heating power therefrom is equal to voltage across times the current through the one or more power transistors or MOSFETs 440.

[0035] Referring to Figure 4, depicted is a schematic elevational diagram of the enclosure using heat tracing as a load resistor, according to another specific example embodiment of this disclosure. Resistive heat tracing 442 may be used with or in place of the at least one power resistor 224. The resistive heat tracing 442 may be deposed on the inside surfaces of the enclosure 102 and/or around some or all of the operational components 116. Electrically, the heat tracing 442 would be coupled to either the battery 118 (during testing thereof) or to the power supply 104 when space heating is required.

[0036] Referring to Figure 4A, depicted is a schematic elevational diagram of the enclosure using at least one power load resistor, according to yet another specific example embodiment of this disclosure. The at least one power resistor 444 is mounted on a thermally conductive bar 446 that is thermally coupled to the enclosure 102 with, for example but not limited to, bolts 448. Convective heating also will occur with airflow around the at least one power resistor or MOSFET 444. Electrically, the at least one power resistor or MOSFET 444

would be coupled to either the battery 118 (during testing thereof) or to the power supply 104 when space heating is required.

[0037] Referring to Figure 5, depicted is a schematic block diagram of the power supply, battery and resistive load shown in Figure 1, according to the specific example embodiments of this disclosure. The power supply 104 is connected to and charges the battery 118. The battery 118 may be connected to the monitoring and control equipment 108, and/or the operational components 116. When space heating of the enclosure 102 is required, *e.g.,* based upon the measured interior temperature and/or relative humidity, switch 550 when in a first position and switch 552 when closed will connect the load 106 to the power supply 104. When the battery 118 is being tested, switch 550 when in a second position and switch 552 when closed will connect the load 106 to the battery 118.

[0038] Switches 552a-552c may be used to select any combination of one or more power elements, such as power resistor 224. It is contemplated and within the scope of this disclosure that many other switching combinations may be used with equal effect, and one having ordinary skill in electrical power switching circuits and the benefit of this disclosure would be able to contemplate such alternative switching combinations. For example, switches 550 and 552 may operate in parallel instead of series and be interlocked so both cannot be closed at the same time. The monitoring and control equipment 108 may be used to control the switches 550 and 552. The switches 550 and 552 may be electro-mechanical relays and/or solid state switches, *e.g.,* power transistors. Load 106 as shown with power resistor elements 224a, 224b, 224c may also be comprised of active power transistors and/or MOSFETs that would replace elements 224a, 224b, 224c.

[0039] Referring to Figure 5A, depicted is a schematic block diagram of the power supply, battery and power transistor load shown in Figure 3A, according to the specific example embodiments of this disclosure. The power supply 104 is connected to and charges the battery 118. The battery 118 may be connected to the monitoring and control equipment 108, and/or the operational components 116. When space heating of the enclosure 102 is required, *e.g.,* based upon the measured interior temperature and/or relative humidity, power switching transistor 560 is turned on into saturation by asserting a logic high on the heat enable control line coupled to the gate of interposing switch transistor 564 which turns it on and causes the power switching transistor 560 to connect the load 106 to the power supply 104. When the battery 118 is being tested, power switching transistor 562 is turned on into saturation by asserting a logic high on the battery test control line coupled to the gate of

interposing switch transistor 566 which turns it on and causes the power switching transistor 562 to connect the load 106 to the battery 118.

[0040] The power transistor load comprises at least one power transistor 440 configured to draw a constant current based upon the value of the emitter resistor 574 and the voltage of the /oner diode 576. When the voltage drop across the resistor 574 is equal to the voltage of the zener 576 minus the Vbe drop, the constant current will be in equilibrium. Diode 576a may also be a shunt regulator the same as or similar to, but not limited to, a single or multiple LM431 shunt regulator(s).

[0041] Referring to Figure 6, depicted is a schematic operational process flow diagram for enabling space heating to prevent moisture build up in the enclosure shown in Figure 1, according to specific example embodiments of this disclosure. In step 602 the monitoring and control equipment 108 is activated. In step 604 the interior relative humidity (RH) of the enclosure 102 is measured with the RH sensor 115. In step 606 the interior temperature of the enclosure 102 is measured with the temperature sensor 114. In step 608 the monitoring and control equipment 106 determines whether the interior RH is greater than a RH threshold value, and if greater than the RH threshold value then in step 616 the space heating 106 is activated to raise the enclosure 102 temperature and prevent moisture condensation therein.

[0042] In step 610 the monitoring and control equipment 106 determines whether the interior temperature of the enclosure 102 is below a low temperature threshold, and optionally, if so, activates the space heating 106 in step 616. Optionally, the rate of change of the RH and interior temperature can be calculated in determining the potential for water vapor condensation and activation of the space heating 106 to prevent the condensation from happening. Step 612 determines whether the interior temperature of the enclosure 102 is above a high temperature threshold and, if so, in step 614 will deactivate the spacing heating 106.

[0043] It is contemplated and within the scope of this disclosure that calculation of RH and temperature change rates, and comparisons to stored expected change rates, control of the load 106, monitoring of the sensors 114 and 115 may be performed by a computer system such as a microcontroller based system (not shown) and may be part of the monitoring and control equipment 108 and/or a remote computer system (not shown) coupled to the communications interface 110.

[0044] Referring to Figure 7, an exemplary embodiment of the present disclosure is shown in the context of a circuit board 6 mounted to a heat sink. Also coupled to the heat sink are power transistors la, lb, and lc. The power transistors la, lb, and 1c are coupled to current sense resistors 2a, 2b, and 2c. In one exemplaiy embodiment, each of resistors 2a, 2b, 2c has a resistance of .75 ohms. A shunt regulator 3 is shown for regulating the base current of the power transistors la, lb, and lc. Also shown in Figure 7 are capacitor 5 and resistors 4a, 4b, 4c, 4d, 4e, 4f, 4g, and 4h.

[0045] Referring to Figure 8, a schematic block diagram of another exemplary embodiment of the present disclosure is illustrated. Figure 8 illustrates an optical coupler 810 coupled to a 5V power supply. The power supply can charge a battery (not shown) via switch transistor 864. A load can be applied to either the power supply for heating or to the battery for testing. The load as shown in the exemplary embodiment in Figure 8 comprises power transistors 840a, 840b, and 840n, shunt regulator 818, capacitor 820, and resistors 814, 816, 870a, 870b, 870c, 871a, 871b, 871c, 872a, 872b, and 872c.

[0046] Although specific example embodiments of the invention have been described above in detail, the description is merely for purposes of illustration. It should be appreciated, therefore, that many aspects of the invention were described above by way of example only and are not intended as required or essential elements of the invention unless explicitly stated otherwise. Various modifications of, and equivalent steps corresponding to, the disclosed aspects of the exemplary embodiments, in addition to those described above, can be made by a person of ordinary skill in the art, having the benefit of this disclosure, without departing from the spirit and scope of the invention defined in the following claims, the scope of which is to be accorded the broadest interpretation so as to encompass such modifications and equivalent structures.

CLAIMS

I claim:

1. An apparatus for testing a battery and space heating an enclosure, comprising:

at least one switchable load located in an enclosure;

a voltage sensor for measuring voltage of a battery; and

monitoring and control equipment coupled to the voltage sensor and controlling the at least one switchable load;

wherein the at least one switchable load is coupled to a power source when temperature is to be raised in the enclosure; and

wherein the monitoring and control equipment couples the at least one switchable load to the battery when a test thereof is performed.

2. The apparatus according to claim 1, further comprising:

a relative humidity sensor for measuring relative humidity within the enclosure;

the monitoring and control equipment coupled to the relative humidity sensor;

wherein the at least one switchable load is coupled to a power source when the measured relative humidity is greater than a certain relative humidity value, whereby the enclosure temperature increases to prevent moisture condensation therein.

3. The apparatus according to claim *1*, wherein the monitoring and control equipment is located in the enclosure.

4. The apparatus according to claim *1*, wherein the battery is located in the enclosure.

5. The apparatus according to claim 1, further comprising a temperature sensor coupled to the monitoring and control equipment, wherein the temperature sensor measures temperature within the enclosure.

6. The apparatus according to claim 5, wherein the monitoring and control equipment couples the at least one switchable load to the power source when the measured temperature is less than a minimum temperature value, whereby the enclosure temperature increases.

7. The apparatus according to claim 5, wherein the monitoring and control equipment couples the at least one switchable load to the power source when the measured temperature indicates a potential moisture condensation condition within the enclosure.

8. The apparatus according to claim 2, wherein the monitoring and control equipment couples the at least one switchable load to the power source when the measured relative humidity indicates a potential moisture condensation condition within the enclosure.

9. The apparatus according to claim 1, further comprising a communications interface coupled to the monitoring and control equipment and adapted for communicating information between the monitoring and control equipment and a remote supervisory and control system.

10. The apparatus according to claim 9, wherein the information between the monitoring and control equipment and the remote supervisory and control system is communicated over a wired medium.

11. The apparatus according to claim 9, wherein the information between the monitoring and control equipment and the remote supervisory and control system is communicated over a wireless medium.

12. The apparatus according to claim 1, wherein the enclosure is selected from the group consisting of, an explosion proof enclosure, a dust proof enclosure, a water proof enclosure, a rain tight enclosure, and an indoor dry use enclosure.

13. The apparatus according to claim 1, wherein the at least one switchable load comprises at least one power resistor, transistor or MOSFET within the enclosure, and at least one switch for coupling the at least one power resistor to either the battery or the power source.

14. The apparatus according to claim 13, wherein the at least one switch is selected from the group consisting of an electro-mechanical relay, a power transistor, and a MOSFET.

15. The apparatus according to claim 1, wherein the at least one switchable load comprises resistive heat tracing within the enclosure, and a switch for coupling the resistive heat tracing to either the battery or the power source.

16. The apparatus according to claim 15, wherein the switch is selected from the group consisting of an electro-mechanical relay, a power transistor, and a MOSFET.

17. The apparatus according to claim 1, wherein the at least one switchable load comprises at least one constant current power transistor or MOSFET.

18. The apparatus according to claim 1, wherein the at least one switchable load is thermally coupled to the enclosure.

19. The apparatus according to claim 1, further comprising a heat sink in thermal communications with the at least one switchable load.

20. The apparatus according to claim 19, further comprising a fan blowing air within the enclosure across the heat sink.

21. A system for testing a battery and space heating an enclosure, said system comprising:

operational electrical components located within an enclosure;

at least one switchable load located within the enclosure;

a battery coupled to at least one of the operational electrical components;

a voltage sensor for measuring voltage of the battery; and

monitoring and control equipment coupled to the voltage sensor and controlling the least one switchable load;

wherein the at least one switchable load is coupled to a power source when temperature is to be raised in the enclosure; and

wherein the monitoring and control equipment couples the at least one switchable load to the battery when a test thereof is performed.

22. The system according to claim 21, further comprising:

a relative humidity sensor for measuring relative humidity within the enclosure;

the monitoring and control equipment coupled to the relative humidity sensor;

wherein the at least one switchable load is coupled to a power source when the measured relative humidity is greater than a certain relative humidity value, whereby the enclosure temperature increases to prevent moisture condensation therein.

23. The system according to claim 21, further comprising a temperature sensor coupled to the monitoring and control equipment, wherein the temperature sensor measures temperature within the enclosure.

24. The system according to claim 23, wherein the monitoring and control equipment couples the at least one switchable load to the power source when the measured temperature is less than a minimum temperature value, whereby the enclosure temperature increases.

25. The system according to claim 21, wherein the operational electrical components are selected from any one or more of the group consisting of at least one circuit breaker, at least one fuse, at least one motor starter, generator control equipment, programmable logic controller (PLC), industrial process controller, radio communications relay and repeater.

26. A method for testing a battery and space heating an enclosure, said method comprising the steps of:

testing a battery by coupling at least one switchable load located within an enclosure to the battery and measuring a voltage drop thereof;

measuring a relative humidity within the enclosure;

determining whether the measured relative humidity within the enclosure is approaching a certain relative humidity value;

connecting the at least one switchable load to a power source when the measured relative humidity is greater than the certain relative humidity value, thereby increasing temperature and reducing the relative humidity within the enclosure; and

returning to the step of measuring the relative humidity within the enclosure.

27. The method according to claim 26, further comprising the steps of:

measuring a temperature within the enclosure;

disconnecting the at least one switchable load from the power source if the measured temperature is greater than a specified high temperature value; and

returning to the step of measuring the temperature within the enclosure.

28. The method according to claim 26, further comprising the steps of:

measuring a temperature within the enclosure;

connecting the at least one switchable load to the power source if the measured temperature is less than a specified low temperature value; and

returning to the step of measuring the temperature within the enclosure.

29. The method according to claim 26, wherein the at least one switchable load comprises at least one power resistor or MOSFET within the enclosure, and at least one switch for coupling the at least one power resistor or MOSFET to either the battery or the power source.

30. The system according to claim 26, wherein the at least one switchable resistive load comprises resistive heat tracing within the enclosure, and switches for coupling the resistive heat tracing to either the battery or the power source.

31. The system according to claim 26, wherein the at least one switchable load comprises at least one constant current power transistor or MOSFET within the enclosure, and switches for coupling the at least one constant current power transistor or MOSFET to either the battery or the power source.

32. A method for testing a battery and space heating an enclosure, said method comprising the steps of:

testing a battery by coupling at least one switchable load located within an enclosure to the battery and measuring a voltage drop thereof;

measuring a temperature within the enclosure;

connecting the at least one switchable load to the power source if the measured temperature is less than a specified low temperature value; and

returning to the step of measuring the temperature within the enclosure.

33. The method according to claim 32, further comprising the steps of:

disconnecting the at least one switchable load from the power source if the measured temperature is greater than a specified high temperature value; and

returning to the step of measuring the temperature within the enclosure.

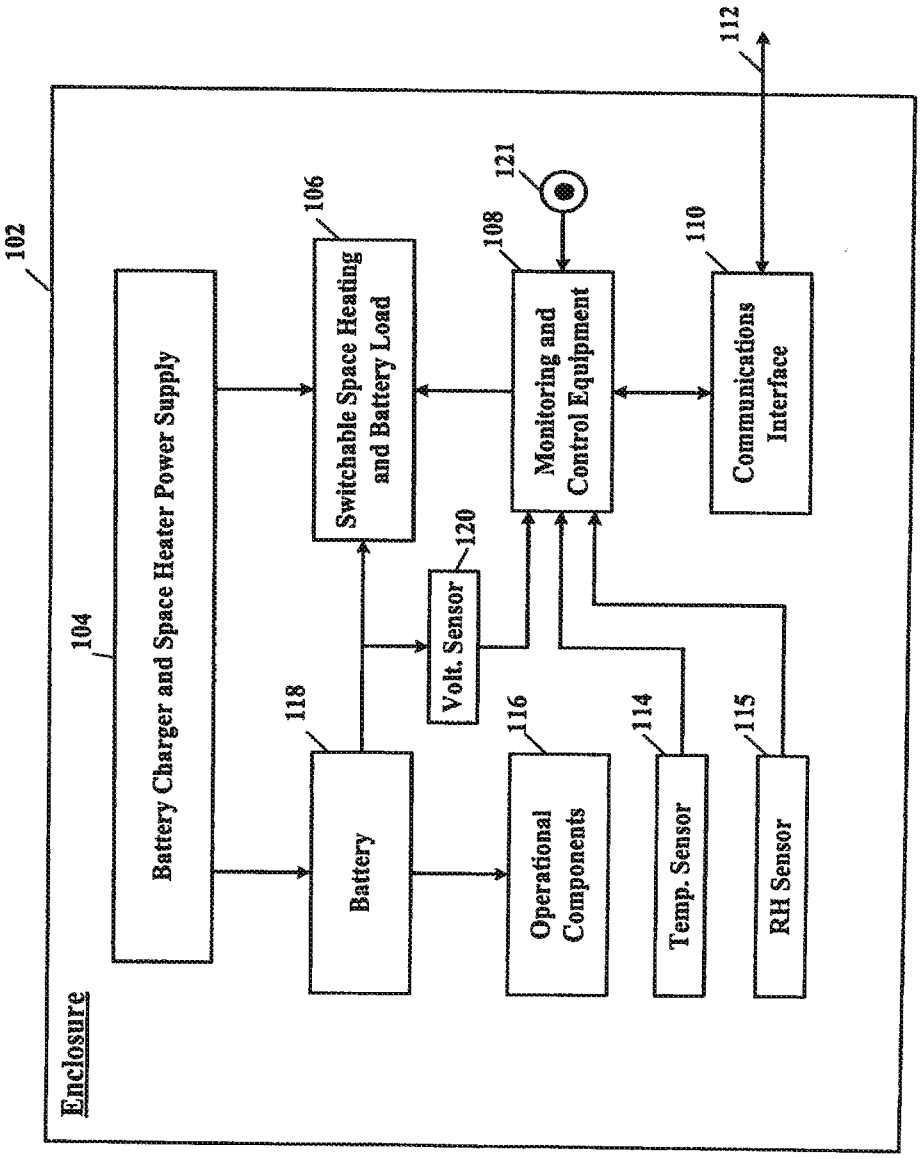
102
Enclosure
104
Battery Charger and Space Heater Power Supply
106
Switchable Space Heating and Battery Load
108
Monitoring and Control Equipment
110
Communications Interface
112
121
118
Battery
120
Volt. Sensor
116
Operational Components
114
Temp. Sensor
115
RH Sensor

FIGURE 1

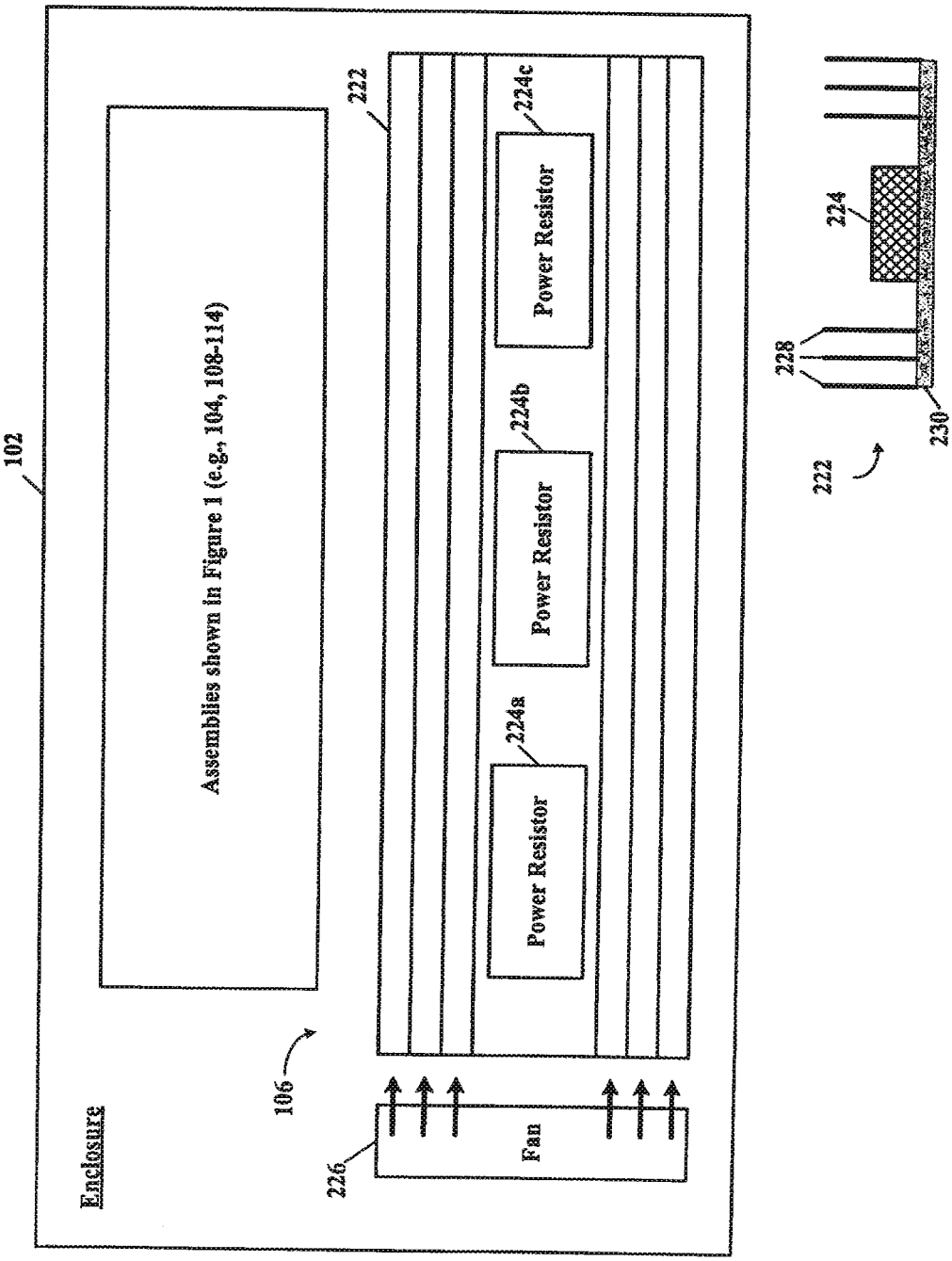
102
Enclosure
Assemblies shown in Figure 1 (e.g., 104, 108-114)
106
222
224a
Power Resistor
224b
Power Resistor
224c
Power Resistor
226
Fan
222
224
228
230

FIGURE 2

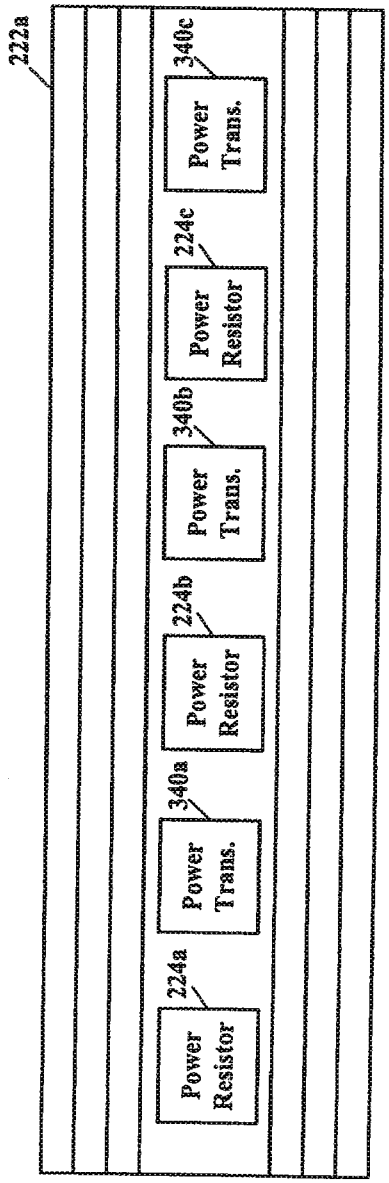
222a
224a
Power Resistor
340a
Power Trans.
224b
Power Resistor
340b
Power Trans.
224c
Power Resistor
340c
Power Trans.

FIGURE 3

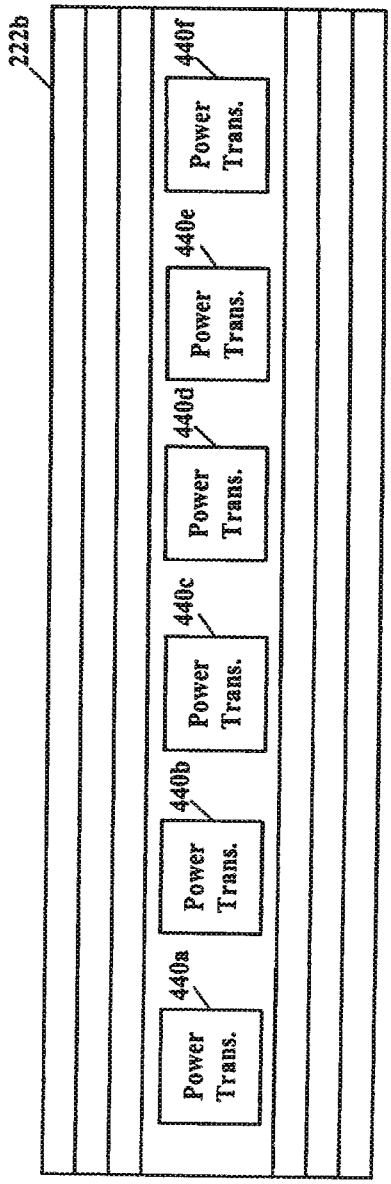
222b
440a
Power Trans.
440b
Power Trans.
440c
Power Trans.
440d
Power Trans.
440e
Power Trans.
440f
Power Trans.

FIGURE 3A

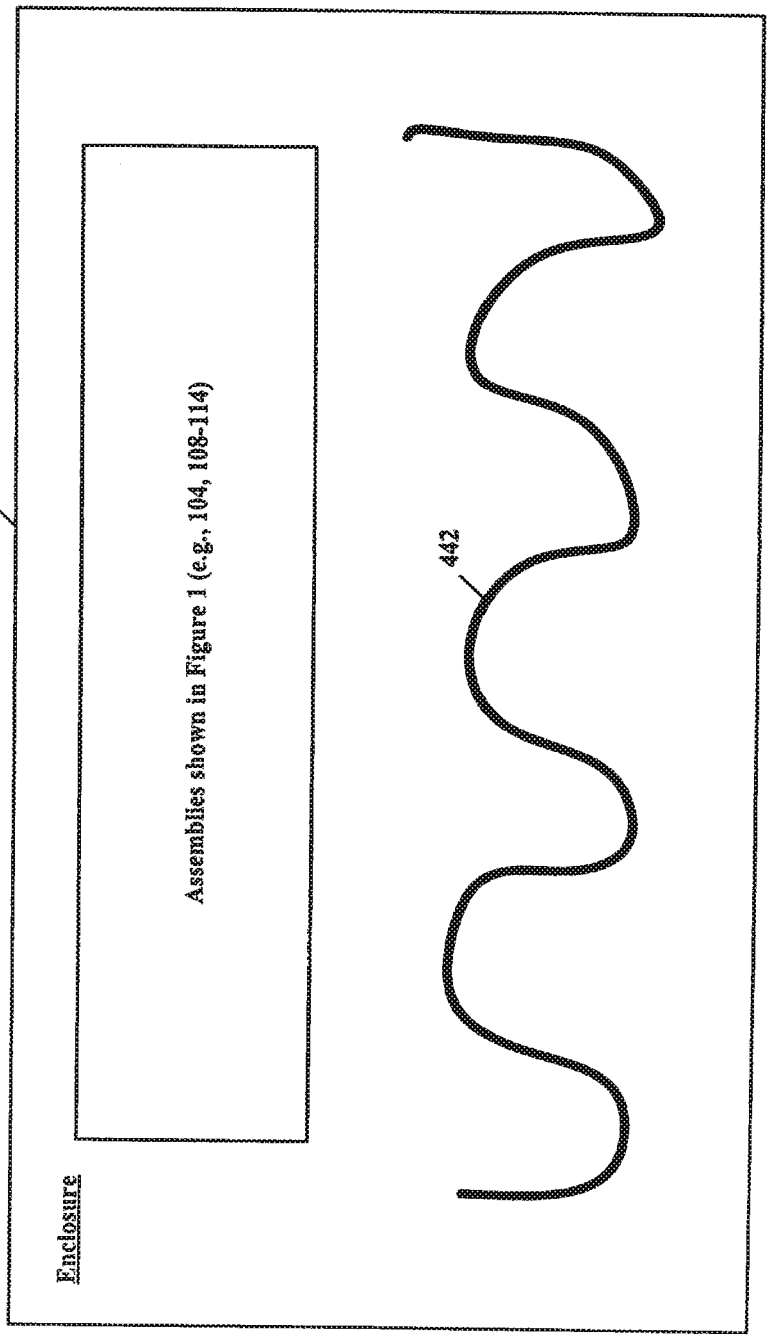
102
Assemblies shown in Figure 1 (e.g., 104, 108-114)
442
Enclosure

FIGURE 4

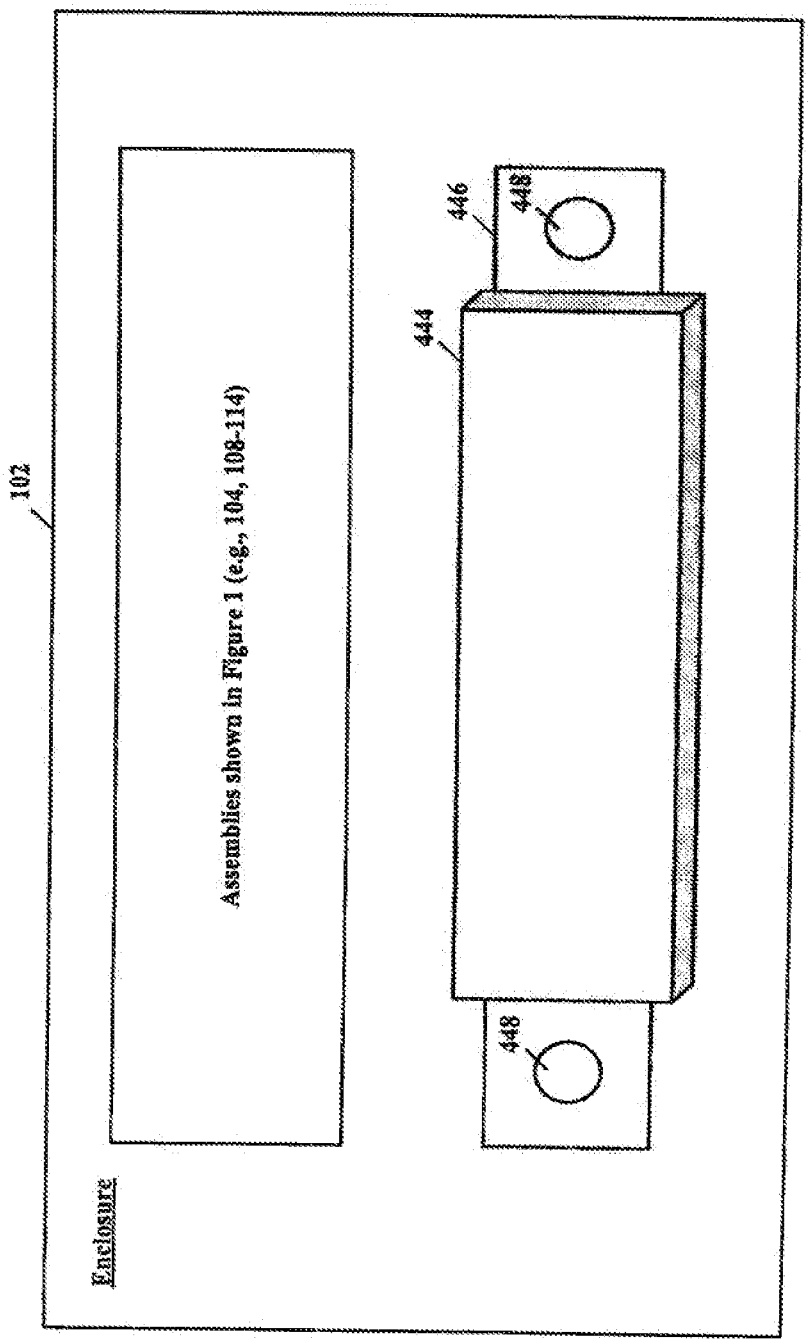
102
Assemblies shown in Figure 1 (e.g., 104, 108-114)
446
448
444
448
Enclosure

FIGURE 4A

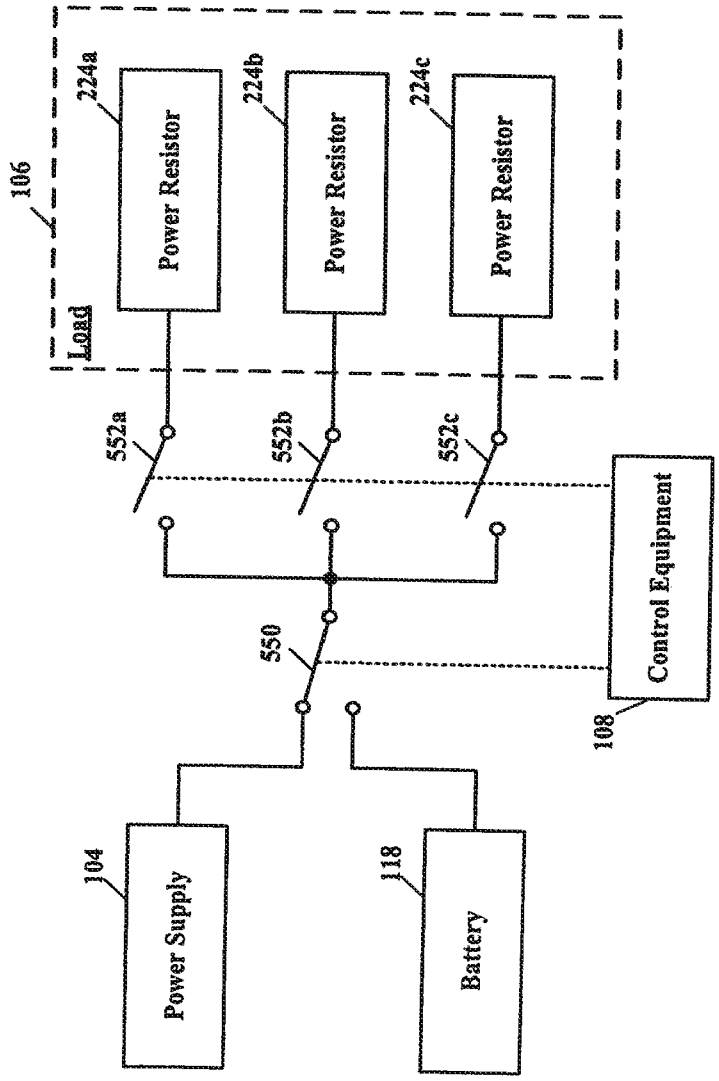
106
Load
224a
Power Resistor
224b
Power Resistor
224c
Power Resistor
552a
552b
552c
550
Control Equipment
108
104
Power Supply
118
Battery

FIGURE 5

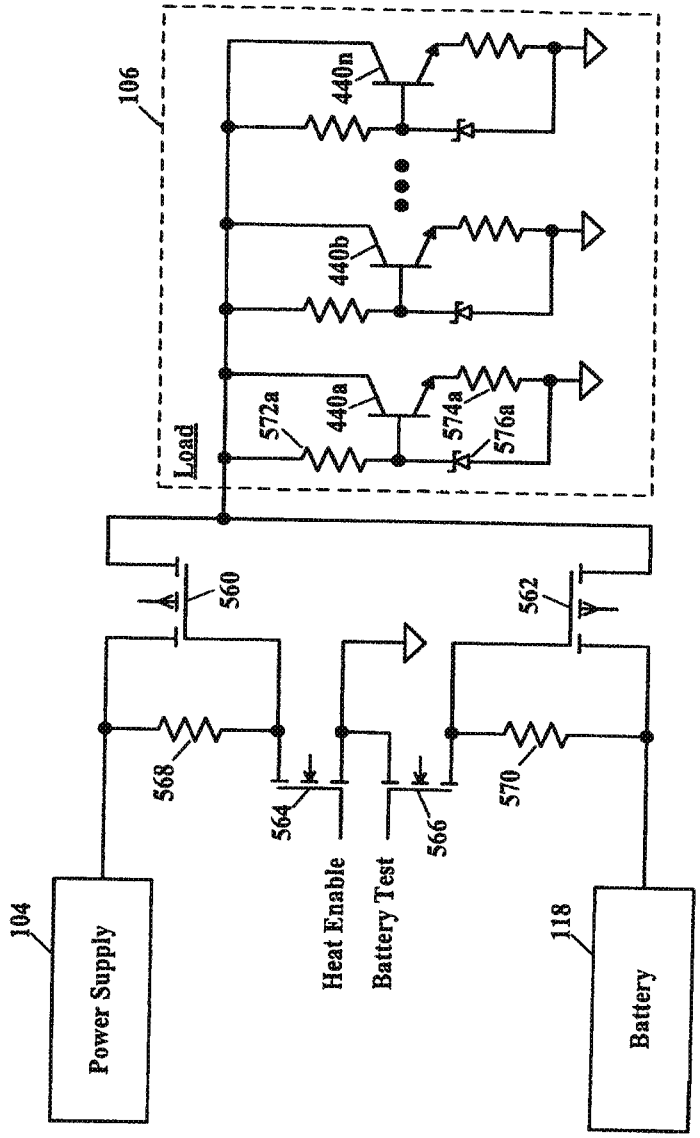
106
440n
440b
440a
572a
574a
576a
Load
560
562
568
564
566
570
Heat Enable
Battery Test
104
Power Supply
118
Battery

FIGURE 5A

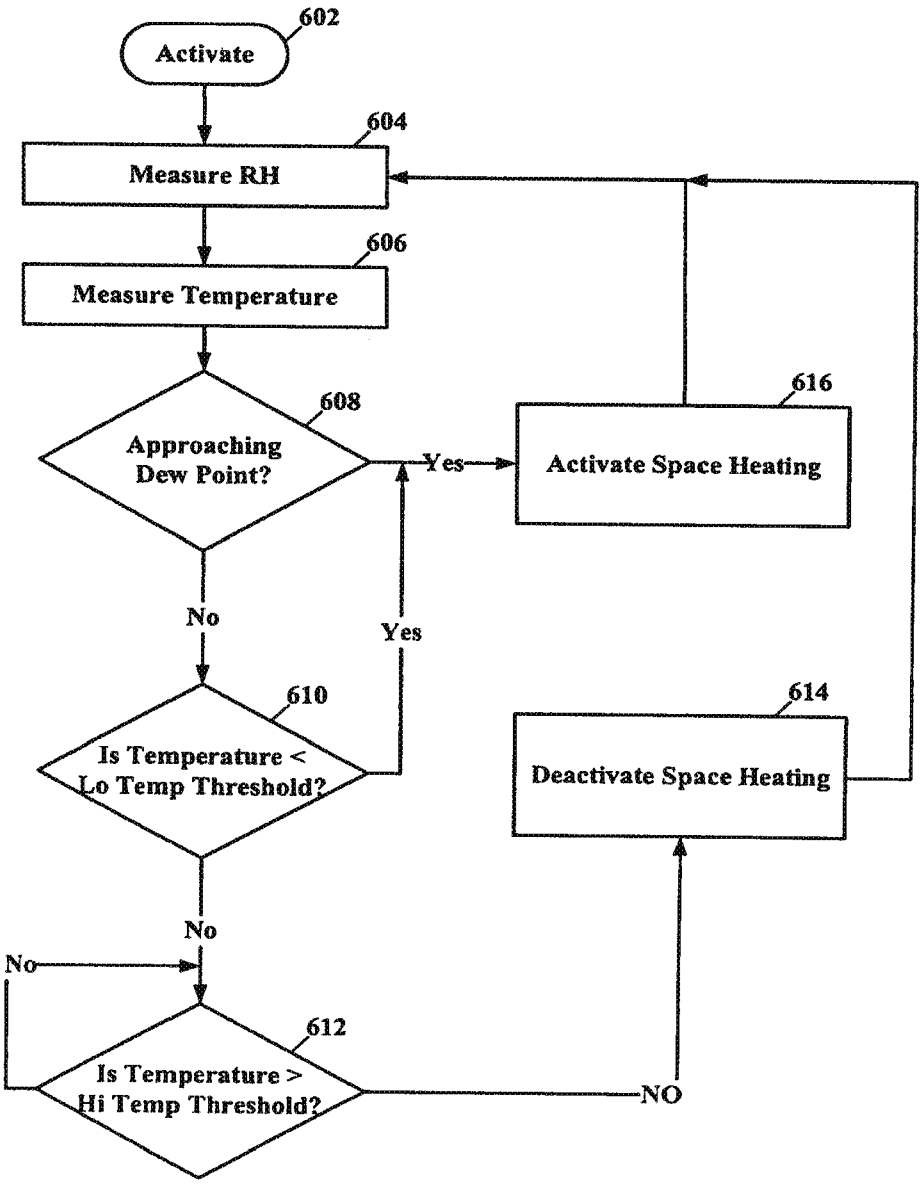
602
Activate
604
Measure RH
606
Measure Temperature
608
Approaching Dew Point?
Yes
616
Activate Space Heating
No
Yes
610
Is Temperature < Lo Temp Threshold?
614
Deactivate Space Heating
No
No
612
Is Temperature > Hi Temp Threshold?
NO

FIGURE 6

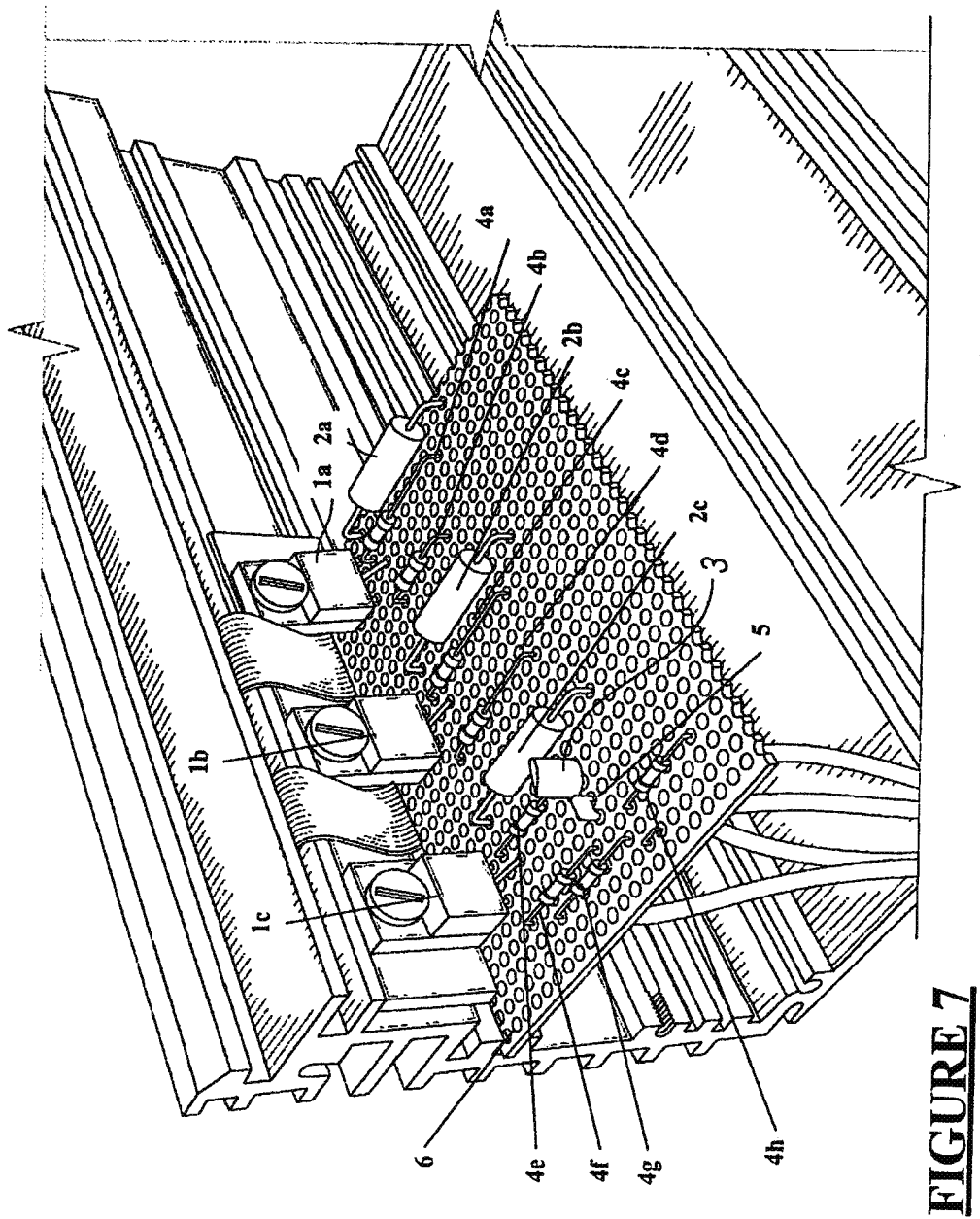

FIGURE 7

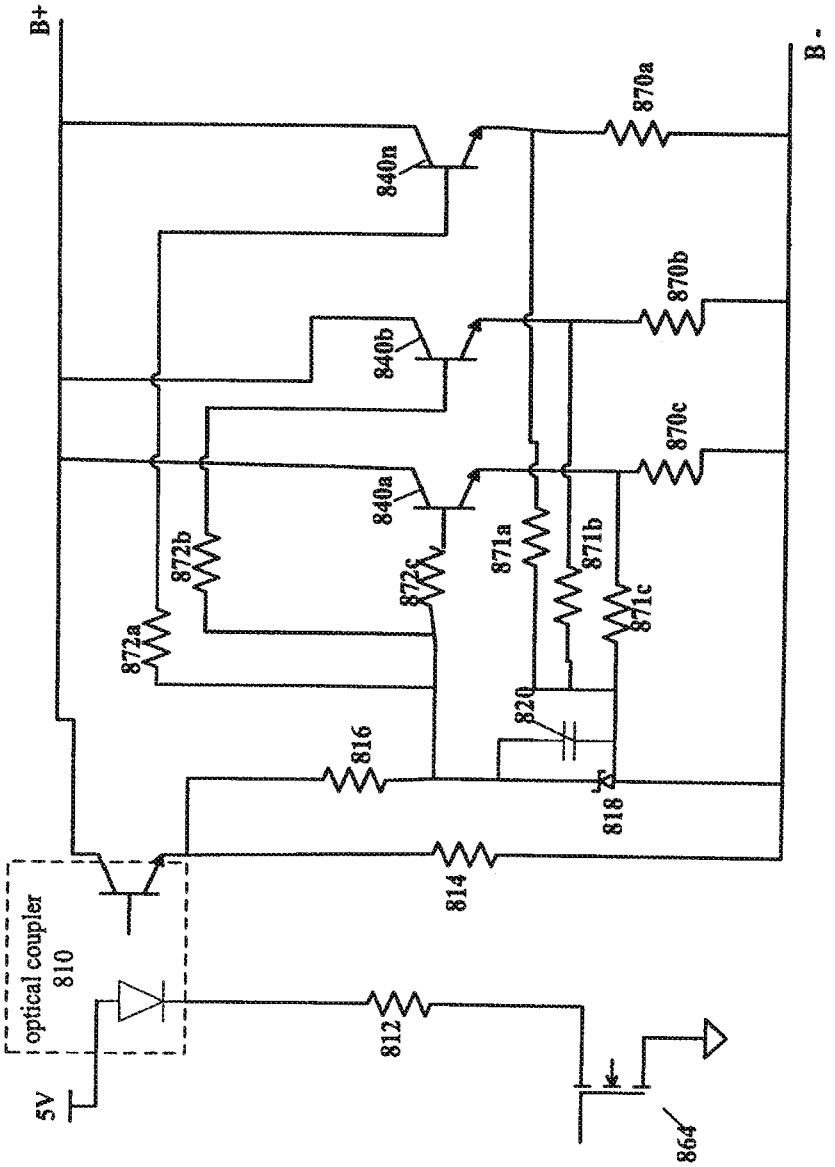
B+
B -
870a
840n
870b
840b
870c
840a
872b
872c
871a
871b
871c
872a
820
816
818
optical coupler
810
814
812
5V
864

FIGURE 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/064418

A. CLASSIFICATION OF SUBJECT MATTER

G01R 31/36(2006.01)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)

G01R 31/36; H02J 7/04; H02J 7/00; H01M 8/00; H01M 10/50

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: test, battery, heating, enclosure, switch, load, voltage, control, temperature, humidity sensor, power source, moisture, communicate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011-0121789 A1 (J0NG-W00N YANG et al.) 26 May 2011 See the abstract, paragraphs [0034]-[0066], claims 1,2 and figures 1,3-5.	1,3-6,12,21,23-25,32,33
A		2,7-11,13-20,22,26-31
Y	US 2011-0288704 A1 (JONATHAN R. SCHWARZ et al.) 24 November 2011 See the abstract, paragraphs [0012]-[0031], claims 1,2, and figures 1,2.	1,3-6,12,21,23-25,32,33
A		2,7-11,13-20,22,26-31
A	US 2009-0243540 A1 (KAI-WAI ALEXANDER CHOI et al.) 01 October 2009 See the abstract, paragraphs [0037]-[0051], and figure 1.	1-33
A	US 2005-0077364 A1 (BYOUNG, WOO HWANG) 14 April 2005 See the abstract, paragraphs [0054]-[0074], [0097]-[0113], and figures 1,4A,4B,5.	1-33

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 MARCH 2013 (18.03.2013)	**19 MARCH 2013 (19.03.2013)**

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

PARK, Keun Yong

Telephone No. 82-42-481-8508

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2012/064418

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 2011-0288704 A1	24.11.2011	DE 102011101760 A1	24.11.2011
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US 2005-0077364 A1	14.04.2005	CN 1003566 21 CO	19.12.2007
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		DE 10361672 A1	12.05.2005
		JP 2005-116499 A	28.04.2005
		KR 10-0527469 B1	09.11.2005
		KR20050035334A	18.04.2005
		US 6994267 B2	07.02.2006