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(54) **System and method for detecting a switching device malfunction**

System und Verfahren zur Erkennung einer Schaltvorrichtungfehlfunktion

Système et procédé de détection d'un dysfonctionnement de dispositif de commutation

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Description

FIELD

[0001] The present invention relates to a method and system for detecting a fault condition, and in particular to a method and system for detecting a fault condition of a switching device.

BACKGROUND

[0002] In safety related systems, when a safety input to a safety controller is activated the controller must bring the system to a safe state. This is typically done by removing power from the process by opening a relay. Many machine safety standards require that in the event of a single fault condition the safety function must still operate. This means there must be redundant relays so that power can be removed even if one of the relays contacts weld. An additional requirement of many machine safety standards is that a single fault condition must be detected so that cumulative faults do not occur. For example, if one of the relays contacts welds the system could still operate using the other relay but if the contacts of the other relay may eventually weld thereby rendering the safety function ineffective.

[0003] Previously, detecting stuck relay contacts in this situation was done using special relays with auxiliary normally closed mirror contacts that can only close if all power contacts have opened. A drawback to this approach is that the mirror contacts could also stick so they are required to be a pair of positively-driven normally open and normally closed contacts. Positively-driven contacts can never be simultaneously open or closed. The mirror contacts are used as inputs to the safety controller to detect stuck contacts. The special relays with auxiliary normally closed mirror contacts required to meet the fault detection requirements are expensive. Document US 2007/035903 discloses a method according to the preamble of claim 1.

SUMMARY

[0004] In an exemplary embodiment of the present disclosure, a method for detecting a malfunction of a switching device is provided. In another exemplary embodiment of the present disclosure, a method of controlling a controlled device with a plurality of switching devices coupled together in series is provided. In yet another exemplary embodiment of the present disclosure, a system for detecting a malfunction of a relay is provided. In another exemplary embodiment of the present disclosure, a system which controls a controlled device with a plurality of switching devices coupled together in series is provided.

[0005] In a exemplary embodiment of the present disclosure, a method of controlling the provision of power from a power source to a controlled device is provided. The method comprising the step of providing a plurality

of switching devices in series between the power source and the controlled device. Each of the switching devices having an open state and a closed state. In the closed state power is able to pass through the respective switching device and in the open state power is not able to pass through the respective switching device. The method further comprising the steps of placing all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a first operation of the controlled device; placing a first switching device of the plurality of switching devices in an open state to end the first operation of the controlled device; monitoring if power is still being provided to the controlled device which would indicate that the first switching device is faulty; placing all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a second operation of the controlled device; placing a second switching device of the plurality of switching devices in an open state to end the second operation of the controlled device; and monitoring if power is still being provided to the controlled device which would indicate that the second switching device is faulty. In one example, the method further comprising the step indicating a fault condition when power is detected as being provided to the controlled device in certain of the above-identified steps. In another example, the step of placing all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a first operation of the controlled device is performed in response to receiving a first action signal from a controlling device. In yet another example, the step of monitoring if power is still being provided to the controlled device which would indicate that the first switching device is faulty includes the step of monitoring if a current is flowing from the power source to the controlled device. In a further example, certain of the above-identified steps are performed automatically by a controller. In a variation thereof, the controller performs an initial check of the plurality of switching devices. In a further variation thereof, the initial check includes the steps of for each of the plurality of switching devices: placing the respective switching device in an open state while the remainder of the plurality of switching devices are in a closed state; and monitoring if power is being provided to the controlled device which would indicate that the respective switching device is faulty. In another variation, the controller changes the state of the plurality of switching devices based on an action signal received from a controlling device. In a further variation thereof, the controlled device is a pump in an underground fuel storage tank and the controlling device is a dispenser which is in fluid communication with the pump of the underground storage tank. In still another example, the above-identified steps are performed in a sequential order.

[0006] In yet another exemplary embodiment, an apparatus for controlling the provision of power from a power source to a controlled device is provided. The appa-

ratus comprising a controller; and a plurality of switching devices in series between the power source and the controlled device. The plurality of switching devices being operatively coupled to the controller, each of the switching devices having an open state and a closed state. In the closed state power is able to pass through the respective switching device and in the open state power is not able to pass through the respective switching device. The apparatus further comprising at least one sensor monitoring the provision of power from the power source to the controlled device. The controller places all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a first operation of the controlled device; places a first switching device of the plurality of switching devices in an open state to end the first operation of the controlled device; monitors with the at least one sensor if power is still being provided to the controlled device which would indicate that the first switching device is faulty; places all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a second operation of the controlled device; places a second switching device of the plurality of switching devices in an open state to end the second operation of the controlled device; and monitors with the at least one sensor if power is still being provided to the controlled device which would indicate that the second switching device is faulty. In one example, the controller indicates a fault condition when power is detected as being provided to the controlled device when one of the plurality of switching devices is supposed to be in an open state. In another example, the controller changes the state of the plurality of switching devices based on an action signal received from a controlling device. In yet another example, the at least one sensor is a current sensor and the controller determines if power is being provided to the controlled device based on a current sensed by the current sensor. In still another example, the controller performs an initial check of the plurality of switching devices by for each of the plurality of switching devices: placing the respective switching device in an open state while the remainder of the plurality of switching devices are in a closed state; and monitoring with the at least one sensor if power is being provided to the controlled device which would indicate that the respective switching device is faulty. In still another example, the controlled device is a pump in an underground fuel storage tank and the controlling device is a dispenser which is in fluid communication with the pump of the underground storage tank.

[0007] In yet another exemplary embodiment of the present disclosure, a fuel dispensing system coupled to a power source is provided. The fuel dispensing system comprising: an underground fuel storage tank adapted to store fuel in an interior thereof; a dispenser including at least one fuel dispensing point, the at least one fuel dispensing point of the dispenser being in fluid communication with the underground fuel storage tank; a pump

positioned in the underground fuel storage tank to pump fuel from the underground fuel storage tank, the pump including a pump motor; and a control system which activates the pump motor to pump fuel from the interior of the underground fuel storage tank to a first dispensing point for a plurality of operations. The control system including a controller and a plurality of switching devices in series between the power source and the pump motor. The plurality of switching devices being operatively coupled to the controller. Each of the switching devices having an open state and a closed state. In the closed state power is able to pass through the respective switching device and in the open state power is not able to pass through the respective switching device. The control system further includes at least one sensor monitoring the provision of power from the power source to the pump motor. The controller: placing all of the switching devices in the closed state when power is requested to be provided to the pump motor to commence a first operation of the pump motor; placing a first switching device of the plurality of switching devices in an open state to end the first operation of the pump motor; monitoring with the at least one sensor if power is still being provided to the pump motor which would indicate that the first switching device is faulty; placing all of the switching devices in the closed state when power is requested to be provided to the pump motor to commence a second operation of the pump motor; placing a second switching device of the plurality of switching devices in an open state to end the second operation of the pump motor; and monitoring with the at least one sensor if power is still being provided to the pump motor which would indicate that the second switching device is faulty. In one example, the plurality of switching devices are relays. In another example, power is requested to be provided to the pump motor to commence the first operation when a hook signal is received from the dispenser. In yet another example, the controller indicates a fault condition when power is detected as being provided to the pump motor when one of the plurality of switching devices is supposed to be in an open state.

[0008] Additional features and advantages of the present invention will become apparent to those skilled in the art upon consideration of the following detailed description of illustrative embodiments exemplifying the best mode of carrying out the invention as presently perceived.

BRIEF DESCRIPTION OF THE DRAWING

[0009] The above-mentioned and other features of the invention, and the manner of attaining them, will become more apparent and will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

[0010] FIG. 1 illustrates a system for controlling a controlled device based on input from a controlling device;

[0011] FIG. 2 illustrates an exemplary processing sequence of the system for controlling the controlled device of FIG. 1 based on input from the controlling device of FIG. 1; and

[0012] FIG. 3 illustrates the system of FIG. 1 incorporated into a fuel dispensing system for controlling a submersible pump motor of the fuel dispensing system based on input from the dispenser of the fuel dispensing system.

[0013] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate embodiments of the disclosure and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE DRAWINGS

[0014] Referring to FIG. 1, a control system 100 is shown. Control system 100 receives an action signal 102 from a controlling device 104. Based on the action signal, the control system 100 controls the provision of power 106 from a power source 108 to a controlled device 110.

[0015] The control system 100 includes at least one switching device 112 which have a first configuration wherein the power signal 106 is not provided to controlled device 110 and a second configuration wherein power signal 106 is provided to controlled device 110. Exemplary switching devices include relays. An exemplary relay is Model No. PBC-012 available from Tyco Electronics/Potter & Brumfield.

[0016] Control system 100 includes a controller 120. Controller 120 is operatively coupled to the at least one switching devices 112. In the illustrated embodiment, controller 120 is operatively coupled to a first relay 122 and a second relay 124. Each of first relay 122 and second relay 124 have a first configuration wherein power signal 106 is not provided to controlled device 110, referred to herein as an open state, and a second configuration wherein power signal 106 is provided to controlled device 110, referred to herein as a closed state. In one embodiment, controller 120 places first relay 122 in a closed state by applying a voltage to line 123 and places first relay 122 in an open state by not applying a voltage to line 123. In one embodiment, controller 120 places second relay 124 in a closed state by applying a voltage to line 125 and places second relay 124 in an open state by not applying a voltage to line 125.

[0017] Controller 120 is further operatively coupled to at least one sensor 130 which monitors the provision of power to controlled device 110 from power source 108. In the illustrated embodiment, at least one sensor 130 is a current sensor 132.

[0018] In one embodiment, controller 120 includes a processor having access to a memory 140. Memory 140 includes relay control software 142. The relay control software 142 monitors the operation of first relay 122 and second relay 124. Memory 140 is a computer readable

medium and may be a single storage device or may include multiple storage devices, located either locally with controller 120 or accessible across a network. Computer-readable media may be any available media that may be accessed by controller 120 and includes both volatile and non-volatile media. Further, computer readable-media may be one or both of removable and non-removable media. By way of example, computer-readable media may include, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, Digital Versatile Disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which may be used to store the desired information and which may be accessed by controller 120. The processor of controller 120 executes relay control software 142 to control the operation of first relay 122 and second relay 124. In one embodiment, controller 120 includes circuitry which functions to operate in the same manner as relay control software 142 or at least part of relay control software 142. In one embodiment, controller 120 is a circuit.

[0019] If one of first relay 122 and second relay 124 malfunctions, controller 120 provides an indication of the failure to an alarm device 148. Exemplary alarm devices include audio devices and visual devices. Exemplary audio devices include speakers, buzzers, and other suitable audio devices. Exemplary video devices include lights, a computer display, and other suitable video devices.

[0020] Referring to FIG. 2, an exemplary processing sequence 200 of relay control software 142 is provided. As mentioned herein, in one embodiment, controller 120 is implemented as a circuit. In this case, the processing sequence 200 of FIG. 2 describes the operation of the circuit.

[0021] In processing sequence 200, at power on or reset of control system 100, controller 120 performs an initial check of the functionality of first relay 122 and second relay 124. Thereafter, controller 120 checks the functionality of first relay 122 and second relay 124 in the absence of an action signal 102.

[0022] At power on or reset of control system 100, controller 120 closes first relay 122 and opens second relay 124, as represented by block 202. Controller 120 by monitoring current sensors 132 determines if a current is passing from power source 108 to controlled device 110, as represented by block 204. Since second relay 124 is supposed to be in an open state, no current should be passing from power source 108 to controlled device 110. If a current is detected by current sensors 132, controller 120 determines that second relay 124 is stuck in a closed state and opens relay 122 to prevent further current passing from power source 108 to controlled device 110, as represented by block 206. As is known, second relay 124 may become stuck in a closed state when its contacts weld together. Controller 120 also indicates that control system 100 is in a fault state, as represented by block 208.

[0023] In one embodiment, when controller 120 determines that control system 100 is in a fault state, controller 120 provides a signal to alarm device 148 of the fault state. Alarm device 148 notifies an operator of the fault state. In one embodiment, red lights flash to indicate a faulty relay and a buzzer is sounded. In one embodiment, controller 120 also provides an indication that it is second relay 124 which is causing the fault state. In one example, this is done by flashing a light which is specific to second relay 124.

[0024] In one embodiment, controller 120 also prohibits the closing of first relay 122 until the fault state is cleared and control system 100 is reset. In one embodiment, controller 120 permits the closing of first relay 122 during a fault state based on a malfunction of second relay 124 when an action signal 102 is received by control system 100. In this manner, control system 100 has notified the operator of the fault state and still permits the operation of controlled device 110 while the fault state of control system 100 is being addressed.

[0025] If a current is not detected at block 204, controller 120 cycles first relay 122 and second relay 124 by opening first relay 122 and closing second relay 124, as represented by block 210. Controller 120 by monitoring current sensors 132 determines if a current is passing from power source 108 to controlled device 110, as represented by block 212. Since first relay 122 is supposed to be in an open state, no current should be passing from power source 108 to controlled device 110. If a current is detected by current sensors 132, controller 120 determines that first relay 122 is stuck in a closed state and opens relay 124 to prevent further current passing from power source 108 to controlled device 110, as represented by block 214. As is known, first relay 122 may become stuck in a closed state when its contacts weld together. Controller 120 also indicates that control system 100 is in a fault state, as represented by block 208.

[0026] As mentioned above, in one embodiment, when controller 120 determines that control system 100 is in a fault state, controller 120 provides a signal to alarm device 148 of the fault state. Alarm device 148 notifies an operator of the fault state by any of the indications provided herein. In one embodiment, controller 120 also provides an indication that it is first relay 122 which is causing the fault state.

[0027] In one embodiment, controller 120 also prohibits the closing of second relay 124 until the fault state is cleared and control system 100 is reset. In one embodiment, controller 120 permits the closing of second relay 124 during a fault state based on a malfunction of first relay 122 when an action signal 102 is received by control system 100. In this manner, control system 100 has notified the operator of the fault state and still permits the operation of controlled device 110 while the fault state of control system 100 is being addressed.

[0028] If a current is not detected at block 212, controller 120 has determined that both first relay 122 and second relay 124 are operating correctly. Since first relay

122 is in an open state, no current is passing from power source 108 to controlled device 110. Controller 120 checks to see if an action signal 102 has been received, as represented by block 216. In one embodiment, controller 120 is simply monitoring a voltage on a line and based on that voltage makes a determination of whether there is an action signal 102 or not. For example, a low voltage may correspond to no action signal while a high voltage corresponds to an action signal. Instead of a voltage, controller 120 may monitor a current, a frequency, or any other suitable characteristic that may be used as a signal. In one embodiment, controller 120 receives one or more conventional message packets over a network from a controller of the controlling device 104 which are interpreted as an action signal 102 or the cancellation of an earlier action signal.

[0029] As long as an action signal 102 has not been received, controller 120 maintains first relay 122 and second relay 124 in their current state. When an action signal 102 is received, controller 120 closes first relay 122, as represented by block 218. By closing first relay 122, both first relay 122 and second relay 124 are closed and power is provided from power source 108 to controlled device 110. This corresponds to the commencement of a first operation with the controlled device 110.

[0030] Power is provided to controlled device 110 until action signal 102 is no longer present, as represented by block 220. In the case wherein, controller 120 is monitoring a voltage on a line as long as the voltage is indicative of the action signal power is provided from power source 108 to controlled device 110. As stated above, instead of a voltage, controller 120 may monitor a current, a frequency, or any other suitable characteristic that may be used as a signal. In the case wherein the action signal is communicated to controller 120 as a conventional message packet, the action signal is present until another message is received cancelling the action signal.

[0031] In one embodiment, controller 120 simply places first relay 122 back in an open state when the action signal 102 is no longer present. In the illustrated embodiment, controller 120 cuts power to controlled device 110 by placing in an open state the one of first relay 122 and second relay 124 which was not the last to be closed. In the present example this is second relay 124. As such, controller 120 opens second relay 124, as represented by block 222. In this manner, controller 120 is balancing the switching of first relay 122 and second relay 124. Block 222 corresponds to the ending of the first operation with the controlled device 110.

[0032] Once controller 120 has placed second relay 124 be in the open state, controller 120 by monitoring current sensors 132 determines if a current is passing from power source 108 to controlled device 110, as represented by block 224. Since second relay 124 is supposed to be in an open state, no current should be passing from power source 108 to controlled device 110. If a current is detected by current sensors 132, controller 120 determines that second relay 124 is stuck in a closed

state and opens relay 122 to prevent further current passing from power source 108 to controlled device 110, as represented by block 226. Controller 120 also indicates that control system 100 is in a fault state, as represented by block 208, and discussed above.

[0033] If a current is not detected at block 224, controller 120 has determined that both first relay 122 and second relay 124 are still operating correctly. Since second relay 124 is in an open state, no current is passing from power source 108 to controlled device 110. Controller 120 checks to see if an action signal 102 has been received, as represented by block 228. As long as an action signal 102 has not been received, controller 120 maintains first relay 122 and second relay 124 in their current state. When an action signal 102 is received, controller 120 closes second relay 124, as represented by block 230. By closing second relay 124, both first relay 122 and second relay 124 are closed and power is provided from power source 108 to controlled device 110. This corresponds to the commencement of a second operation with the controlled device 110.

[0034] Power is provided to controlled device 110 until action signal 102 is no longer present, as represented by block 232. In order to continue to balance the switching of first relay 122 and second relay 124, controller 120 cuts power to controlled device 110 by placing first relay 122 in an open state, as represented by block 234. Block 234 corresponds to the ending of the second operation with the controlled device 110. Control then passes back up to between blocks 210 and 212 wherein controller 120 checks to see if a current is detected at block 212.

[0035] Controller 120 continues to switch which one of first relay 122 and second relay 124 is opened in response to the absence of action signal 102 during operation of control system 100. Although two relays, first relay 122 and second relay 124, are illustrated, in one embodiment control system 100 may include three or more relays in series. In such a case, controller 120 would cycle through each relay of the multiple relays to balance the switching of each of the relays.

[0036] Referring to FIG. 3, control system 100 is shown as part of a fuel dispensing system 300, such as one for use at a conventional retail gasoline station. The fuel dispensing system 300 includes multiple fuel dispensers 302 (only one illustrated), each having one or more dispensing points 304. Each dispensing point 304 includes a hose 306 and a nozzle 308, for dispensing fuel from a storage tank 310. The nozzle 308 may be a Healy 900 Series EVR/ORVR nozzle, sold by Franklin Fueling Systems, Inc., of Madison, WI.

[0037] As illustrated, storage tank 310 is an underground storage tank. Storage tank 310 may also be positioned above ground. Storage tank 310 is filled with fuel 312 through a fuel pipe (not shown). Fuel dispensing system 300 also includes a fuel delivery system 320 for transferring fuel 312 from storage tank 310 to each of dispensers 304. The fuel delivery system 320 includes a fuel supply line 332 to provide a common conduit for fuel de-

livery from storage tank 310 to a branch fuel line 334 associated with a respective one of dispensers 302.

[0038] A pump 340 is provided in storage tank 310 to pump fuel 312 through fuel supply line 332 to dispensing point 304 when requested. Pump 340 includes a pump motor 342 which powers the pump 340 as needed. Pump motor 342 is one example of the controlled device 110 for control system 100. Dispenser 302 is one example of the controlling device 104 for control system 100.

[0039] When a user at dispenser 302 removes nozzle 308 from dispenser 302 a switch 350 is closed. The closing of the switch 350 is a hook signal. The hook signal corresponds to the action signal 102 received by controller 120. In one embodiment, switch 350 is closed in response to the user removing nozzle 308 from dispenser 302. In one embodiment, switch 350 is closed in response to when the user lifts or rotates a handle or lever or provides some other input at dispenser 302. Switch 350 is opened again when fueling is complete. In one embodiment, switch 350 is opened again when nozzle 308 is cradled in dispenser 302. In one embodiment, switch 350 is opened again when the user moves the handle or lever or provides some other input at dispenser 302.

[0040] As illustrated in FIG. 3, two lines 354 run from dispenser 302 to controller 120. In one embodiment, controller 120 monitors a voltage relative to lines 354 to determine if switch 350 is closed or opened. In one embodiment, when dispenser 302 includes a controller (not shown), dispenser 302 provides a message to control system 100 to indicate when a given dispensing point 304 is activated for pumping fuel or not.

[0041] Power source 108 in fuel dispensing system 300 is a three phase power source 360. Three phase power source 360 has three output lines 362A-C each of which when connected with pump motor 342 provide power to pump motor 342. Lines 362A-C are connected to first relay 122 which is connected in series to second relay 124. Second relay 124 is in turn connected to three lines 364A-C which are connected to pump motor 342. The current passing along lines 362A-C is monitored by current sensors 366A-C. In one embodiment, the current passing along lines 366A-C is monitored by current sensors 366A-C. Exemplary relays for use with three phase power source 360 are PBC-012 available from Tyco Electronics/Potter & Brumfield..

Claims

1. A method of controlling the provision of power from a power source to a controlled device, the method comprising the steps of:

(a) providing a plurality of switching devices in series between the power source and the controlled device, each of the switching devices having an open state and a closed state, in the closed state power is able to pass through the

- respective switching device and in the open state power is not able to pass through the respective switching device;
- (b) placing all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a first operation of the controlled device;
- (c) placing a first switching device of the plurality of switching devices in an open state to end the first operation of the controlled device;
- (d) monitoring if power is still being provided to the controlled device which would indicate that the first switching device is faulty; **characterised by**
- (e) placing all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a second operation of the controlled device;
- (f) placing a second switching device of the plurality of switching devices in an open state to end the second operation of the controlled device; and
- (g) monitoring if power is still being provided to the controlled device which would indicate that the second switching device is faulty.
2. The method of claim 1, further comprising the step indicating a fault condition when power is detected as being provided to the controlled device in one of step (d) or step (g).
 3. The method of claim 1, wherein step (b) is performed in response to receiving a first action signal from a controlling device.
 4. The method of claim 1, wherein step (d) includes the step of monitoring if a current is flowing from the power source to the controlled device.
 5. The method of claim 1, wherein steps (b)-(g) are performed automatically by a controller.
 6. The method of claim 5, wherein the controller performs an initial check of the plurality of switching devices prior to steps (b)-(g).
 7. The method of claim 6, wherein the initial check includes the steps of for each of the plurality of switching devices:
 - placing the respective switching device in an open state while the remainder of the plurality of switching devices are in a closed state; and
 - monitoring if power is being provided to the controlled device which would indicate that the respective switching device is faulty.
 8. The method of claim 5, wherein the controller chang-

es the state of the plurality of switching devices based on an action signal received from a controlling device.

9. The method of claim 8, wherein the controlled device is a pump in an underground fuel storage tank and the controlling device is a dispenser which is in fluid communication with the pump of the underground storage tank.
10. The method of claim 1, wherein steps (a)-(g) are performed in a sequential order.
11. An apparatus for controlling the provision of power from a power source to a controlled device, the apparatus comprising:

a controller (120),
 a plurality of switching devices (122, 124) in series between the power source (360) and the controlled device, the plurality of switching devices being operatively coupled to the controller, each of the switching devices having an open state and a closed state, in the closed state power is able to pass through the respective switching device and in the open state power is not able to pass through the respective switching device; and
 at least one sensor (132) monitoring the provision of power from the power source to the controlled device, wherein the controller:

places all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a first operation of the controlled device;
 places a first switching device of the plurality of switching devices in an open state to end the first operation of the controlled device;
 monitors with the at least one sensor if power is still being provided to the controlled device which would indicate that the first switching device is faulty;
 places all of the switching devices in the closed state when power is requested to be provided to the controlled device to commence a second operation of the controlled device;
 places a second switching device of the plurality of switching devices in an open state to end the second operation of the controlled device; and
 monitors with the at least one sensor if power is still being provided to the controlled device which would indicate that the second switching device is faulty.

12. The apparatus of claim 11, wherein the controller indicates a fault condition when power is detected as being provided to the controlled device when one of the plurality of switching devices is supposed to be in an open state. 5
13. The apparatus of claim 11, wherein the controller changes the state of the plurality of switching devices based on an action signal received from a controlling device. 10
14. The apparatus of claim 11, wherein the at least one sensor is a current sensor and the controller determines if power is being provided to the controlled device based on a current sensed by the current sensor. 15
15. The apparatus of claim 11, wherein the controller performs an initial check of the plurality of switching devices by for each of the plurality of switching devices: 20
- placing the respective switching device in an open state while the remainder of the plurality of switching devices are in a closed state; and 25
- monitoring with the at least one sensor if power is being provided to the controlled device which would indicate that the respective switching device is faulty. 30
16. The apparatus of claim 11, wherein the controlled device is a pump in an underground fuel storage tank and the controlling device is a dispenser which is in fluid communication with the pump of the underground storage tank. 35
17. A fuel dispensing system coupled to a power source, comprising: 40
- an underground fuel storage tank adapted to store fuel in an interior thereof;
- a dispenser including at least one fuel dispensing point, the at least one fuel dispensing point of the dispenser being in fluid communication with the underground fuel storage tank; 45
- a pump positioned in the underground fuel storage tank to pump fuel from the underground fuel storage tank, the pump including a pump motor; and
- a control system which activates the pump motor to pump fuel from the interior of the underground fuel storage tank to a first dispensing point for a plurality of operations, the control system including 50
- a controller; 55
- a plurality of switching devices in series between the power source and the pump motor, the plurality of switching devices being operatively cou-

pled to the controller, each of the switching devices having an open state and a closed state, in the closed state power is able to pass through the respective switching device and in the open state power is not able to pass through the respective switching device; and

at least one sensor monitoring the provision of power from the power source to the pump motor, wherein the controller:

placing all of the switching devices in the closed state when power is requested to be provided to the pump motor to commence a first operation of the pump motor;

placing a first switching device of the plurality of switching devices in an open state to end the first operation of the pump motor;

monitoring with the at least one sensor if power is still being provided to the pump motor which would indicate that the first switching device is faulty;

placing all of the switching devices in the closed state when power is requested to be provided to the pump motor to commence a second operation of the pump motor;

placing a second switching device of the plurality of switching devices in an open state to end the second operation of the pump motor; and

monitoring with the at least one sensor if power is still being provided to the pump motor which would indicate that the second switching device is faulty.

18. The fuel dispensing system of claim 17, wherein the plurality of switching devices are relays.

19. The fuel dispensing system of claim 17, wherein power is requested to be provided to the pump motor to commence the first operation when a hook signal is received from the dispenser.

20. The fuel dispensing system of claim 17, wherein the controller indicates a fault condition when power is detected as being provided to the pump motor when one of the plurality of switching devices is supposed to be in an open state.

Patentansprüche

1. Verfahren zur Steuerung der Bereitstellung von Energie von einer Energiequelle an eine gesteuerte Vorrichtung, wobei das Verfahren die folgenden Schritte umfasst:

(a) Bereitstellen einer Vielzahl von Schaltvorrichtungen in Reihe zwischen der Energiequelle

- und der gesteuerten Vorrichtung, wobei jede der Schaltvorrichtungen einen geöffneten Zustand und einen geschlossenen Zustand aufweist, wobei im geschlossenen Zustand Energie durch die jeweilige Schaltvorrichtung gelangen kann und wobei im geöffneten Zustand keine Energie durch die jeweilige Schaltvorrichtung gelangen kann;
- (b) Versetzen aller Schaltvorrichtungen in den geschlossenen Zustand, wenn Energie angefordert wird, um an die gesteuerte Vorrichtung geliefert zu werden, um einen ersten Betrieb der gesteuerten Vorrichtung zu starten;
- (c) Versetzen einer ersten Schaltvorrichtung der Vielzahl von Schaltvorrichtungen in einen geöffneten Zustand, um den ersten Betrieb der gesteuerten Vorrichtung zu beenden;
- (d) Überwachen, ob noch immer Energie an die gesteuerte Vorrichtung geliefert wird, was anzeigen würde, dass die erste Schaltvorrichtung defekt ist; **gekennzeichnet durch das**
- (e) Versetzen aller Schaltvorrichtungen in den geschlossenen Zustand, wenn Energie angefordert wird, um an die gesteuerte Vorrichtung geliefert zu werden, um einen zweiten Betrieb der gesteuerten Vorrichtung zu starten;
- (f) Versetzen einer zweiten Schaltvorrichtung der Vielzahl von Schaltvorrichtungen in einen geöffneten Zustand, um den zweiten Betrieb der gesteuerten Vorrichtung zu beenden; und
- (g) Überwachen, ob noch immer Energie an die gesteuerte Vorrichtung geliefert wird, was anzeigen würde, dass die zweite Schaltvorrichtung defekt ist.
2. Verfahren nach Anspruch 1, ferner umfassend den Schritt des Anzeigens eines Störzustands, wenn in einem von Schritt (d) oder Schritt (g) festgestellt wird, dass Energie an die gesteuerte Vorrichtung geliefert wird.
 3. Verfahren nach Anspruch 1, wobei Schritt (b) als Antwort auf den Empfang eines ersten Aktivitätssignals von einer Steuerungsvorrichtung ausgeführt wird.
 4. Verfahren nach Anspruch 1, wobei Schritt (d) den Schritt des Überwachens umfasst, ob ein Strom von der Energiequelle zur gesteuerten Vorrichtung fließt.
 5. Verfahren nach Anspruch 1, wobei die Schritte (b) - (g) automatisch von einem Regler ausgeführt werden.
 6. Verfahren nach Anspruch 5, wobei der Regler vor den Schritten (b) - (g) eine anfängliche Überprüfung der Vielzahl von Schaltvorrichtungen durchführt.
 7. Verfahren nach Anspruch 6, wobei die anfängliche

Überprüfung für jede der Vielzahl von Schaltvorrichtungen die folgenden Schritte umfasst:

- Versetzen der jeweiligen Schaltvorrichtung in einen geöffneten Zustand, während der Rest der Vielzahl von Schaltvorrichtungen in einem geschlossenen Zustand ist; und
- Überwachen, ob Energie an die gesteuerte Vorrichtung geliefert wird, was anzeigen würde, dass die jeweilige Schaltvorrichtung defekt ist.
8. Verfahren nach Anspruch 5, wobei der Regler den Zustand der Vielzahl von Schaltvorrichtungen auf der Basis eines Aktivitätssignals ändert, das ausgehend von einer Steuerungsvorrichtung empfangen wurde.
 9. Verfahren nach Anspruch 8, wobei die gesteuerte Vorrichtung eine Pumpe in einem unterirdischen Treibstoffspeichertank ist und die Steuerungsvorrichtung eine Abgabevorrichtung ist, die in Fluidverbindung mit der Pumpe des unterirdischen Speichertanks steht.
 10. Verfahren nach Anspruch 1, wobei die Schritte (a) - (g) der Reihe nach durchgeführt werden.
 11. Vorrichtung zur Steuerung der Bereitstellung von Energie von einer Energiequelle an eine gesteuerte Vorrichtung, wobei die Vorrichtung umfasst:
 - einen Regler (120);
 - eine Vielzahl von Schaltvorrichtungen (122, 124) in Reihe zwischen der Energiequelle (360) und der gesteuerten Vorrichtung, wobei die Vielzahl von Schaltvorrichtungen operativ mit dem Regler gekoppelt ist, wobei jede der Schaltvorrichtungen einen geöffneten Zustand und einen geschlossenen Zustand aufweist, wobei im geschlossenen Zustand Energie durch die jeweilige Schaltvorrichtung gelangen kann und wobei im geöffneten Zustand keine Energie durch die jeweilige Schaltvorrichtung gelangen kann; und
 - mindestens einen Sensor (132), der die Bereitstellung von Energie von der Energiequelle zur gesteuerten Vorrichtung überwacht, wobei der Regler:
 - alle Schaltvorrichtungen in den geschlossenen Zustand versetzt, wenn Energie angefordert wird, um an die gesteuerte Vorrichtung geliefert zu werden, um einen ersten Betrieb der gesteuerten Vorrichtung zu starten;
 - eine erste Schaltvorrichtung der Vielzahl von Schaltvorrichtungen in einen geöffneten Zustand versetzt, um den ersten Betrieb der gesteuerten Vorrichtung zu beenden;

- mit dem mindestens einen Sensor überwacht, ob noch immer Energie zur gesteuerten Vorrichtung geliefert wird, was anzeigen würde, dass die erste Schaltvorrichtung defekt ist;
 alle Schaltvorrichtungen in den geschlossenen Zustand versetzt, wenn Energie angefordert wird, um an die gesteuerte Vorrichtung geliefert zu werden, um einen zweiten Betrieb der gesteuerten Vorrichtung zu starten;
 eine zweite Schaltvorrichtung der Vielzahl von Schaltvorrichtungen in einen geöffneten Zustand versetzt, um den zweiten Betrieb der gesteuerten Vorrichtung zu beenden; und
 mit dem mindestens einen Sensor überwacht, ob noch immer Energie zur gesteuerten Vorrichtung geliefert wird, was anzeigen würde, dass die zweite Schaltvorrichtung defekt ist.
12. Vorrichtung nach Anspruch 11, wobei der Regler einen Störszustand anzeigt, wenn festgestellt wird, dass Energie an die gesteuerte Vorrichtung geliefert wird, wenn eine der Vielzahl von Schaltvorrichtungen in einem geöffneten Zustand sein soll.
13. Vorrichtung nach Anspruch 11, wobei der Regler den Zustand der Vielzahl von Schaltvorrichtungen auf der Basis eines Aktivitätssignal ändert, das ausgehend von einer Steuerungsvorrichtung empfangen wird.
14. Vorrichtung nach Anspruch 11, wobei der mindestens eine Sensor ein Stromsensor ist und der Regler auf der Basis eines Stroms, der von dem Stromsensor nachgewiesen wird, feststellt, ob Energie an die gesteuerte Vorrichtung geliefert wird.
15. Vorrichtung nach Anspruch 11, wobei der Regler eine anfängliche Überprüfung der Vielzahl von Schaltvorrichtungen durchführt, indem für jede der Vielzahl von Schaltvorrichtungen:
- die jeweilige Schaltvorrichtung in einen geöffneten Zustand versetzt wird, während der Rest der Vielzahl von Schaltvorrichtungen in einem geschlossenen Zustand ist; und
 mit dem mindestens einen Sensor überwacht wird, ob Energie an die gesteuerte Vorrichtung geliefert wird, was anzeigen würde, dass die jeweilige Schaltvorrichtung defekt ist.
16. Vorrichtung nach Anspruch 11, wobei die gesteuerte Vorrichtung eine Pumpe in einem unterirdischen Treibstoffspeichertank ist und die Steuerungsvorrichtung eine Abgabevorrichtung ist, die in Fluidver-

bindung mit der Pumpe des unterirdischen Speichertanks steht.

17. Mit einer Energiequelle gekoppeltes Treibstoffabgabesystem, umfassend:

einen unterirdischen Treibstoffspeichertank, der geeignet ist, in seinem Inneren Treibstoff zu speichern;
 eine Abgabevorrichtung, umfassend mindestens einen Treibstoffabgabepunkt, wobei der mindestens eine Treibstoffabgabepunkt der Abgabevorrichtung in Fluidverbindung mit dem unterirdischen Treibstoffspeichertank steht;
 eine Pumpe, die in dem unterirdischen Treibstoffspeichertank angeordnet ist, um Treibstoff aus dem unterirdischen Treibstoffspeichertank zu pumpen, wobei die Pumpe einen Pumpenmotor umfasst; und
 ein Steuersystem, das den Pumpenmotor aktiviert, um für eine Vielzahl von Vorgängen Treibstoff aus dem Inneren des unterirdischen Treibstoffspeichertanks zu einem ersten Abgabepunkt zu pumpen, wobei das Steuersystem umfasst:

einen Regler;
 eine Vielzahl von Schaltvorrichtungen in Reihe zwischen der Energiequelle und dem Pumpenmotor, wobei die Vielzahl von Schaltvorrichtungen operativ mit dem Regler gekoppelt ist, wobei jede der Schaltvorrichtungen einen geöffneten Zustand und einen geschlossenen Zustand aufweist, wobei im geschlossenen Zustand Energie durch die jeweilige Schaltvorrichtung gelangen kann und wobei im geöffneten Zustand keine Energie durch die jeweilige Schaltvorrichtung gelangen kann; und
 mindestens einen Sensor, der die Bereitstellung von Energie von der Energiequelle zum Pumpenmotor überwacht, wobei der Regler:

alle Schaltvorrichtungen in den geschlossenen Zustand versetzt, wenn Energie angefordert wird, um an den Pumpenmotor geliefert zu werden, um einen ersten Betrieb des Pumpenmotors zu starten;
 eine erste Schaltvorrichtung der Vielzahl von Schaltvorrichtungen in einen geöffneten Zustand versetzt, um den ersten Betrieb des Pumpenmotors zu beenden;
 mit dem mindestens einen Sensor überwacht, ob noch immer Energie zum Pumpenmotor geliefert wird, was

anzeigen würde, dass die erste Schaltvorrichtung defekt ist;
 alle Schaltvorrichtungen in den geschlossenen Zustand versetzt, wenn Energie angefordert wird, um an den Pumpenmotor geliefert zu werden, um einen zweiten Betrieb des Pumpenmotors zu starten;
 eine zweite Schaltvorrichtung der Vielzahl von Schaltvorrichtungen in einen geöffneten Zustand versetzt, um den zweiten Betrieb des Pumpenmotors zu beenden; und
 mit dem mindestens einen Sensor überwacht, ob noch immer Energie zum Pumpenmotor geliefert wird, was anzeigen würde, dass die zweite Schaltvorrichtung defekt ist.

18. Treibstoffabgabesystem nach Anspruch 17, wobei die Vielzahl von Schaltvorrichtungen Relais sind.
19. Treibstoffabgabesystem nach Anspruch 17, wobei Energie angefordert wird, um an den Pumpenmotor geliefert zu werden, um den ersten Betrieb zu starten, wenn ein Aufhängesignal ausgehend von der Abgabevorrichtung empfangen wird.
20. Treibstoffabgabesystem nach Anspruch 17, wobei der Regler einen Stöorzustand anzeigt, wenn festgestellt wird, dass Energie zum Pumpenmotor geliefert wird, wenn eine der Vielzahl von Schaltvorrichtungen in einem geöffneten Zustand sein soll.

Revendications

1. Une méthode de contrôle de la provision d'énergie à partir d'une source d'alimentation vers un dispositif contrôlé, la méthode comprenant les étapes de :
 - (a) Fourniture d'une pluralité de dispositifs de commutation en série entre la source d'alimentation et le dispositif contrôlé, chacun des dispositifs de commutation ayant un état ouvert et un état fermé, dans l'état fermé l'alimentation peut passer au travers du dispositif de commutation respectif et dans l'état ouvert, l'alimentation ne peut pas passer au travers du dispositif de commutation respectif ;
 - (b) Mise en place de tous les dispositifs de commutation dans l'état fermé lorsqu'il est nécessaire de fournir une alimentation au dispositif contrôlé pour commencer un premier fonctionnement du dispositif contrôlé ;
 - (c) Mise en place d'un premier dispositif de commutation de la pluralité de dispositifs de commutation dans un état ouvert pour terminer le

premier fonctionnement du dispositif contrôlé ;
 (d) Surveillance si l'alimentation est toujours fournie au dispositif contrôlé ce qui indiquerait que le premier dispositif de commutation est défectueux ; **caractérisé par**

(e) La mise en place de tous les dispositifs de commutation dans l'état fermé lorsqu'il est nécessaire de fournir une alimentation au dispositif contrôlé pour commencer un deuxième fonctionnement du dispositif contrôlé ;
 (f) Mise en place d'un deuxième dispositif de commutation de la pluralité des dispositifs de commutation dans un état ouvert pour terminer le deuxième fonctionnement du dispositif contrôlé ; et
 (g) Surveillance si l'alimentation est toujours fournie au dispositif contrôlé ce qui indiquerait que le deuxième dispositif de commutation est défectueux.

2. La méthode de la revendication 1, comprenant de plus l'étape indiquant une condition défectueuse lorsque l'alimentation est détectée comme étant fournie au dispositif contrôlé dans l'étape (d) ou l'étape (g).
3. La méthode de la revendication 1, où l'étape (b) est effectuée pour répondre à la réception d'un premier signal d'action à partir d'un dispositif de contrôle.
4. La méthode de la revendication 1, où l'étape (d) inclut l'étape de surveillance si un courant passe de la source d'alimentation au dispositif contrôlé.
5. La méthode de la revendication 1, où les étapes (b) - (g) sont effectuées automatiquement par un contrôleur.
6. La méthode de la revendication 5, où le contrôleur effectue une vérification initiale de la pluralité des dispositifs de commutation avant les étapes (b) - (g).
7. La méthode de la revendication 6, où la vérification initiale inclut les étapes, pour chacune des étapes de la pluralité de dispositifs de commutation, de :
 - Mise en place du dispositif de commutation dans un état ouvert alors que le reste de la pluralité des dispositifs de commutation est dans un état fermé ; et
 - Surveillance si l'alimentation est fournie au dispositif contrôlé ce qui indiquerait que le dispositif de commutation respectif est défectueux.
8. La méthode de la revendication 5, où le contrôleur change l'état de la pluralité des dispositifs de commutation basé sur un signal d'action reçu à partir d'un dispositif de contrôle.

9. La méthode de la revendication 8, où le dispositif contrôlé est une pompe dans un réservoir de stockage de fioul souterrain et le dispositif de contrôle est un distributeur qui est en communication fluide avec la pompe du réservoir de stockage souterrain. 5

10. La méthode de la revendication 1, où les étapes (a) - (g) sont réalisées dans un ordre séquentiel.

11. Un appareil pour contrôler la provision d'énergie d'une source d'alimentation vers un dispositif contrôlé, l'appareil comprenant :

Un contrôleur (120) ;

Une pluralité de dispositifs de commutation (122, 124) en série entre la source d'alimentation (360) et le dispositif contrôlé, la pluralité de dispositifs de commutation étant raccordée de façon opérationnelle au contrôleur, chaque dispositif de commutation ayant un état ouvert et un état fermé, dans l'alimentation en état fermé étant capable de passer au travers du dispositif de commutation respectif et dans l'alimentation en état ouvert n'étant pas capable de passer au travers du dispositif de commutation respectif ; et 25

Au moins un capteur (132) surveillant la provision d'énergie de la source d'alimentation vers le dispositif contrôlé, où le contrôleur :

Place tous les dispositifs de commutation dans l'état fermé lorsqu'il est nécessaire de fournir une alimentation au dispositif contrôlé pour commencer un premier fonctionnement du dispositif contrôlé ; 35

Place un premier dispositif de commutation de la pluralité de dispositifs de commutation dans un état ouvert pour terminer le premier fonctionnement du dispositif contrôlé ;

Surveille avec au moins un capteur si l'alimentation est toujours fournie au dispositif contrôlé, ce qui indiquerait que le premier dispositif de commutation est défectueux ; 40

Place tous les dispositifs de commutation dans l'état fermé lorsqu'il est nécessaire que l'alimentation soit fournie au dispositif contrôlé pour commencer un deuxième fonctionnement du dispositif contrôlé ; 45

Place un deuxième dispositif de commutation de la pluralité de dispositifs de commutation dans un état ouvert pour terminer le deuxième fonctionnement du dispositif contrôlé ; et 50

Contrôle avec au moins un capteur si l'alimentation est encore fournie au dispositif contrôlé ce qui indiquerait que le deuxième dispositif de commutation est défectueux. 55

12. L'appareil de la revendication 11, où le contrôleur indique une condition défectueuse lorsqu'il est détecté que l'alimentation est fournie au dispositif contrôlé quand l'une des pluralités de dispositifs de commutation est supposée être dans un état ouvert.

13. L'appareil de la revendication 11, où le contrôleur change l'état de la pluralité des dispositifs de commutation basé sur un signal d'action reçu à partir d'un dispositif de contrôle.

14. L'appareil de la revendication 11, où au moins un capteur est un capteur de courant et le contrôleur détermine si l'alimentation est fournie au dispositif contrôlé basé sur un courant détecté par le capteur de courant.

15. L'appareil de la revendication 11, où le contrôleur réalise une vérification initiale de la pluralité des dispositifs de commutation pour chacune des pluralités des dispositifs de commutation, en :

mettant en place le dispositif de commutation respectif dans un état ouvert alors que le reste de la pluralité des dispositifs de commutation est dans un état fermé ; et

surveillant avec au moins un capteur si l'alimentation est fournie au dispositif contrôlé qui indiquerait que le dispositif de commutation respectif est défectueux.

16. L'appareil de la revendication 11, où le dispositif contrôlé est une pompe dans un réservoir de stockage de fioul souterrain et le dispositif de contrôle est un distributeur qui est en communication fluide avec la pompe du réservoir de stockage souterrain.

17. Un système de distribution de fioul raccordé à une source d'alimentation, comprenant :

Un réservoir de stockage de fioul souterrain adapté pour stocker du fioul à l'intérieur ;

Un distributeur incluant au moins un point de distribution de fioul, au moins un point de distribution de fioul du distributeur étant en communication fluide avec le réservoir de stockage de fioul souterrain ;

Une pompe positionnée dans le réservoir de stockage de fioul souterrain pour pomper du fioul à partir du réservoir de stockage de fioul souterrain, la pompe incluant un moteur de pompe ; et

Un système de contrôle qui active le moteur de pompe pour pomper du fioul de l'intérieur du réservoir de stockage de fioul souterrain vers un point de distribution pour une pluralité de fonctionnements, le système de contrôle incluant Un contrôleur ;

Une pluralité de dispositifs de commutation en série entre la source d'alimentation et le moteur de pompe, la pluralité de dispositifs de commutation étant raccordée de façon opérationnelle au contrôleur, 5
 chacun des dispositifs de commutation ayant un état ouvert et un état fermé, dans l'état fermé l'alimentation est capable de passer par le dispositif de commutation respectif et dans l'état ouvert, l'alimentation n'est pas capable de passer au travers du dispositif de commutation respectif ; et 10
 Au moins un capteur surveillant la provision d'énergie de la source d'alimentation au moteur de pompe où le contrôleur : 15

Met tous les dispositifs de commutation dans l'état fermé lorsqu'il est nécessaire que l'alimentation soit fournie au moteur de pompe pour commencer un premier fonctionnement du moteur de pompe ; 20
 Met en place un premier dispositif de commutation de la pluralité des dispositifs de commutation dans un état ouvert pour terminer le premier fonctionnement du moteur de pompe ; 25
 Surveille avec au moins un capteur si l'alimentation est toujours fournie au moteur de pompe ce qui indiquerait que le premier dispositif de commutation est défectueux ; 30
 Met en place tous les dispositifs de commutation dans l'état fermé lorsqu'il est nécessaire que l'alimentation soit fournie au moteur de pompe pour commencer un deuxième fonctionnement du moteur de pompe ; 35
 Met en place un deuxième dispositif de commutation de la pluralité des dispositifs de commutation dans un état ouvert pour terminer le deuxième fonctionnement du moteur de pompe ; et 40
 Surveillance avec au moins un capteur si l'alimentation est toujours fournie au moteur de pompe ce qui indiquerait que le deuxième dispositif de commutation est défectueux. 45

18. Le système de distribution du fioul de la revendication 17, où la pluralité des dispositifs de commutation sont des relais. 50
19. Le système de distribution du fioul de la revendication 17, où il est nécessaire que l'alimentation soit fournie au moteur de pompe pour commencer le premier fonctionnement lorsqu'un signal de raccrochage est reçu à partir du distributeur. 55
20. Le système de distribution du fioul de la revendication 17, où le contrôleur indique une condition dé-

fectueuse lorsqu'il est détecté que l'alimentation est fournie au moteur pompe lorsqu'une des pluralités de dispositifs de commutation est supposée être en état ouvert.

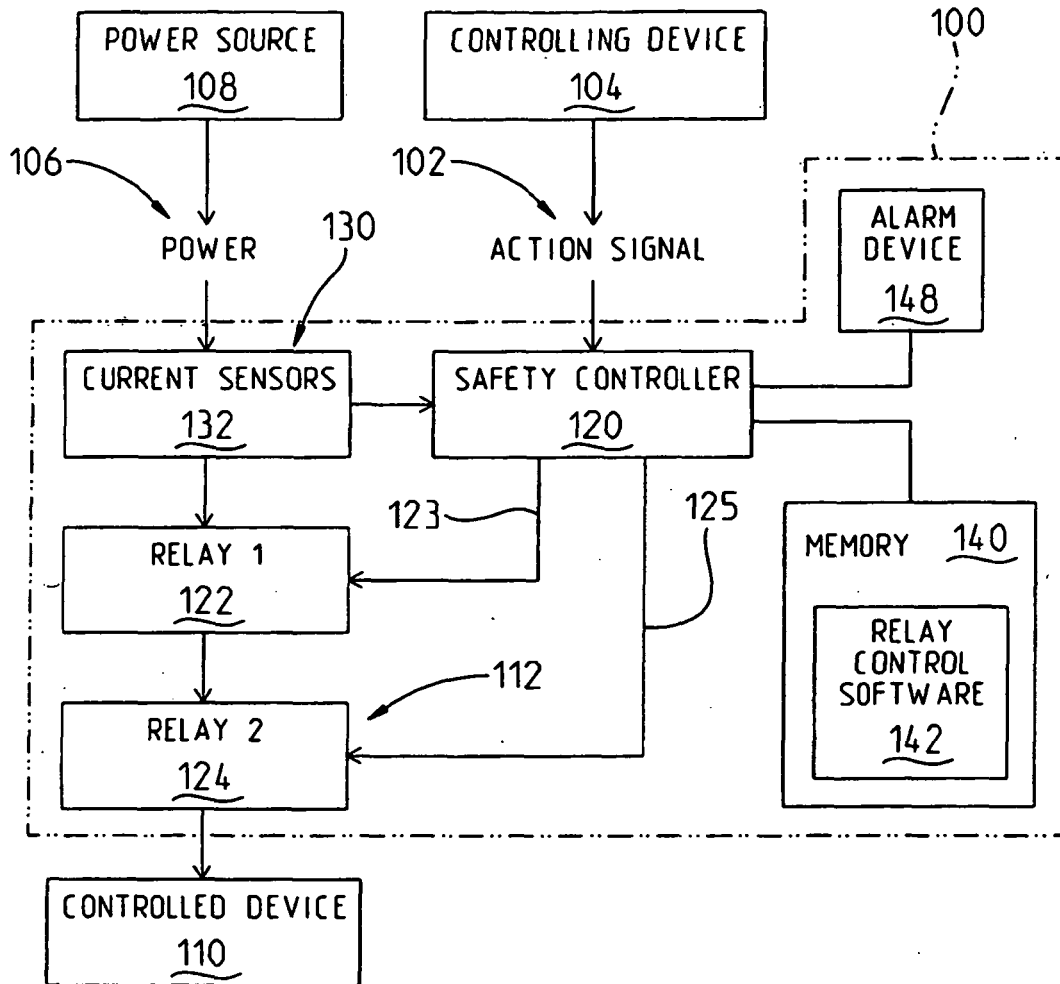
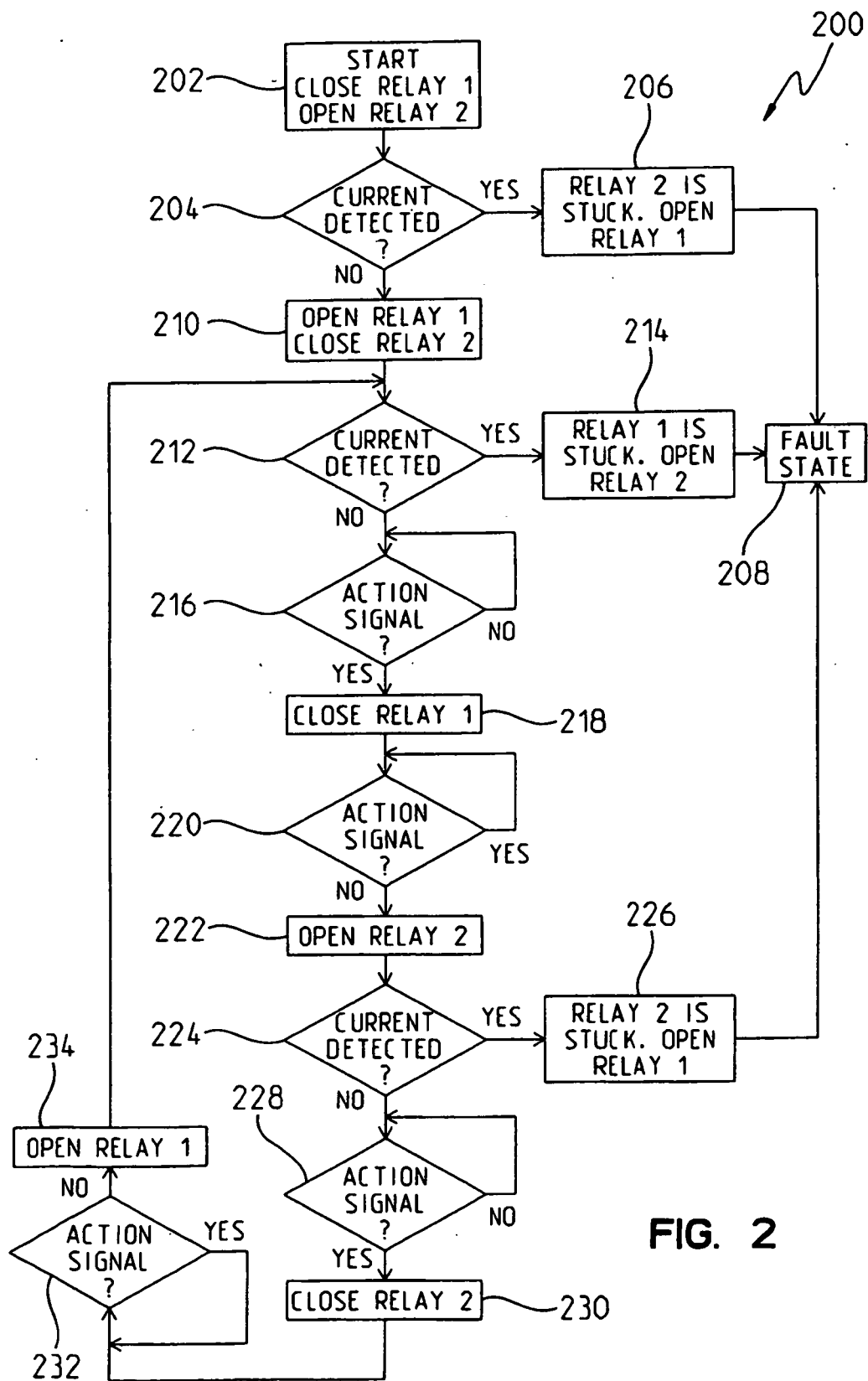


FIG. 1



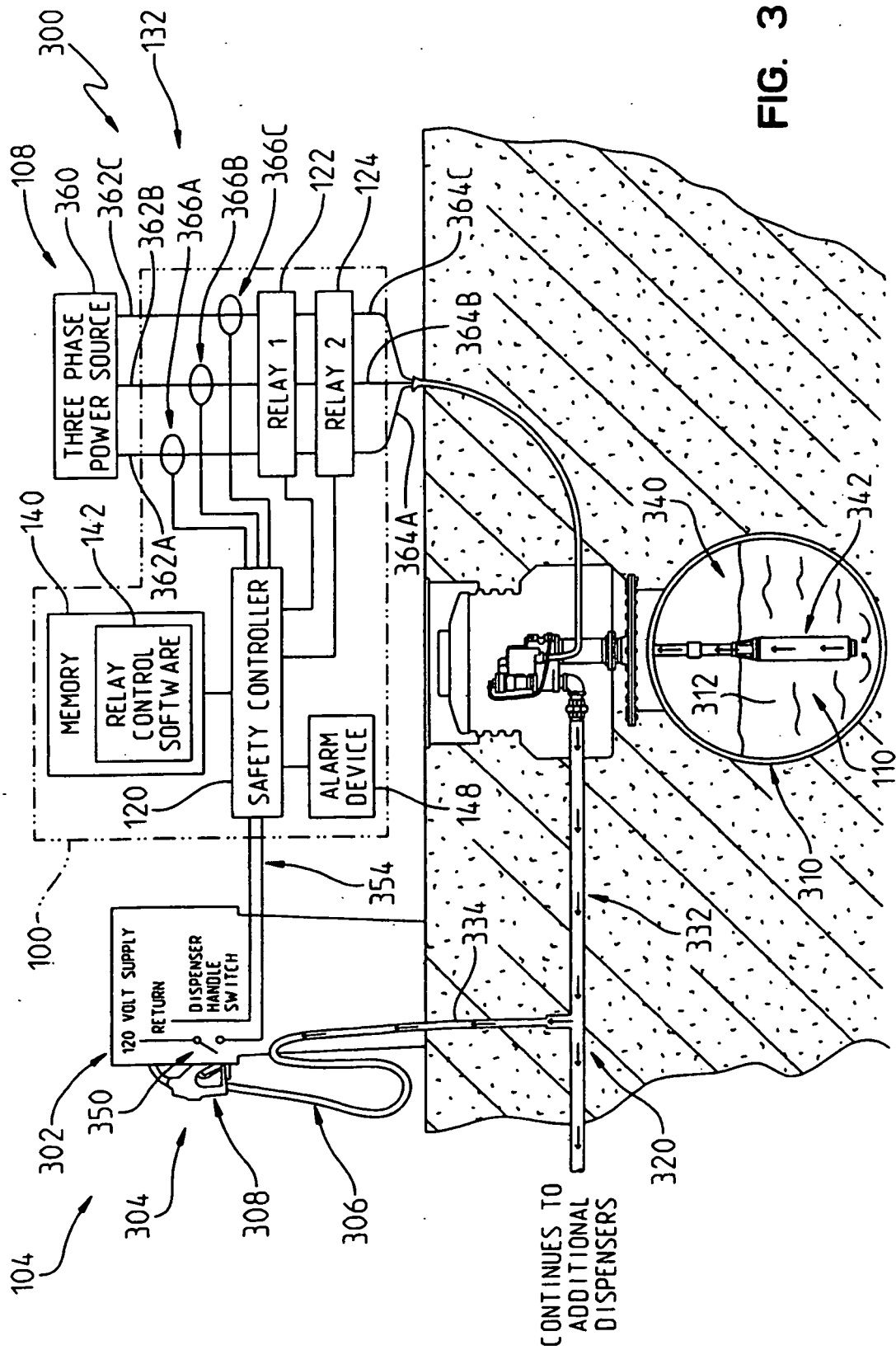


FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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