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(54) **Absorption refrigerator unit with temperature and level monitoring**

(57) A control system 50 for a refrigerator 10 having an absorption cooling arrangement 12 and a generator 18 can include a temperature sensor 94 associated with the generator 18 and operable to sense a temperature of the cooling arrangement 12, a level sensor 98 associated with the refrigerator 10 and operable to sense a level condition of the cooling arrangement 12, and a heat source operably associated with at least the generator 18. A control circuit can include a processor 62 and can be in communication with at least the temperature sensor 94, the level sensor 98 and the heat source, and can be configured to determine a sensed temperature from the temperature sensor 94 and a sensed level condition from the level sensor 98. The control circuit can be configured to turn off the heat source based on determining the sensed temperature is below a first predetermined threshold or based at least in part on determining the sensed level condition exceeds a second predetermined threshold.

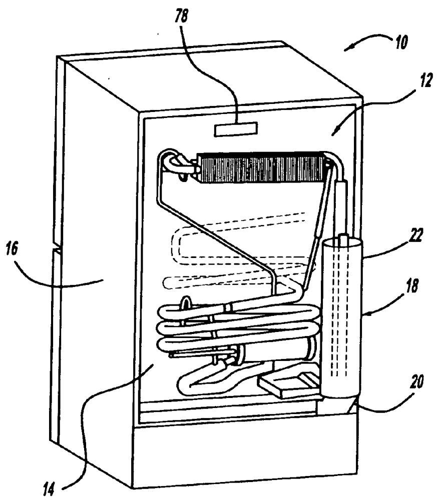

FIG - 1

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Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/407,961, filed on October 29, 2010, the disclosure of which is hereby incorporated herein by reference.

FIELD

[0002] The present disclosure relates generally to cooling systems and, more particularly, to control systems and methodologies for ammonia absorption refrigerators.

BACKGROUND

[0003] This section merely provides background information related to the present disclosure and may not constitute prior art.

[0004] Vehicles, including but not limited to, recreational vehicles ("RVs", in the United States and "Caravans" in Europe), tractor trailers, airplanes, boats, trains and the like, often incorporate refrigerators for the comfort and convenience of the occupants. For example, recreational vehicle campers often find it convenient, or even necessary, to refrigerate food, drinks, and medicine during their journey and while at their campsites. While many prepared camp sites in parks and commercial campgrounds provide for electrical outlets, many do not. Moreover, many highly desirable camping locations exist outside of these prepared sites. Thus, a popular solution has been to equip the recreational vehicle with an absorption refrigerator.

[0005] Absorption refrigerators typically employ heat to vaporize a coolant-water mixture (typically ammonia-water) thereby driving the refrigeration loop in a manner well known to those skilled in the art. Popular heat sources include electrical heaters and fuel burners. The fuel burners typically employ propane which is readily available at camping supply stores, barbeque supply stores, and numerous gas stations. Though, any liquid or gaseous fuel would work well and be controllable through simple, automated control systems.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] In one form, a control system for a refrigerator having an absorption cooling arrangement and a generator is provided in accordance with various aspects of the present teachings. The control system can be associated with a temperature sensor, a level sensor, a heat source and a control circuit. The temperature sensor can be associated with the generator and can be operable to sense a temperature of the cooling arrangement proximate the generator. The level sensor can be associated with the refrigerator and can be operable to sense a level condition of the cooling arrangement, and the heat source can be operably associated with at least the generator. The control circuit can include a processor and can be in communication with at least the temperature sensor, the level sensor and the heat source. The control circuit can be configured to determine a sensed temperature from the temperature sensor and a sensed level condition from the level sensor. The control circuit can be configured to turn off the heat source based on determining the sensed temperature is below a first predetermined threshold or based at least in part on determining the sensed level condition exceeds a second predetermined threshold.

[0008] In another form, a control system for a refrigerator having an absorption cooling arrangement and a generator is provided in accordance with various aspects of the present teachings. The control system can be associated with a temperature sensor, a level sensor, a heat source, a user interface and a control circuit. The temperature sensor can be associated with the generator and can be operable to sense a temperature of the cooling arrangement proximate the generator. The level sensor can be associated with the refrigerator and can be operable to sense a level condition of the cooling arrangement. The heat source can be operably associated with at least the generator, and the user interface can be operably associated with the refrigerator. The control circuit can have a processor, and can be in communication with at least the temperature sensor, the level sensor, the heat source and the user interface. The control circuit can be configured to determine a sensed temperature from the temperature sensor and a sensed level condition from the level sensor, and can be operable to turn off the heat source if the sensed temperature is determined to be exceed a first predetermined threshold.

[0009] In yet another form, a method for controlling an absorption cooling arrangement of a refrigerator is provided in accordance with various aspects of the present teachings. The method can include determining if a predetermined period of time has elapsed since the cooling arrangement received a signal to initiate cooling of the refrigerator. A temperature proximate a generator associated with the cooling arrangement can be sensed after determining the predetermined period of time has elapsed. The sensed temperature can then be compared to a predetermined temperature condition. A heat source operably associated with the cooling arrangement can be selectively turned off based upon the comparison of the sensed temperature to the predetermined temperature condition.

[0010] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0011] The present teachings will become more fully understood from the detailed description, the appended claims and the following drawings. The drawings are for illustrative purposes only of selected embodiments and not all possible limitations, and are not intended to limit the scope of the present disclosure.

[0012] Figure 1 is a rear perspective view of an exemplary gas absorption refrigerator in accordance with the teachings of the present disclosure;

[0013] Figure 2 is a view of an exemplary user interface or control panel in accordance with the teachings of the present disclosure;

[0014] Figure 3 is a view of an exemplary block diagram of a control system configuration in accordance with the teachings of the present disclosure;

[0015] Figure 4 is a view of an exemplary schematic of the control system in accordance with the teachings of the present disclosure; and

[0016] Figures 5 and 6A-6C are flowcharts illustrating an exemplary operation of the control system in accordance with the teachings of the present disclosure.

DETAILED DESCRIPTION

[0017] The following description is merely exemplary in nature and is not intended to limit the present disclosure, its application, or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

[0018] Exemplary embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous details are set forth such as examples of specific components, devices, systems and/or methods, so as to provide a thorough understanding of exemplary embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that exemplary embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some exemplary embodiments, well-known processes, well-known device structures, and/or well-known technologies are not described in detail.

[0019] The devices, methods and systems described herein can be applied to a wide variety of cooling units. For the purpose of illustration, though, a typical absorption refrigeration system is used that has a cold storage compartment. Those skilled in the art will understand that the illustrative refrigeration system does not limit the present teachings in any way, but is used only to explain the present teachings.

[0020] With general reference to the drawings, an exemplary gas absorption refrigerator 10 including a control system 50 is provided in accordance with the present teachings. The refrigerator 10 can include a cooling system having an absorption cooling arrangement 12 mounted on a back wall 14 of a cabinet 16. The cabinet 16 can enclose an insulated compartment (not specifically shown). The cooling arrangement 12 can include conventional gas absorption cooling components. In this regard, the cooling arrangement 12 can include an absorber, an evaporator, a condenser and a generator 18. In one exemplary configuration, the generator 18 can include a boiler or boiler tube. Insofar as the present teachings are concerned, it will be understood that these basic components of the gas absorption refrigerator 10 are conventional in both construction and operation.

[0021] The cooling arrangement 12 can be controlled electrically or with a gas source. In this regard, the cooling arrangement 12 can additionally include an optional DC electrical heater, an AC electrical heater and/or a gas burner. The cooling arrangement 12 can further include a burner and burner box 20. The generator 18 and heaters can be contained within a generator enclosure or canister 22 that upwardly extends proximate the burner box 20.

[0022] As is well known in the art of absorption cooling, the coolant mixture (typically ammonia and water) is heated in the generator or boiler tube 18 to preferentially release ammonia vapor. From the generator 18, the ammonia vapor flows to the condenser. In the condenser, the ammonia vapor cools and condenses. By gravity, the cool liquid ammonia flows from the condenser and into the evaporator. In the evaporator, the liquid ammonia absorbs heat from the interior of the refrigerator 10 thereby cooling the interior of the refrigerator 10. The vaporized ammonia then flows from the evaporator to the absorber where the partially depleted water-ammonia mixture absorbs the ammonia vapor to complete the refrigeration cycle.

[0023] Heat is required to vaporize the ammonia in the ammonia-water mixture. The heat source may be an electrical heater, a burner flame, a solar heater, a fuel cell and/or any other conventional heat source. More particularly, the electric heater may be either an AC (e.g., 120-240 V AC) or a DC (e.g., 12-48 V DC) heater. In the alternative, both types of electrical heaters and a burner flame may be provided with controls to allow the user to switch between the sources of heat. The energy source for the burner flame can be a gas, such as butane or natural gas, or a liquid fuel, such as diesel or kerosene. When the refrigerator 10 is operating with the electrical heat source, a relatively large quantity of electrical power must be supplied from a source external to the refrigerator 10 (e.g., from the recreational vehicle electrical system or from a hook up provided at the camp site). In certain applications, the refrigerator 10 may automatically choose the best available energy source upon which to operate.

[0024] Somewhere on the refrigerator 10 viewable by the user, or in a viewable location remote from the refrigerator 10, an exemplary user interface or control panel 24 can be provided so that the user can turn the refrigerator 10 on and off, adjust the temperature of one or more interior sections, and monitor the performance of the refrigerator 10. Controls for these functions can be provided such as the on/off switch 26, an operating mode selector (gas/electric/auto) 28, and a temperature set point selector 30, as generally shown in Figure 2. In particular, the control panel 24 and/or monitoring control can include a refrigeration monitor 32 to allow the user to determine whether the absorption cooling arrangement 12 is operating properly, as will be discussed below. The monitor 32 can include a display area for displaying information and/or error codes, as will also be discussed below.

[0025] It is desirable to operate the generator 18 and/or other heat sources of the cooling arrangement 12 within an optimum temperature range. It is also desirable to operate the absorption cooling arrangement 12 in a relatively level position (i.e., without a deviation of more than, for example, 2-3 degrees from vertical) due to the arrangement's dependency on gravity and buoyancy to cause the circulation of working fluids in the required thermodynamic cycles. Accordingly, the present inventors recognized a need to monitor a temperature condition and a level condition of the absorption refrigerator 10 to improve control of the cooling arrangement 12.

[0026] Turning now to Figures 3 and 4, an exemplary control system configuration 50 and associated exemplary control circuitry are illustrated. The exemplary control system circuitry can include an exemplary power or circuit board 54, an exemplary monitoring control or circuit board 58, and the exemplary control panel/user interface 24. In one exemplary configuration, the control system circuitry can include a first microprocessor 62 operatively associated with the power board 54, a second microprocessor 66 operatively associated with the monitoring control board 58, a relay 68, a high temperature limit circuit 70, and a third microprocessor 88 operatively associated with the control panel/user interface 24. The control system 50 can be operatively associated with an AC heater 78, a gas valve 82, an optional DC heater 86, a cabinet thermistor 90, a cooling arrangement temperature sensor 94 and an onboard level sensor 98.

[0027] It is appreciated that while the following discussion will continue with reference to the control circuitry of control system 50 including the individual power board 54, monitoring control board 58, and control panel/user interface 24, the control circuitry can be configured to include either a single circuit board incorporating the features and components of boards 54 and 58, or separate power and monitoring control boards. In this regard, in the exemplary configuration having a single board, the control system configuration 50 can use either a single microprocessor incorporating the features and functions of microprocessors 62 and 66 discussed above, or maintain separate microprocessors. It is also appreciated that the control circuitry could be configured to use a single microprocessor incorporating the features and functions of microprocessors 62, 66 and 88.

[0028] In the exemplary configuration illustrated, the high temperature limit circuit 70 can include first and second wires or electrical circuit board connections 102, 106 that electrically connect limit-in and limit-out switches or terminals 110, 114 associated with power board 54 and the relay 68 associated with monitoring control board 58. It is appreciated that the high temperature limit circuit 70 and its associated components can also be provided on a single circuit board, as discussed above. In one exemplary configuration, the high temperature limit circuit 70 and the relay 68 can be in communication with microprocessors 62, 66 and 88.

[0029] The cooling arrangement temperature sensor 94 can include a thermocouple, a thermistor, a resistance thermal detector or any other temperature sensing device that is well known in the art. The cooling arrangement temperature sensor 94 can be positioned on the boiler tube / generator 18, as shown for example in Figure 4. The cooling arrangement temperature sensor 94 can be operatively associated with the control system 50, cooling arrangement 12, and control panel or user interface 24. In the exemplary configuration illustrated, the cooling arrangement temperature sensor 94 can be electrically connected to the control circuitry via monitoring control board 58 and can be configured to sense a temperature of the generator 18 and/or a temperature proximate generator 18. The level sensor 98 can include an accelerometer or any other appropriate level sensing device known in the art and can be operatively associated with the refrigerator 10, cooling arrangement 12 and the control circuitry of control system 50, as shown for example in Figures 1 and 4. In the exemplary configuration illustrated, the level sensor 98 can be electrically connected to the control circuitry via power board 54.

[0030] With additional reference to Figures 5-6C, exemplary operation of the control system 50 will now be discussed in accordance with the present teachings. The control system 50 in cooperation with microprocessors 62, 66, 88 and associated control circuitry and software can continuously monitor the temperature sensed via the cooling arrangement temperature sensor 94 and the output of the onboard level sensor 98 to control the cooling arrangement 12. Anytime the control system 50 is powered on, such as via on/off switch 26 of control panel 24, a monitoring control algorithm 118 can be activated at block 120 that includes at least the features discussed below. The control system 50 can include control features advantageously configured to both substantially minimize or prevent damage to the cooling arrangement 12 as well as provide error codes for troubleshooting purposes.

[0031] In an exemplary control configuration shown in Figure 5, the control circuitry of control system 50 can monitor the high temperature limit circuit 70 at block 122 to determine if there is an open circuit any time the relay 68 is not energized. If an open circuit in the limit circuit 70 is sensed, the control system 50 can turn off all heat sources and cause the monitor 32 to display a first unique error code indicative of such a condition at block 126. In one exemplary configuration, the sensed open circuit can be indicative of a situation where one or more of the wires (i.e., wires 102 and 106) that comprise the limit circuit 70 are not connected or are electrically open. The control system 50 can allow the heat sources to operate normally once the high temperature limit circuit 70 is electrically closed, as shown at blocks 130 and 134.

[0032] In a similar manner, the control system 50 can also monitor the cooling arrangement temperature sensor 94 at block 138 to determine if there is an electrically open condition associated therewith and/or if the sensor 94 is determined to be operating outside of its normal operating range. If such a condition is sensed or determined by control system 50, the control circuitry of control system 50 can cause all of the heat sources to be turned off and cause the monitor 32 to display a second unique error code indicative of such a condition at block 142. Examples of an electrically open temperature sensor 94 can include a defective or broken temperature sensor 94 or a condition where the temperature sensor 94 is not electrically connected (i.e., plugged in) to the monitoring control board 58 associated with control system 50. The control system 50 can allow the heat source outputs and/or cooling arrangement 12 to operate normally once the cooling arrangement temperature sensor 94 is determined to be electrically closed and/or operating within its normal operating range, as shown in blocks 146 and 150.

[0033] The control system 50 can also be configured to control operation of the cooling arrangement 12 based on sensed temperatures from the temperature sensor 94 and/or a sensed condition of the level parameters of the cooling arrangement 12 via level sensor 98, as will be discussed below.

[0034] In an exemplary control configuration shown in Figure 6A, the control circuitry of control system 50 can monitor the cooling arrangement temperature sensor 94 to determine if the sensed temperature is less than a predetermined temperature threshold after a predetermined period of time since a call or signal for cooling has been received by control system 50 from the user interface 24, as set forth at block 158. As an example, the predetermined temperature threshold can be 250°F and the predetermined period of time can be 15 minutes. If the sensed temperature is less then the predetermined threshold after the predetermined period of time, the control circuitry of control system 50 can cause the relay 68 to energize to provide an open circuit in the high temperature limit circuit 70 and can cause all heat sources to be turned off at block 162. The control system 50 can also be operable to cause the monitor 32 to display a third unique error code indicative of this fault condition at block 162. This control feature can prevent the limit-in and limit-out terminals 110, 114 of circuit board 54 from being short circuited. It should be appreciated that this fault condition can also be indicative of a loose cooling arrangement temperature sensor 94.

[0035] The power to the control system 50 can be turned off and then back on to reset the third error code and/or control system 50, such as via on/off switch 26 of user interface 24, as set forth at block 166. This can allow the heat sources to return to normal operation. If the sensed temperature is not less than the predetermined threshold after the predetermined period of time at block 158, the microprocessors 62, 66, 88 can cause the control system 50 to resume normal operation at block 170.

[0036] In another aspect of the exemplary control configuration shown in Figures 6B and 6C, the control circuitry of control system 50 can also monitor the cooling arrangement temperature sensor 94 to determine if a temperature greater than a predetermined threshold is sensed for a predetermined period of time at block 178. As an example, the predetermined temperature threshold can be 430°F and the predetermined period of time can be 5 minutes. If the sensed temperature is not greater than the predetermined threshold for the predetermined period of time, microprocessors 62, 66, 88 can cause the heat sources and/or cooling arrangement 12 to resume normal operation at block 182. If the sensed temperature is greater than the predetermined threshold for the predetermined period of time, the control system 50 can then interrogate the level sensor 98 to determine the level parameters of the cooling arrangement 12 at block 186. Preventing the boiler from operating at high temperatures can avoid consumption of sodium chromate, which can be used in the coolant mixture to neutralize any corrosive effects of the ammonia solution.

[0037] In a first scenario where the level parameters are determined to be above a predetermined limit (e.g., side to side angle greater than 5 degrees and/or front to back angle greater than 6 degrees) at blocks 190 and 194, the control circuitry of control system 50 can cause the relay 68 to energize to provide an open circuit in the high temperature limit circuit 70 and can cause all heat sources to be turned off at block 198. The control system 50 can also cause a fifth unique error code and/or audible alarm indicative of this fault condition to be displayed via monitor 32 for troubleshooting purposes at block 198.

[0038] This control feature can prevent operation of the cooling arrangement 12 at elevated temperatures and provide an indication (via the fifth error code) that the fault condition could be related to an off-level operating condition of the refrigerator 10 and cooling arrangement 12. The control system 50 can be operable to allow the heat sources and/or cooling arrangement 12 to operate normally at block 202 once the temperature sensed via temperature sensor 94 is less than a predetermined threshold (e.g., 200°F) at block 206 and the level sensor 98 indicates the level parameters of the cooling arrangement are within acceptable limits at block 210.

[0039] In a second scenario where the level parameters are determined to be within the acceptable limits at the time the control system 50 determined the sensed temperature was greater than the predetermined threshold for the predetermined period of time at block 178, the control circuitry of control system 50 can similarly cause the relay 68 to energize to provide an open circuit in the high temperature limit circuit 70 and can cause all heat sources to be turned off at block 214. The control system 50 can cause a fourth unique error code indicative of this fault condition to be displayed via monitor 32 for troubleshooting purposes. The control system 50 can also issue an audible alarm. In this second scenario, the fault condition can remain in a lock-out mode, as set forth at block 218, thereby preventing further operation of the cooling arrangement 12 and/or heat sources of refrigerator 10 until the lock-out mode is reset at block 222. In one exemplary configuration, the cooling arrangement 12 and/or heat sources can remain in the lock-out mode until a reset signal is received from the user interface 24. This control feature can also prevent operation of the cooling arrangement 12 at elevated temperatures and can indicate via the fourth error code that the fault condition could be due to a faulty cooling arrangement or unit 12.

[0040] While specific examples have been discussed in the specification and illustrated in the drawings, it will be understood by those skilled in the art that various changes may be made and equivalence may be substituted for elements thereof without departing from the scope of the present teachings. Furthermore, the mixing and matching of features, elements and/or functions between various examples may be expressly contemplated herein so that one skilled in the art would appreciate from the present teachings that features, elements and/or functions of one example may be incorporated into another example as appropriate, unless discussed otherwise above. Moreover, many modifications may be made to adapt a particular situation or material to the present teachings without departing from the essential scope thereof. Therefore, it may be intended that the present teachings not be limited to the particular examples illustrated by the drawings and discussed in the specification as the best mode of presently contemplated for carrying out the present teachings but that the scope of the present disclosure will include any embodiments following within the foregoing description and any appended claims.

Claims

1. A control system 50 for a refrigerator 10 having an absorption cooling arrangement 12 and a generator 18, the control system 50 including a temperature sensor 94 associated with the generator 18 and operable to sense a temperature of the cooling arrangement 12 proximate the generator 18 and a heat source operably associated with at least the generator 18, **characterized in that**:

    a level sensor 98 is associated with the refrigerator 10 and operable to sense a level condition of the cooling arrangement 12; and
    a control circuit in communication with at least the temperature sensor 94, the level sensor 98 and the heat source, the control circuit including a processor 62 and configured to determine a sensed temperature from the temperature sensor 94 and a sensed level condition from the level sensor 98 and configured to turn off the heat source based on determining the sensed temperature is below a first predetermined threshold or based at least in part on determining the sensed level condition exceeds a second predetermined threshold.

2. The system 50 of Claim 1, further comprising a user interface 24 associated with the refrigerator 10 and operably associated with the control circuit, the control circuit configured to cause the user interface 24 to display a first error code if the sensed temperature is below the first predetermined threshold and a second error code if the sensed level condition exceeds the second predetermined threshold.

3. The system 50 of Claim 1, wherein the control circuit further comprises a limit circuit 70 operably associated with at least a processor 62 and a relay 68, the control circuit configured to energize the relay 68 providing an electrically open circuit in the limit circuit 70 and cause the heat source to be turned off based on determining the sensed temperature is below the first predetermined threshold or based at least in part on determining the sensed level condition exceeds the second predetermined threshold.

4. The system 50 of Claim 3, wherein the control circuit is configured to monitor the limit circuit 70 to determine if an electrically open circuit condition exists in an absence of the relay 68 being energized and, if so, cause the heat source to be turned off.

5. The system 50 of Claim 3, wherein the control circuitry is configured to energize the relay 68 after a first predetermined period of time has elapsed since the control circuitry received a signal to initiate cooling and the sensed temperature is below the first predetermined threshold.

6. The system 50 of Claim 3, further comprising the control circuitry configured to energize the relay 68 and cause the heat source to be turned off after: a first predetermined time has elapsed since the control circuitry received a signal to initiate cooling; the sensed level condition is determined to exceed the second predetermined threshold; and the sensed temperature is determined to exceed a third predetermined threshold.

7. The system 50 of Claim 6, further comprising the control circuitry configured to determine whether the sensed temperature exceeds the third predetermined threshold before determining whether the

sensed level condition exceeds the second predetermined threshold.

8. The system 50 of Claim 6, further comprising the control circuitry configured to cause the heat source to be turned on after determining the sensed temperature is below a fourth predetermined threshold and after determining the sensed level condition is below the second predetermined threshold, wherein the fourth predetermined threshold is less than the third predetermined threshold.

9. The system 50 of Claim 1, wherein the first predetermined threshold includes a temperature of approximately 250 degrees Fahrenheit.

10. The system 50 of Claim 1, wherein the second predetermined threshold includes a range of approximately 5-6 degrees.

11. The system 50 of Claim 8, wherein the third predetermined threshold includes a temperature of approximately 430 degrees Fahrenheit.

12. The system 50 of Claim 1, further comprising the control circuitry configured to determine if the sensed temperature is outside of a predetermined normal operating range of the temperature sensor 94 and, if so, cause the heat source to be turned off until at least the sensed temperature is within the predetermined normal operating range.

13. The system 50 of Claim 1, wherein the heat source comprises a boiler tube 18, an alternating current heater 78, a direct current heater 86, or combinations thereof.

14. A method for controlling an absorption cooling arrangement 12 of a refrigerator 10 with the control system 50 of Claim 1, comprising:

determining if a predetermined period of time has elapsed since the cooling arrangement 12 received a signal to initiate cooling of the refrigerator 10;
sensing a temperature proximate the generator 18 after determining the predetermined period of time has elapsed;
comparing the sensed temperature to a predetermined temperature condition; and
selectively turning off the heat source operably associated with the cooling arrangement 12 based upon the comparison of the sensed temperature to the predetermined temperature condition.

15. The method of Claim 14, wherein comparing the sensed temperature includes determining if the sensed temperature is outside of a normal operating range of temperature sensor 94 used to sense the temperature; and
wherein selectively turning off the heat source occurs if the sensed temperature is determined to be outside of the normal operating range.

16. The method of Claim 14, wherein comparing the sensed temperature includes determining if the sensed temperature is below a predetermined threshold; and
wherein selectively turning off a heat source occurs if the sensed temperature is determined to be below the predetermined threshold.

17. The method of Claim 14, wherein comparing the sensed temperature includes determining if the sensed temperature is greater than a first predetermined threshold and, if so, sensing a level condition of the cooling arrangement 12 and determining if the level condition exceeds a second predetermined threshold.

18. The method of Claim 17, further comprising:

turning off the heat source upon determining the level condition does not exceed the second predetermined threshold;
providing an error code to a user interface 24 indicative of the sensed temperature being greater than the first predetermined threshold; and
activating a lock-out mode where the heat source remains turned off until the error code is reset.

19. The method of Claim 17, further comprising:

turning off the heat source upon determining the level condition exceeds the second predetermined threshold;
providing an error code to a user interface 24 indicative of the sensed temperature and the sensed level condition of the cooling arrangement 12 being greater than the respective first and second predetermined thresholds;
monitoring the temperature proximate the generator 18 and the level condition of the cooling arrangement 12; and
turning on the heat source upon determining the sensed temperature and the sensed level condition are below the respective first and second predetermined thresholds.

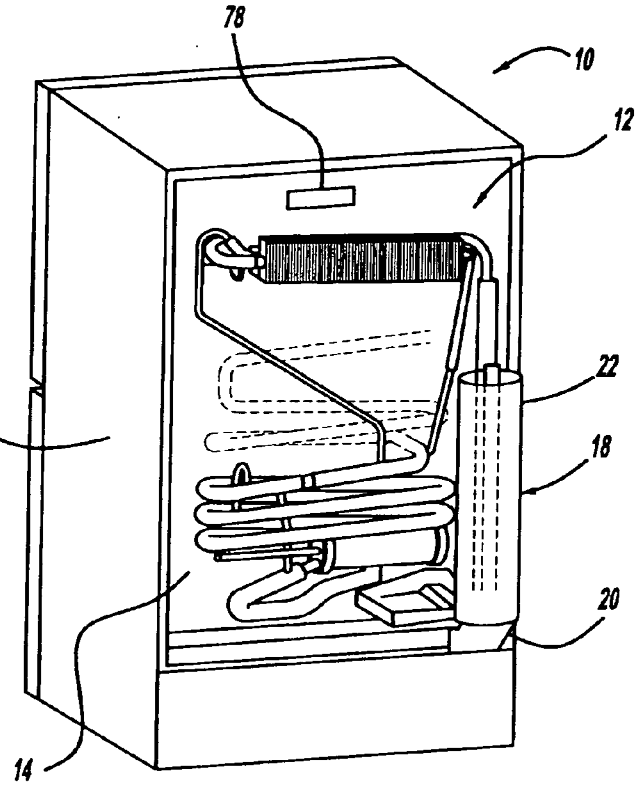
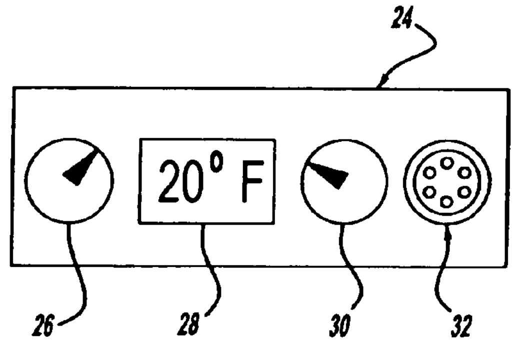


FIG - 1

FIG - 2



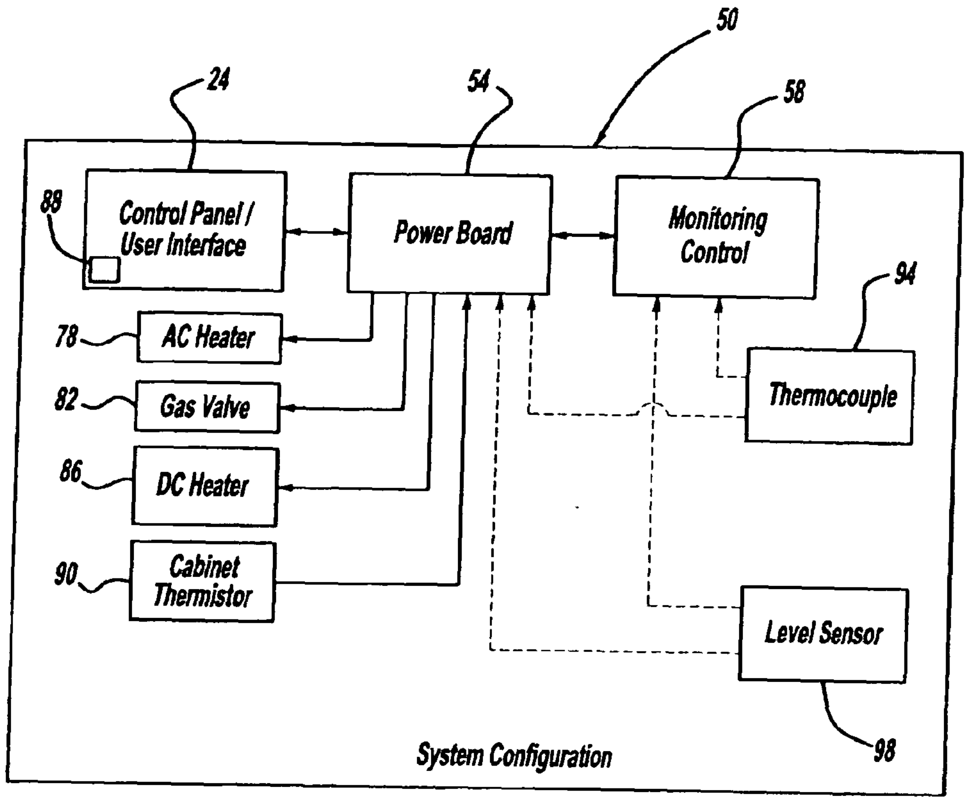
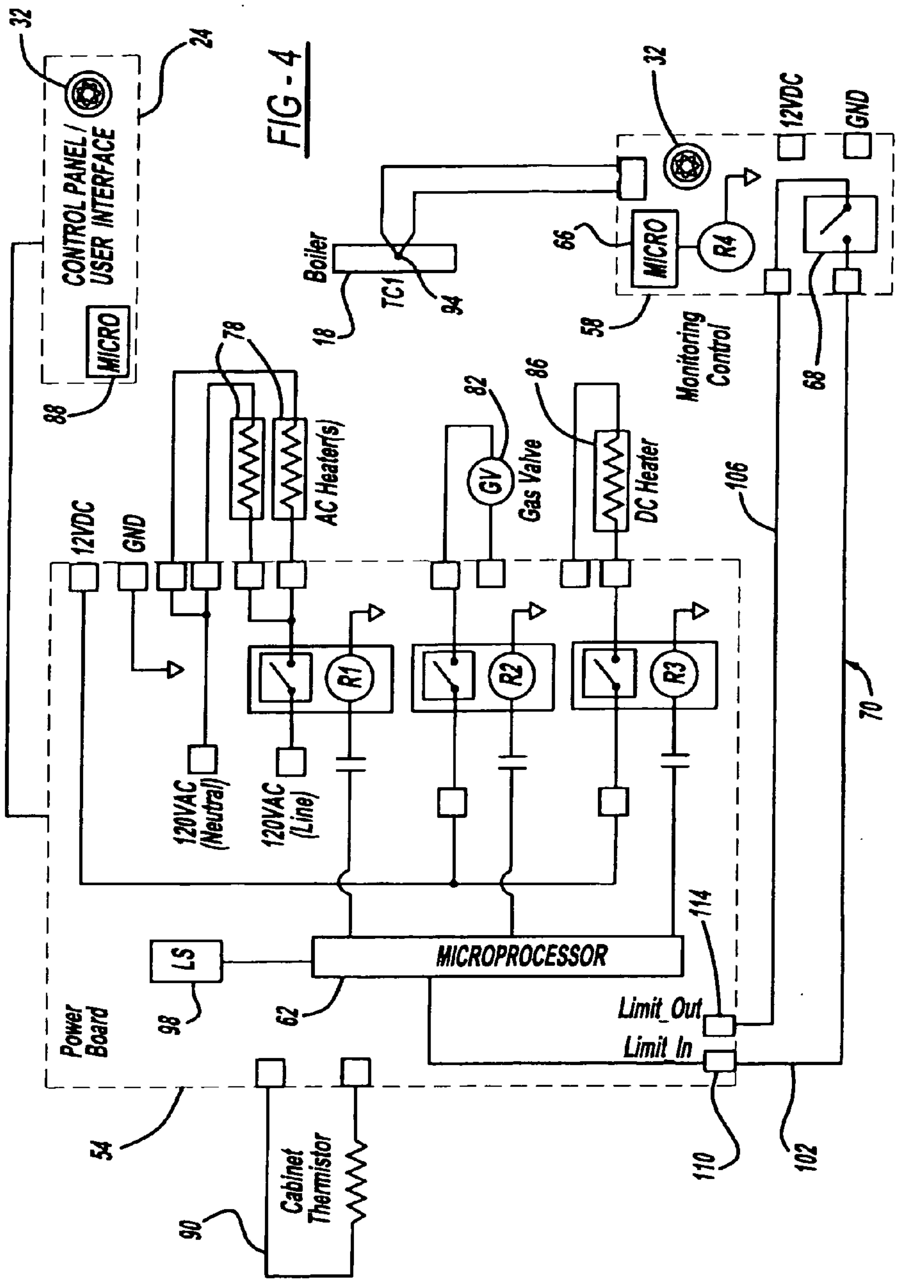

50
24
54
58
88
Control Panel / User Interface
Power Board
Monitoring Control
94
78
AC Heater
82
Gas Valve
Thermocouple
86
DC Heater
90
Cabinet Thermistor
Level Sensor
98
System Configuration

FIG - 3


32
24
CONTROL PANEL / USER INTERFACE
MICRO
88
32
Boiler
18
TC1
94
66
MICRO
R4
58
Monitoring Control
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GND
68
78
AC Heater(s)
82
GV
Gas Valve
86
DC Heater
106
12VDC
GND
R1
R2
R3
120VAC (Neutral)
120VAC (Line)
70
LS
98
MICROPROCESSOR
62
114
Limit_Out
Limit_In
Power Board
54
110
102
Cabinet Thermistor
90

FIG - 4

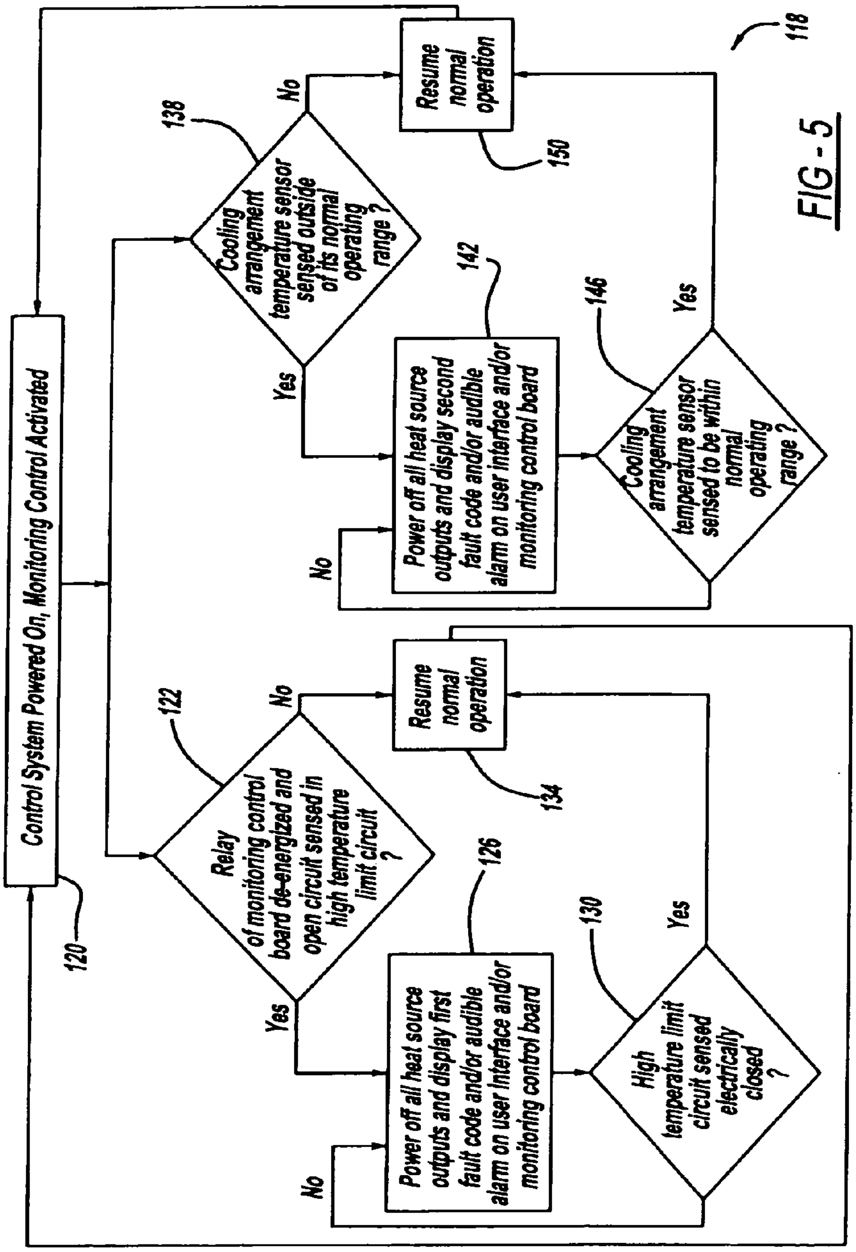
Control System Powered On, Monitoring Control Activated
120
Relay of monitoring control board de-energized and open circuit sensed in high temperature limit circuit ?
122
Yes
No
Power off all heat source outputs and display first fault code and/or audible alarm on user interface and/or monitoring control board
126
High temperature limit circuit sensed electrically closed ?
130
Yes
No
Resume normal operation
134
Cooling arrangement temperature sensor sensed outside of its normal operating range ?
138
Yes
No
Power off all heat source outputs and display second fault code and/or audible alarm on user interface and/or monitoring control board
142
Cooling arrangement temperature sensor sensed to be within normal operating range ?
146
Yes
No
Resume normal operation
150
118

FIG - 5

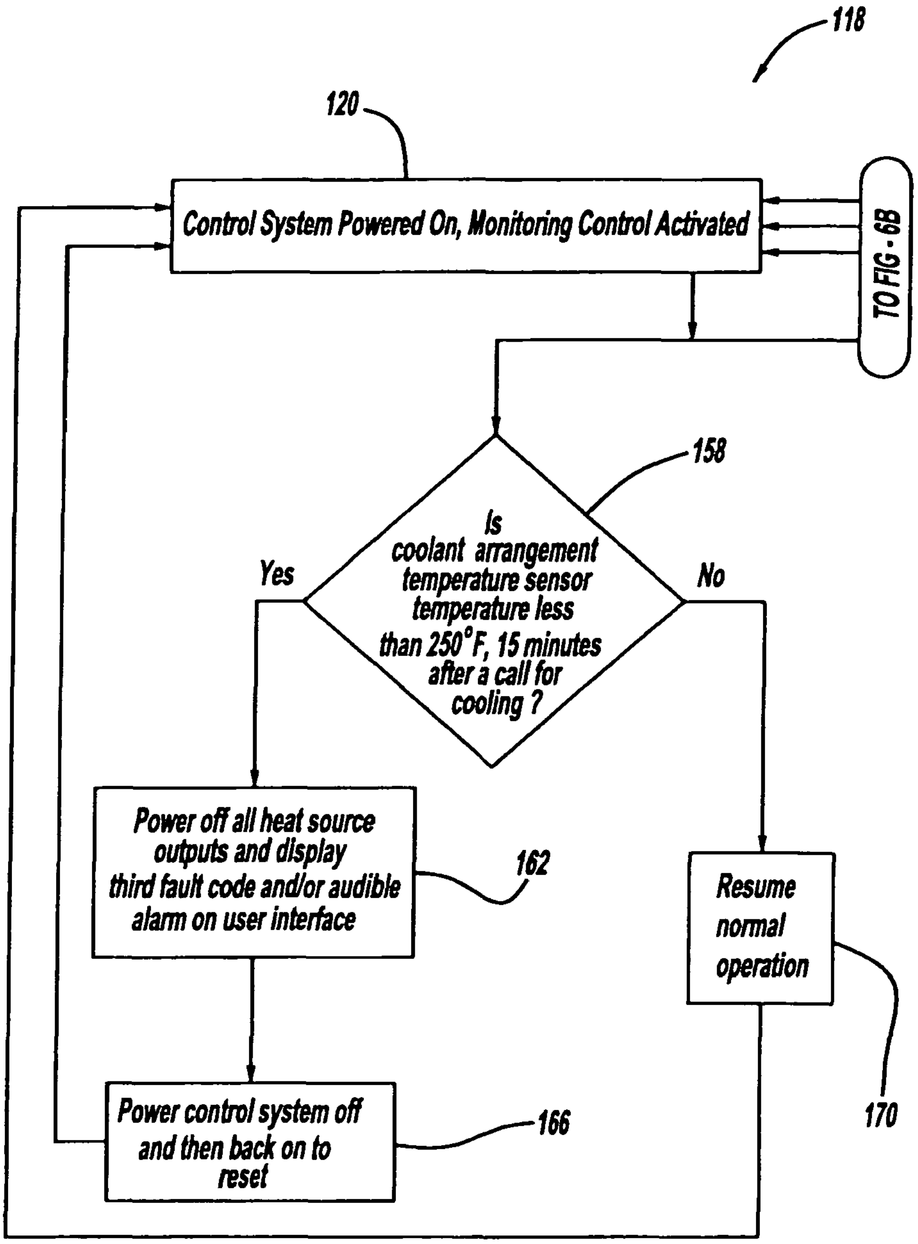
118
120
Control System Powered On, Monitoring Control Activated
TO FIG - 6B
158
Is coolant arrangement temperature sensor temperature less than 250°F, 15 minutes after a call for cooling ?
Yes
No
Power off all heat source outputs and display third fault code and/or audible alarm on user interface
162
Resume normal operation
170
Power control system off and then back on to reset
166

FIG - 6A

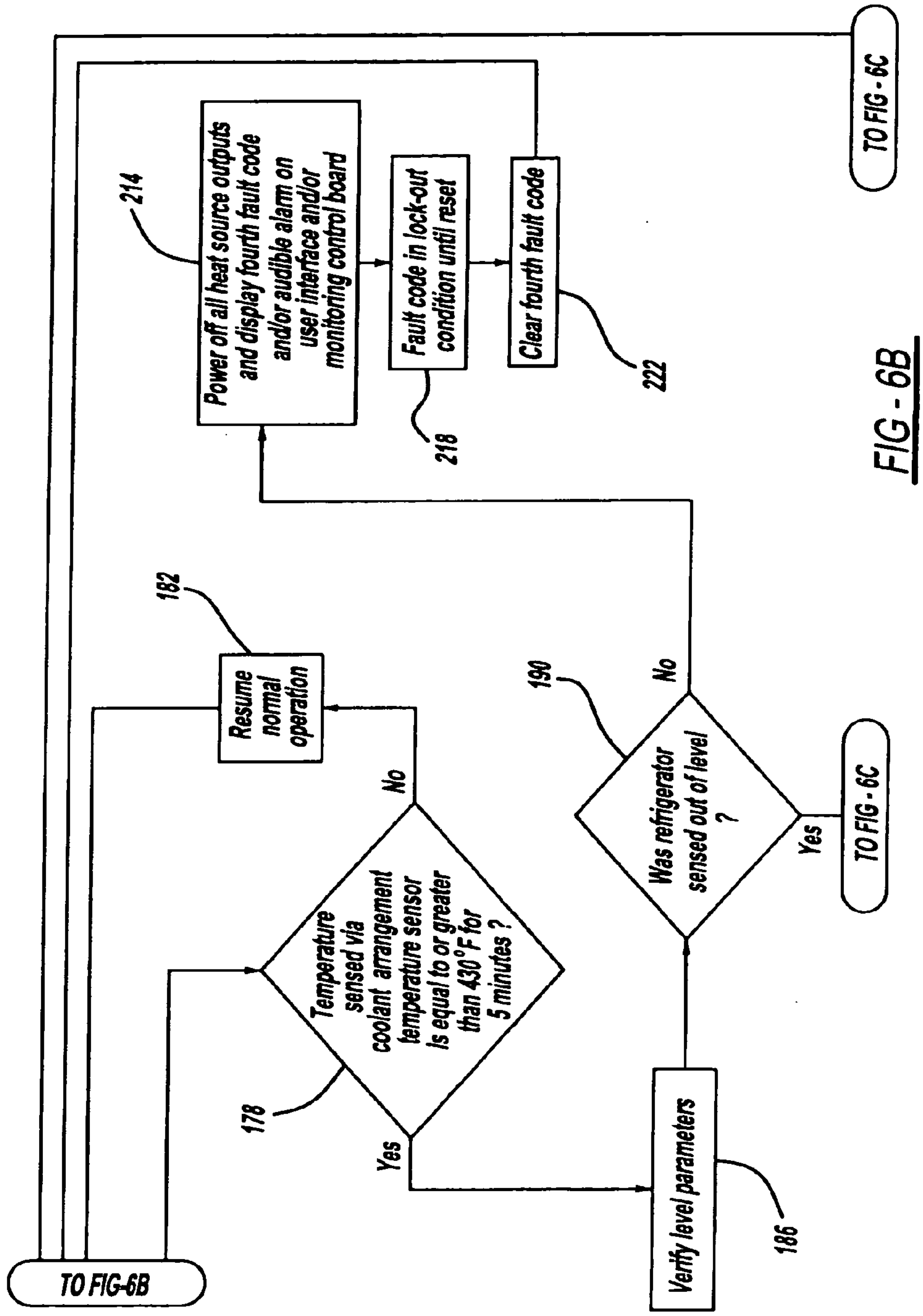
TO FIG-6B
178
Temperature sensed via coolant arrangement temperature sensor Is equal to or greater than 430°F for 5 minutes ?
No
Yes
182
Resume normal operation
186
Verify level parameters
190
Was refrigerator sensed out of level ?
No
Yes
TO FIG - 6C
214
Power off all heat source outputs and display fourth fault code and/or audible alarm on user interface and/or monitoring control board
218
Fault code in lock-out condition until reset
222
Clear fourth fault code
TO FIG - 6C

FIG - 6B

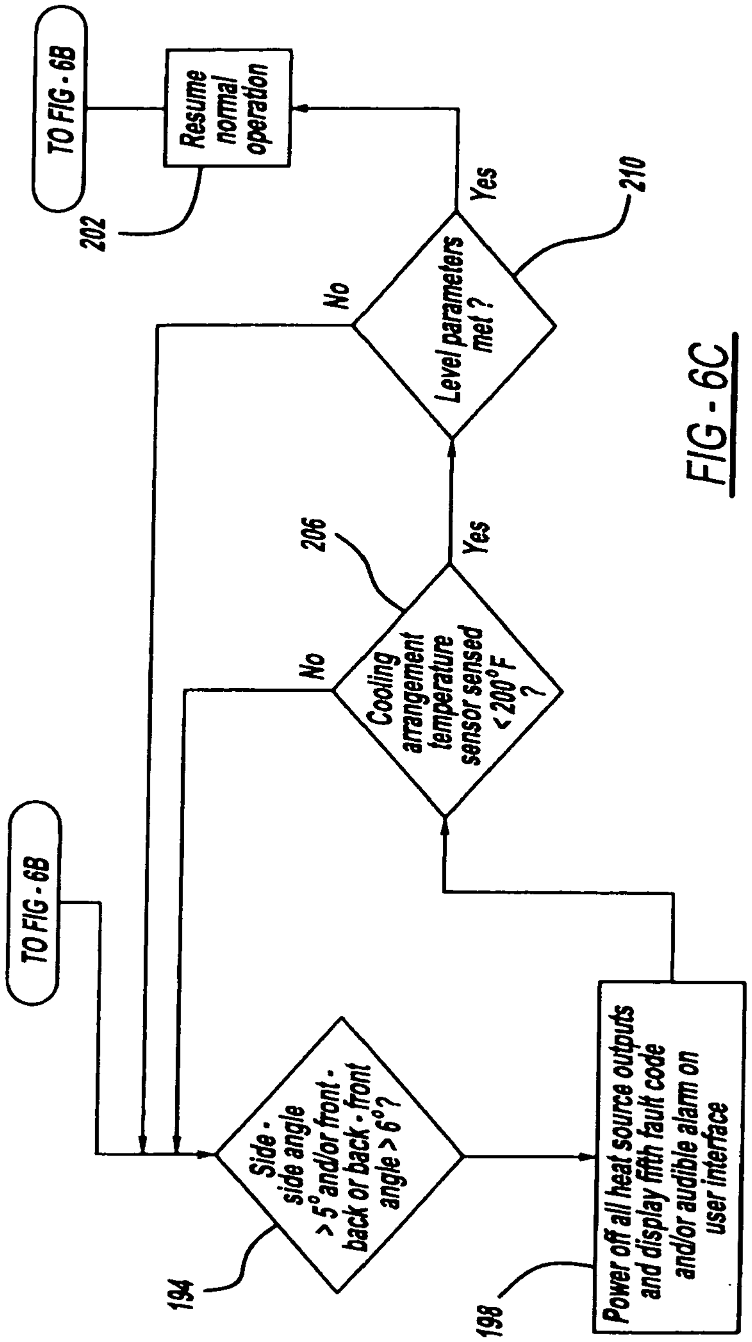
TO FIG - 6B
Side - side angle > 5° and/or front - back or back - front angle > 6°?
194
Power off all heat source outputs and display fifth fault code and/or audible alarm on user interface
198
Cooling arrangement temperature sensor sensed < 200°F ?
206
No
Yes
Level parameters met ?
210
No
Yes
Resume normal operation
202
TO FIG - 6B

FIG - 6C

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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