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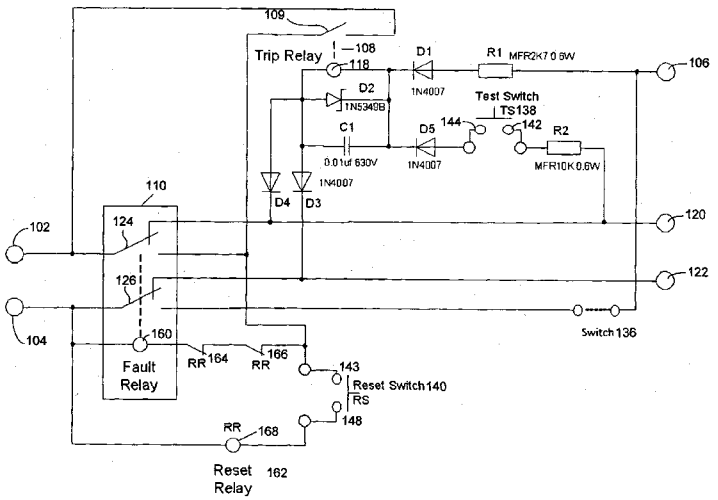

FIGURE 4A

(57) Abstract: Disclosed is an electrical protection device, control circuit and electrical system. In one aspect, the control circuit includes: at least two input terminals including a first and second terminal for electrically connecting with an active and neutral terminal of the supply; at least two output terminals for electrically connecting with an active and neutral terminal of the load; a sensor line for electrical connection to a reference which should be electrically isolated from the active terminal and in some circumstances the neutral terminal of the supply; at least one fault relay operable in a first mode such that the input and output terminals are electrically connected, and a second mode where the input and output terminals are electrically isolated; and a detector for actuating the at least one fault relay in response to sensing a current flowing through the sensor line which meets or exceeds a threshold current.

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ELECTRICAL PROTECTION DEVICE, SYSTEM AND CONTROL CIRCUIT

Cross-Reference to Related Application

This application claims priority from Australian provisional patent application 2012901988, filed 16 May 2012, the entire contents of which is hereby incorporated by reference.

Field of Invention

The present invention relates to an electrical protection device, system and control circuit.

Background

Any discussion of the background art throughout the specification should in no way be considered as an admission that such art is widely known or forms part of common general knowledge in the field.

It is known to provide protection to electrical loads used in a multiple earth neutral (MEN) (also known as a 'TN/TT network') electrical distribution system (EDS) on the one hand, and in a floating EDS (also known as an 'IT network') on the other. One common form of such protection is a residual current device (RCD) that most typically monitors the differential in the current between the active and neutral to selectively isolate the load. To operate effectively, there is a need for a reliable and effective earth connection. In an MEN EDS (TN/TT network) it is possible to often have a good earth connection for a given electrical load. However, there are many instances where the earth connection is compromised, lost, or simply not available. A floating earth EDS (IT network) does not include an earth connection and, as such, does not allow proper operation of the RCD.

Notwithstanding the operational limitations of RCD, it is often mandatory to have such devices installed in an EDS. This not only exposes personnel to danger, it also provides a false sense of security to those personnel.

Summary

In a first aspect there is provided a control circuit for an electrical protection device including:

at least two input terminals including a first terminal for electrically connecting with an active terminal of a supply and a second terminal for electrically connecting with a neutral terminal of the supply;

at least two output terminals including a first output terminal for electrically connecting with a load active terminal of an electrical load and a second output terminal for electrically connecting with a neutral terminal of the load;

a sensor line for electrical connection to a reference which should be electrically isolated from the active and neutral terminals of the supply;

at least one fault relay operable in a first mode and a second mode, wherein in the first mode the input and output terminals are electrically connected for allowing the load to receive electrical supply via the at least one fault relay, and in the second mode the input and output terminals are electrically isolated thereby preventing electrical supply being provided to the load; and

a detector for actuating the at least one fault relay in response to sensing a current flowing through the sensor line which meets or exceeds a threshold current.

In certain embodiments, when the at least one fault relay operates in the second mode, the at least one fault relay connects the sensor line with the neutral terminal of the supply.

In certain embodiments, the control circuit includes a mode switch to selectively configure the control circuit to connect the sensor line with the neutral terminal of the supply when the at least one fault relay operates in the second mode.

In certain embodiments, the detector is a trip relay which operates in an energized mode in response to the current flowing through the sensor line meets or exceeds the threshold current.

In certain embodiments, the trip relay is a low voltage trip relay.

In certain embodiments, in response to the at least one fault relay progressing to the second mode, the trip relay progresses to a de-energized mode whilst the at least one fault relay is maintained in the second mode.

In certain embodiments, the control circuit includes a test switch which upon user actuation causes current to flow through the sensor line which is sufficient for the detector to actuate the at least one fault relay to operate in the second mode.

In certain embodiments, the control circuit includes a reset switch arrangement including a reset switch and a reset relay, wherein upon user actuation of the reset switch, the reset relay progresses from an initial state to a reset state to cause the at least one fault relay to operate in the first mode.

In certain embodiments, upon the at least one fault relay progressing back to the first mode in response to the user action of the reset switch, the reset relay progresses from the reset state to the initial state.

In certain embodiments, the control circuit includes a first fault relay and a second fault relay, wherein in response to the trip relay progressing to the energized mode, the first fault relay isolates the first input terminal from the first output terminal and the second fault relay isolates the second input terminal from the second output terminal.

In certain embodiments, the first and second fault relay operate substantially simultaneously in response to the trip relay operating in the energized mode.

In certain embodiments, the control circuit includes a single fault relay including a first and second contact which electrically connect the respective input and output terminals in the first state, wherein in response to the trip relay progressing to the energized mode, the first and second contacts move such that the single fault relay operates in the second mode where the input and output terminals are isolated from each other.

In a second aspect there is provided an electrical protection system including:

a residual current device (RCD) connected to an active terminal and a neutral terminal of a supply, wherein the RCD includes an active output terminal and a neutral output terminal; and

an electrical protection device including a control circuit electrically connected to the RCD, wherein the control circuit includes:

at least two input terminals including a first terminal for electrically connecting with the active output terminal of the RCD and a second terminal for electrically connecting with the neutral output terminal of the RCD;

at least two output terminals including a first output terminal for electrically connecting with a load active terminal of an electrical load and a second output terminal for electrically connecting with a load neutral terminal;

a sensor line for electrical connection to a reference which should be electrically isolated from the active terminal of the supply;

at least one fault relay operable in a first mode and a second mode, wherein in the first mode the input and output terminals are electrically connected for allowing the load to receive electrical supply via the at least one fault relay, and in the second mode the input and output terminals are electrically isolated, and the sensor line is connected with the neutral output terminal of the RCD, wherein in response to the sensor line being connected to the neutral output terminal of the RCD, the RCD senses a fault condition and disconnects the active and neutral terminals of the supply from the active and neutral output terminals of the RCD; and

a detector for actuating the at least one fault relay in response to sensing a current flowing through the sensor line which meets or exceeds a threshold current.

In certain embodiments, the detector is a trip relay which operates in an energized mode in response to the current flowing through the sensor line meeting or exceeding the threshold current.

In certain embodiments, the trip relay is a low voltage trip relay.

In certain embodiments, in response to the at least one fault relay progressing to the second mode, the trip relay progresses to an de-energized mode whilst the at least one fault relay is maintained in the second mode.

In certain embodiments, the control circuit includes a test switch which upon user actuation causes current to flow through the sensor line which is sufficient for the detector to actuate the at least one fault relay to operate in the second mode.

In certain embodiments, the control circuit includes a reset switch arrangement including a reset switch and a reset relay, wherein upon user actuation of the reset switch, the reset relay progresses from an initial state to a reset state to cause the at least one fault relay to operate in the first mode.

In certain embodiments, upon the at least one fault relay progressing back to the first mode in response to the user action of the reset switch, the reset relay progresses from the reset state to the initial state.

In certain embodiments, the control circuit includes a first fault relay and a second fault relay, wherein in response to the trip relay progressing to the energized mode, the first fault relay isolates the first input terminal from the first output terminal and the second fault relay isolates the second input terminal from the second output terminal.

In certain embodiments, the first and second fault relay operate substantially simultaneously in response to the trip relay operating in the energized mode.

In certain embodiments, the control circuit includes a single fault relay including a first and second contact which electrically connect the respective input and output terminals in the first state, wherein in response to the trip relay progressing to the energized state, the first and second contacts move such that the single fault relay operates in the second mode where the input and output terminals are isolates from each other.

In a third aspect there is provided an electrical protection device including:

a housing; and

a control circuit according to the first aspect, wherein the housing at least partially houses the control circuit.

In certain embodiments, the control circuit includes a first electrical plug and a second electrical plug which extend from the housing, wherein the first electrical plug is for electrically connecting the supply active and neutral terminals to the input terminals of the control circuit and the second electrical plug is for electrically connecting the load active and neutral terminals with the output terminals of the control circuit.

In certain embodiments, the second electrical plug includes a connector which is the sensor line for connecting with an earth pin of the load.

Further aspects and embodiments will be appreciated throughout the detailed description.

Brief Description of the Figures

One or more preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawing in which:

Figure 1A is a schematic of an example of a control circuit of the electrical protection device operating in a non-isolated mode;

Figure 1B is a schematic of the control circuit of Figure 1A operating in an isolated mode;

Figure 2A is a schematic of another example of a control circuit of the electrical protection device operating in the non-isolated mode;

Figure 2B is a schematic of the control circuit of Figure 2A operating in the isolated mode;

Figure 3 is a schematic of an electrical protection system including an example of an electrical protection device;

Figure 4A is a schematic of another example of a control circuit of an electrical protection device operating in the non-isolated mode;

Figure 4B is a schematic of the control circuit of Figure 4A operating in the isolated mode;

Figure 5A is a schematic of another example of a control circuit of an electrical protection device operating in the non-isolated mode;

Figure 5B is a schematic of the control circuit of Figure 5A operating in the isolated mode; and

Figure 6 is a front view of an example of the electrical protection device.

Description of Embodiments

Referring to Figures 1A and 1B there is shown a first example of a control circuit 100 of the electrical protection device 10 (see Figure 3). The control circuit 100 includes at least two input terminals 102, 104 for connecting with terminals 190, 192 of an electrical supply 191. The connection between the input terminals 102, 104 of the control circuit 100 and the terminals 190, 192 of the electrical supply 191 may be direct (as shown in Figures 1A and 1B), or indirect via an intermediary circuit, as will be discussed later in relation to Figure 3.

The input terminals 102, 104 of the control circuit 100 include a first input terminal 102 for electrically connecting with an active terminal 190 of the supply 191 and a second terminal 104 for electrically connecting with a neutral terminal 192 of the supply 192.

The control circuit 100 also includes at least two output terminals 120, 122 including a first output terminal 120 for electrically connecting with a load terminal 150 of an electrical

load 154 and a second output terminal 152 for electrically connecting a neutral terminal 152 the load 154 with the neutral output terminal 122.

The control circuit 100 also includes a sensor line 106 for electrical connection to a reference 200 which should be electrically isolated from the active conductor 190, and in particular circumstances the neutral conductor 192.

The control circuit 100 also includes a detector 108, provided in the form of a trip relay and preferably a low voltage trip relay such as a 5Volt relay, which electrically actuates one or more fault relays 110 (see Figures 2A and 2B in relation to multiple fault relays) in response to sensing a current flowing through the sensor line 106 which meets or exceeds a threshold current.

The one or more fault relays 110 progress from a first mode, as shown in Figure 1A, to a second mode, as shown in Figure 1B, in response to electrical actuation by the trip relay 108. In the first mode, the input and output terminals 102, 104, 120, 122 are electrically connected for allowing the load 154 to receive electrical supply via the at least one fault relay 110. In the second mode, the input and output terminals 102, 104, 120, 122 are electrically isolated from each other by the at least one fault relay 110 such as to prevent electrical supply to the load. In particular embodiments, each of the one or more fault relays 110 may be provided as a 240 Volt relay.

In addition, when the at least one fault relay 110 progresses to the second mode, the sensor line 106 is connected with the neutral terminal 192 of the supply 191. This can be advantageous in situations as shown in Figure 3 where the control circuit 100 of the electrical protection device 10 may be in electrical communication with a RCD 112 which may not have tripped as a result of the electrical fault. Due to the at least one fault relay 110 causing the sensor line 106 to connect to the neutral terminal 192, an imbalance in current flows through the active and neutral conductors which is sensed by the RCD 112, thereby causing the RCD 112 to trip. Once the RCD trips, the output terminals of the RCD 112 provide no power to the input terminals 102, 104 of the control circuit 100. Due to no

electrical power being provided to the input terminals 102, 104 of the control circuit 100, the at least one fault relay 110 de-energizes, thereby returning to the first mode. Once the electrical fault has been corrected, the RCD 112 can be manually switched to a de-energised position such that electrical power 192 is once again supplied to the control circuit 100.

When the fault relay 110 operates in the first mode, the control circuit 100 and electronic protection device 10 operate in a non-isolated mode, and when the fault relay 110 operates in the second mode, the control circuit 100 and electronic protection device 10 operate in an isolated mode.

The electronic protection device 10 can be used in both a MEN (TN/TT network) and non-MEN electrical systems (IT network). Non-MEN electrical systems (IT network) such as that which are provided via inverters and generators which do not include an earth reference point. In the event that the electronic protection device is used in a non-MEN system (IT network), the sensor line 106 may sense a current caused by either a floating earth voltage or an active terminal voltage present at the reference.

In the event that the active conductor 190 comes into electrical contact with the reference object 200 (i.e. an equipment fault, a person touching the active conductor with one hand and the housing of the electrical protection device with the other hand), a current flows through the sensor line 106 which can exceed the threshold current. This causes the current flowing through the sensor line 106 to flow through resistor R1, diode D4, the coil 118 of the trip relay 108 and diode D1 due to being electrically connected with the neutral output terminal 122. Due to the current in the sensor line 106 exceeding the current threshold, the trip relay 108 energizes, resulting in the fault relay 110 energizing. When the fault relay energizes sufficiently, contacts 124, 126 of the fault relay 110 move such that the active and neutral terminals 190, 192 of the power source 191 are isolated from the load active and neutral terminals 150, 152 thereby electrically disconnecting the load 154 from the power source 191. As such, the reference object 200 which the sensor line 106 is electrically connected with also is electrically disconnected from the power source 191.

In the event that the neutral conductor 116 comes into electrical contact with the reference object 200 (i.e. an equipment fault, a person touching the neutral conductor with one hand and the housing of the electrical protection device with the other hand) which is provided within a floating earth EDS and thus is likely not to be earth, a current flows through the sensor line 106 which can exceed the threshold current. This causes the current flowing through the sensor line 106 to flow through resistor R1, diode D4, the coil 118 of the trip relay 108 and diode D2 due to being electrically connected with the active output terminal 120. In the event the current threshold is met or exceeded, the low voltage trip relay 108 closes, thereby causing the fault relay 108 to energize so that the contacts 124, 126 move, thereby electrically disconnecting the load 154 from the power source 191. As such, the reference object 200 which the sensor line 106 is electrically connected with also is electrically disconnected from the power source 191.

Referring more specifically to Figure 1A which shows the fault relay 110 in the first mode, a first contact 124 of the fault relay 110 is connected to the active input terminal 102 and the active output terminal 120. In the first mode, a second contact 104 of the fault relay 110 is connected to the neutral input terminal 104 and the neutral output terminal 122. When the fault relay 110 is electrically actuated by the trip relay 108 to progress the fault relay 110 to the second mode, the first contact 124 electrically disconnects from the active output terminal 120 and electrically connects with the coil 160 of the fault relay 110 such that the coil 160 of the fault relay 110 is electrically connected with the active input terminal 102. Additionally, upon the trip relay 108 electrically actuating the fault relay 110, the second contact 126 of the fault relay 110 electrically disconnects from the neutral output terminal 122. In certain embodiments suitable for MEN distribution systems, the second contact 126 can electrically connect with the sensor line 106, thereby pulling the sensor line 106 to neutral.

As shown in Figures 1A and 1B, the coil 160 of the fault relay 110 is in electrical connection with the neutral input terminal 192 of the power supply 191 in both first and second modes. When the contact 109 of the trip relay 108 closes such that the coil 160 is in

electrical connection with the active input terminal 102, a sufficient current flows through the coil 160 of the fault relay 110, thereby causing the contacts 124, 126 of the fault relay 110 to move, isolating the active and neutral output terminals 120, 122 from the active and neutral input terminals 102, 104 of the electrical power supply 191. As the first contact 124 of the fault relay 110 electrically connects the active input terminal 102 with the coil 160 of the fault relay 110 in the second mode, a sufficient current continues to flow through the coil 160 such that the fault relay 110 is maintained in the second mode whilst the electrical power supply 191 is connected to the control circuit 100.

Once the active output terminal 120 has been disconnected from the active input terminal 102, current fails to flow through the sensor line 106. This thereby causes the trip relay 108 to de-energize such that the contact 109 of the trip relay 108 re-opens. However, due to the first contact 124 of the fault relay 110 connecting the coil 160 to the active input terminal 190 of the electrical power supply 191 in the second mode, the action of the trip relay 108 progressing back to the open state does not alter the state of the fault relay 110 which is maintained in the second mode. Advantageously, due to the fault relay 110 being maintained in the second mode, the active load and neutral terminals 150, 152 of the load are isolated from the electrical power supply 191.

As shown in Figures 1A and 1B, a single fault relay 110 can be used for isolating the load 154 from the power source 191 in the event of a detected fault condition. In one particular configuration the fault relay 110 may be an 8 Amp fault relay. However, for applications which may experience higher current flows due to larger loads, more than one fault relay may be used in combination as shown in Figures 2A and 2B. In particular, a first fault relay 128 includes a contact 132 which disconnects the active supply terminal 190 from the active load terminal 150 in the event that the first fault relay 128 is electrically actuated by the trip relay 108. A second fault relay 130 includes a contact 134 which disconnects the neutral supply terminal 190 from the neutral load terminal 152 in the event that the second fault relay 130 is electrically actuated by the trip relay 108. It will be appreciated that the first and second fault relay 128, 130 operate substantially simultaneously. In one particular configuration, the first and second fault relays 128, 130 may be both 16 Amp fault relays

such that the electronic protection device 10 is rated for 16 Amp applications. In an additional configuration, the fault relay 110 of the embodiment discussed in relation to Figures 1A and 1B may be provided in the form of a 30 Amp fault relay for larger loads.

Referring to Figures 1A and 1B there is shown a capacitor C1 which is connected in parallel across the fault relay 110. The capacitor C1 is provided to prevent a racing condition. For example, in the event that the fault condition has been sensed such that the contacts 124, 126 of the fault relay 110 have closed, the capacitor C1 charges due to being connected to the active and neutral input terminals 102, 104. Once electrical power 191 is not provided to the input active and neutral terminals 102, 104, the capacitor C1 discharges so that the contacts 124, 126 of the fault relay 124, 126 do not immediately switch back to the first mode once the electrical power source 191 has been disconnected. An alternate configuration is provided in Figures 2A, 2B, 4A, 4B, 5A and 5B where the capacitor C1 is connected in parallel across the trip relay 108. When the fault relay 110 progresses to the second mode thereby disconnecting electrical power to the trip relay 108, the capacitor C1 discharges such that the progression of the trip relay 108 to a de-energized mode is delayed until the capacitor C1 has discharged sufficiently.

Referring to Figure 4A and 4B, there is shown another embodiment of the control circuit 100 of the electrical protection device 10. A number of components are in common between the control circuit 100 of Figures 4A and 4B compared to the embodiments shown in Figures 1A and 1B. As such, similar components share the same reference. It will be appreciated that similar functionality exists between the circuits 100 of these embodiments.

Referring more specifically to Figures 4A, 4B, 5A and 5B the control circuit 100 additionally includes a test switch 138 and a reset switch 140.

The test switch 138 that can be actuated by a user to test whether the control circuit 100 operates correctly. User actuation of the test switch 138 causes the trip relay 108 to energize which then causes the fault relay 110 to progress from the first mode to the second mode, where the input and output terminals 102, 104, 120, 122 are electrically

isolated from each other. Once the fault relay 110 progresses to the second mode due to actuation of the test switch 138, the fault relay remains in the second mode until either the electrical supply 191 is disconnected from circuit 100 or a reset switch 140 is actuated.

The reset switch 140 can be user actuated to cause the fault relay 110 to progress from the second mode to the first mode. The reset switch 140 can be actuated in response to a user having actuated the test switch 138 such that the fault relay 110 progresses back from the second mode to the first mode. Additionally, in the event that the fault relay 110 operates in the second mode due to a sensed fault in the electrical system, the reset switch 140 may be actuated in an attempt to return the fault relay 110 to the first mode when the electrical system has been corrected.

Referring more specifically to Figures 4A and 4B, the test switch 138 includes a first terminal 142 in electrical connection with the active output terminal 120 via a resistor R2. A second terminal 144 of the test switch 138 is in electrical connection with the neutral output terminal 122. The test switch 138 has a first mode, where no electrical connection exists between the terminals 142, 144, and a second mode where the test switch has been actuated creating an electrical connection between terminals 142, 144. When the test switch 138 has been actuated, a current will flow through the resistor R2, the diode D5, the coil 118 of the trip relay and the diode D3 due to the actuated test switch 138 completing an electrical connection between the active and neutral output terminals 120, 122. The current that flows through the sensor line 106 meets or exceeds the current thresholds, thereby causing the trip relay 108 to energize and operate in an energized mode by closing the respective contact 109.

When the trip relay 108 progresses to the energized mode, the closed contact 109 of the trip relay 108 causes the active input terminal 102 to be in electrical connection with the coil 160 of the fault relay 110. As the coil 160 of the fault relay 110 is also electrically connected with the neutral input terminal 104, a sufficient current passes through the coil 160 of the fault relay 110 to cause the fault relay 110 to energize. When the fault relay 110 energizes, the first contact 124 disconnects the active input terminal 190 of the power

supply 191 from the active output terminal 120 and connects the active input terminal 102 to coil 160 of the fault relay 110, thereby maintaining the fault relay 110 in the second mode due to the coil 160 being energized by this electrical connection. Additionally, when the fault relay 110 energizes, the second contact 126 disconnects the neutral input terminal 104 from the neutral output terminal 122 and connects the neutral input terminal 104 to the sensor line 106 in the event that the device 10 is being operated in an MEN distribution system. It will be appreciated that the first and second contacts 124, 126 move substantially simultaneously.

Referring more specifically to Figure 4A and 4B, in the second mode, the active input terminal 190 of the electrical supply 191 is electrically connected with the coil 160 of the fault relay 110 via one or more contacts 164, 166 of a reset relay 162. In particular, as shown in Figure 4A and 4B, the reset relay 162 includes two contacts 164, 166 which are in a closed position and electrically connect the active input terminal 102 with the coil 160. The contacts 164, 166 of the reset relay 162 remain in the closed position until the reset switch 140 is actuated, as discussed in more detail below.

When the trip relay 108 progresses to the energized mode, the closed contact 109 of the trip relay 108 also causes a first terminal 146 of the reset switch 140 to be electrically connected with the active input terminal 102, and thus the active conductor of the power supply 191. A second terminal 148 of the reset switch 140 is electrically connected to the neutral input terminal 104 via the coil 168 of the reset relay 162.

It will be appreciated that the test switch 138 can progress back to the first mode whilst the fault relay 110 continues to operate in the second mode. The fault relay 110 will continue to operate in the second mode until the power supply 191 is disconnected or the reset switch 140 is actuated as will be discussed in more detail below.

It will also be appreciated that when the fault relay 110 progresses to the second mode such that the second contact 126 of the fault relay 110 disconnects the neutral input terminal 104 from being in electrical connection with the neutral output terminal 122, the

trip relay 108 de-energizes such that contact 109 of the trip relay 108 re-opens. However, due to the first contact 124 of the fault relay 110 electrically connecting the active input terminal 102 to the coil 160 of the fault relay 110, the fault relay 110 is maintained in the second mode despite the contact 109 of the trip relay 108 reopening.

When the user actuates the reset switch 140 due to the fault relay 110 operating in the second mode, the active input terminal 102 is electrically connected to the coil 168 of the reset relay 162. This causes a sufficient current to flow through the coil 168 of the reset relay 162 such that the one or more contacts 164, 166 of the reset relay 162 open. When the one or more contacts 164, 166 of the reset relay 162 open, the coil 160 of the fault relay 110 are no longer in electrical connection with the active conductor of the power supply 191 such that the fault relay 110 de-energizes. When the fault relay 110 has de-energized, the first and second contacts 124, 126 of the fault relay 110 reconnect the active and neutral input terminals 102, 104 with the active and neutral output terminals 120, 122, such that electrical power 191 can once again be provided to the load 154.

As a result of the fault relay 110 returning to the first mode, the coil 168 of the reset relay 162 is electrically disconnected from the active conductor 114 of the power supply 191 such that the reset relay 162 de-energizes and the contacts 164, 166 of the reset relay 162 return to a closed position. As such it will be appreciated that the one or more contacts 164, 166 of the reset relay 162 only open for a short period of time prior to returning to a closed position.

The fault relay 110 shown in embodiment of the control circuit in Figures 4A and 4B may be provided in the form of a 30 Amp fault relay for larger loads.

As discussed in relation to Figure 2A and 2B, the control circuit 110 may include two fault relays 128, 130. Figure 5A and 5B illustrates a modified version of the control circuit 100 of Figures 4A and 4B which includes two fault relays 128, 130. In particular, a first fault relay 128 includes a contact 132 which disconnects the active input terminal 102 from the active output terminal 120 in the event that the first relay 128 is electrically actuated by the

trip relay 108. A second fault relay 130 includes a contact 134 which disconnects the neutral input 104 terminal from the neutral output terminal 122 in the event that the second relay 130 is electrically actuated by the trip relay 108. In one particular configuration, the first and second relays 128, 130 may be both 16 Amp fault relays such that the control circuit 100 is rated for 16 Amp applications.

As shown in Figures 1A, 1B, 4A and 4B, the control circuit 100 may include a mode switch 136 electrically connected between the fault relay 110 and the sensor line 106. The mode switch 136 can include two positions. In a first position, the mode switch 136 is closed such that when the fault relay 110 energizes and operates in the second mode, the sensor line 106 is pulled to neutral as discussed above. Generally, the mode switch is to be placed in the first position in the event that the electronic protection device 10 is to be used for a MEN distribution system (TN/TT network). In a second position, the mode switch 136 is open such that when the fault relay 110 energizes and operates in the second mode, the sensor line 106 is not pulled to neutral. Generally, the mode switch 136 is to be placed in the second position in the event that the electronic protection device 10 is to be used for a non-MEN distribution system (IT network). Therefore, when the electronic protection device 10 is being installed, the installer can toggle the mode switch 136 between the first and second position depending upon the type of electrical distribution system which is supplying the load 154. A similar configuration is provided for the embodiment of Figures 2A, 2B, 4A and 4B. In particular, the second fault relay 130 is electrically connected to the mode switch 136 which is in turn electrically connected to the sensor line 106. The operation of the mode switch 136 in this embodiment is the same to that for the embodiments discussed in relation to Figures 1A, 1B, 4A, and 4B.

As shown in the figures, a GMOV 170 may be located between the active and neutral input terminals such to provide protection against voltage spikes and the like.

When the electronic protection device 10 is installed in a MEN EDS (TN/TT network) which has an RCD feeding into the input terminals of the electronic protection device, diode D2 is removed from the control circuit 100 thereby creating an open circuit in this

part of the control circuit 100, thereby preventing false trips of the RCD.

Referring to Figure 6 there is shown a front view of an example of the electrical protection device 10. In particular, the electrical protection device 10 includes a housing 610 which at least partially houses the control circuit 10 (shown in dotted line). The control circuit includes a first electrical plug 602 and second electrical plug 606 that extend from the housing 610 via respective electrical cables 604, 608. The first electrical plug is for electrically connecting the input terminals 102, 104 of the control circuit provided in the form of the two pins of the first electrical plug with the power supply active and neutral terminals 190, 192. The first electrical plug may be provided in the form of a male electrical plug. The second electrical plug is for electrically connecting the output terminals 120, 122 with the load active and neutral terminals 150, 152. The second electrical plug can be provided with three electrical connectors, wherein the first and second connectors are the active and load output terminals 120, 122 of the control circuit 100 and the third connector is the sensor line which couples to the earth wire of the load. As shown in Figure 6, the test switch 138 and reset switch 140 projected from a wall of the housing 610. The test and reset switches 138, 140 may be provided in the form of press-buttons. As shown in Figure 6, the electrical cables 604, 608 may be of varying length for the particular application. In the event that the electrical protection device 10 is to be connected to an RCD 112, the first electrical plug can be replaced with two wires connected to the input terminals 102, 104 of the control circuit 100 which extend from the housing 610. The two wires can be electrically connected to respective output terminals of the RCD 112.

It will be appreciated that the provision of the first and second electrical plugs 602, 604 are preferable in circumstances where the electrical protection device 10 is to be physically located between an electrical output of a power supply 191 and an electrical input of the load. However, it is possible to retrofit a power supply 191, such as an inverter or a generator, with the electronic protection device 10 or the control circuit 100 such that the electrical protective device 10 or the control circuit 100 is connected between the power supply 191 output and the power supply 191 power outlet. In particular, the electronic

protection device 10 or control circuit 100 does not include conventional first and second electrical plugs, but simply a set of electrical connectors (i.e. wires or similar) which can be electrically connected to particular electrical portions of the power supply 191. Specifically, the active and neutral output terminals 190, 192 of the power supply 191 which are connected to the general power outlet (GPO) of the power supply 191 can be disconnected and electrically connected to the active and neutral input connectors 102, 104 of the control circuit 10. The active and neutral output connectors 120, 122 of the control circuit 10 can be electrically connected to the active and neutral electrical connectors of the GPO. An electrical connector of the sensor line 106 can be electrically connected to the earth electrical connection of the GPO of the power supply 191.

The housing 610 of the electronic protection device 10 or the control circuit 100 can be mounted within a housing of the power supply 191. One or more holes can be formed in the housing of the power supply 191 to expose the test and reset switches 138, 140 through the housing of the power supply 191.

Embodiments of the invention have been particularly developed for protecting electrical loads that are use in either or both of a MEN electrical distribution system (TN/TT network) or a floating earth electrical distribution system (IT network). While some embodiments have been described with particular reference to that application, it will be appreciated that the invention is not limited to such a field of use, and is applicable in broader contexts, for example, in a DC voltage EDS.

Many modifications will be apparent to those skilled in the art without departing from the scope of the present invention.

It is to be noticed that the term connected, when used, should not be interpreted as being limited to direct connections only. The terms "coupled" and "connected," along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. Thus, the scope of the expression a device A connected to a device B should not be limited to devices or systems wherein an output of device A is

directly connected to an input of device B. It means that there exists a path between an output of A and an input of B which may be a path including other devices or means. "Connected" may mean that two or more elements are either in direct physical or electrical contact, or that two or more elements are not in direct contact with each other but yet still co-operate or interact with each other.

Claims

1. A control circuit for an electrical protection device including:

at least two input terminals including a first terminal for electrically connecting with an active terminal of a supply and a second terminal for electrically connecting with a neutral terminal of the supply;

at least two output terminals including a first output terminal for electrically connecting with a load active terminal of an electrical load and a second output terminal for electrically connecting with a neutral terminal of the load;

a sensor line for electrical connection to a reference which should be electrically isolated from the active and neutral terminals of the supply;

at least one fault relay operable in a first mode and a second mode, wherein in the first mode the input and output terminals are electrically connected for allowing the load to receive electrical supply via the at least one fault relay, and in the second mode the input and output terminals are electrically isolated thereby preventing electrical supply being provided to the load; and

a detector for actuating the at least one fault relay in response to sensing a current flowing through the sensor line which meets or exceeds a threshold current.

2. The control circuit according to claim 1, wherein when the at least one fault relay operates in the second mode, the at least one fault relay connects the sensor line with the neutral terminal of the supply.

3. The control circuit according to claim 2, wherein the control circuit includes a mode switch to selectively configure the control circuit to connect the sensor line with the neutral terminal of the supply when the at least one fault relay operates in the second mode.

4. The control circuit according to any one of claims 1 to 3, wherein the detector is a trip relay which operates in an energized mode in response to the current flowing through the sensor line meets or exceeds the threshold current.

5. The control circuit according to claim 4, wherein the trip relay is a low voltage trip relay.

6. The control circuit according to claim 4 or 5, wherein in response to the at least one fault relay progressing to the second mode, the trip relay progresses to a de-energized mode whilst the at least one fault relay is maintained in the second mode.

7. The control circuit according to any one of claims 1 to 6, wherein the control circuit includes a test switch which upon user actuation causes current to flow through the sensor line which is sufficient for the detector to actuate the at least one fault relay to operate in the second mode.

8. The control circuit according to claim 7, wherein the control circuit includes a reset switch arrangement including a reset switch and a reset relay, wherein upon user actuation of the reset switch, the reset relay progresses from an initial state to a reset state to cause the at least one fault relay to operate in the first mode.

9. The control circuit according to claim 8, wherein upon the at least one fault relay progressing back to the first mode in response to the user action of the reset switch, the reset relay progresses from the reset state to the initial state.

10. The control circuit according to any one of claims 1 to 9, wherein the control circuit includes a first fault relay and a second fault relay, wherein in response to the trip relay progressing to the energized mode, the first fault relay isolates the first input terminal from the first output terminal and the second fault relay isolates the second input terminal from the second output terminal.

11. The control circuit according to claim 10, wherein the first and second fault relay operate substantially simultaneously in response to the trip relay operating in the energized mode.

12. The control circuit according to any one of claims 1 to 9, wherein the control circuit includes a single fault relay including a first and second contact which electrically connect the respective input and output terminals in the first state, wherein in response to the trip relay progressing to the energized mode, the first and second contacts move such that the single fault relay operates in the second mode where the input and output terminals are isolated from each other.

13. An electrical protection system including:

a residual current device (RCD) connected to an active terminal and a neutral terminal of a supply, wherein the RCD includes an active output terminal and a neutral output terminal; and

an electrical protection device including a control circuit electrically connected to the RCD, wherein the control circuit includes:

at least two input terminals including a first terminal for electrically connecting with the active output terminal of the RCD and a second terminal for electrically connecting with the neutral output terminal of the RCD;

at least two output terminals including a first output terminal for electrically connecting with a load active terminal of an electrical load and a second output terminal for electrically connecting with a load neutral terminal;

a sensor line for electrical connection to a reference which should be electrically isolated from the active terminal of the supply;

at least one fault relay operable in a first mode and a second mode, wherein in the first mode the input and output terminals are electrically connected for allowing the load to receive electrical supply via the at least one fault relay, and in the second mode the input and output terminals are electrically isolated, and the sensor line is connected with the neutral output terminal of the RCD, wherein in response to the sensor line being connected to the neutral output terminal of the RCD, the RCD senses a fault condition and disconnects the active and neutral terminals of the supply from the active and neutral output terminals of the RCD; and

a detector for actuating the at least one fault relay in response to sensing a current flowing through the sensor line which meets or exceeds a threshold current.

14. The electrical protection system according to claim 13, wherein the detector is a trip relay which operates in an energized mode in response to the current flowing through the sensor line meeting or exceeding the threshold current.

15. The electrical protection system according to claim 14, wherein the trip relay is a low voltage trip relay.

16. The electrical protection system according to claim 14 or 15, wherein in response to the at least one fault relay progressing to the second mode, the trip relay progresses to an de-energized mode whilst the at least one fault relay is maintained in the second mode.

17. The electrical protection system according to any one of claims 14 to 16, wherein the control circuit includes a test switch which upon user actuation causes current to flow through the sensor line which is sufficient for the detector to actuate the at least one fault relay to operate in the second mode.

18. The electrical protection system according to claim 17, wherein the control circuit includes a reset switch arrangement including a reset switch and a reset relay, wherein upon user actuation of the reset switch, the reset relay progresses from an initial state to a reset state to cause the at least one fault relay to operate in the first mode.

19. The electrical protection system according to claim 18, wherein upon the at least one fault relay progressing back to the first mode in response to the user action of the reset switch, the reset relay progresses from the reset state to the initial state.

20. The electrical protection system according to any one of claims 14 to 19, wherein the control circuit includes a first fault relay and a second fault relay, wherein in response to the trip relay progressing to the energized mode, the first fault relay isolates the first input terminal from the first output terminal and the second fault relay isolates the second input terminal from the second output terminal.

21. The electrical protection system according to claim 20, wherein the first and second fault relay operate substantially simultaneously in response to the trip relay operating in the energized mode.

22. The electrical protection system according to any one of claims 14 to 19, wherein the control circuit includes a single fault relay including a first and second contact which electrically connect the respective input and output terminals in the first state, wherein in response to the trip relay progressing to the energized state, the first and second contacts move such that the single fault relay operates in the second mode where the input and output terminals are isolates from each other.

23. An electrical protection device including:

a housing; and

a control circuit according to any one of claims 1 to 12, wherein the housing at least partially houses the control circuit.

24. The electrical protection device according to claim 23, wherein the control circuit includes a first electrical plug and a second electrical plug which extend from the housing, wherein the first electrical plug is for electrically connecting the supply active and neutral terminals to the input terminals of the control circuit and the second electrical plug is for electrically connecting the load active and neutral terminals with the output terminals of the control circuit.

25. The electrical protection device according to claim 23 or 24, wherein the second electrical plug includes a connector which is the sensor line for connecting with an earth pin of the load.

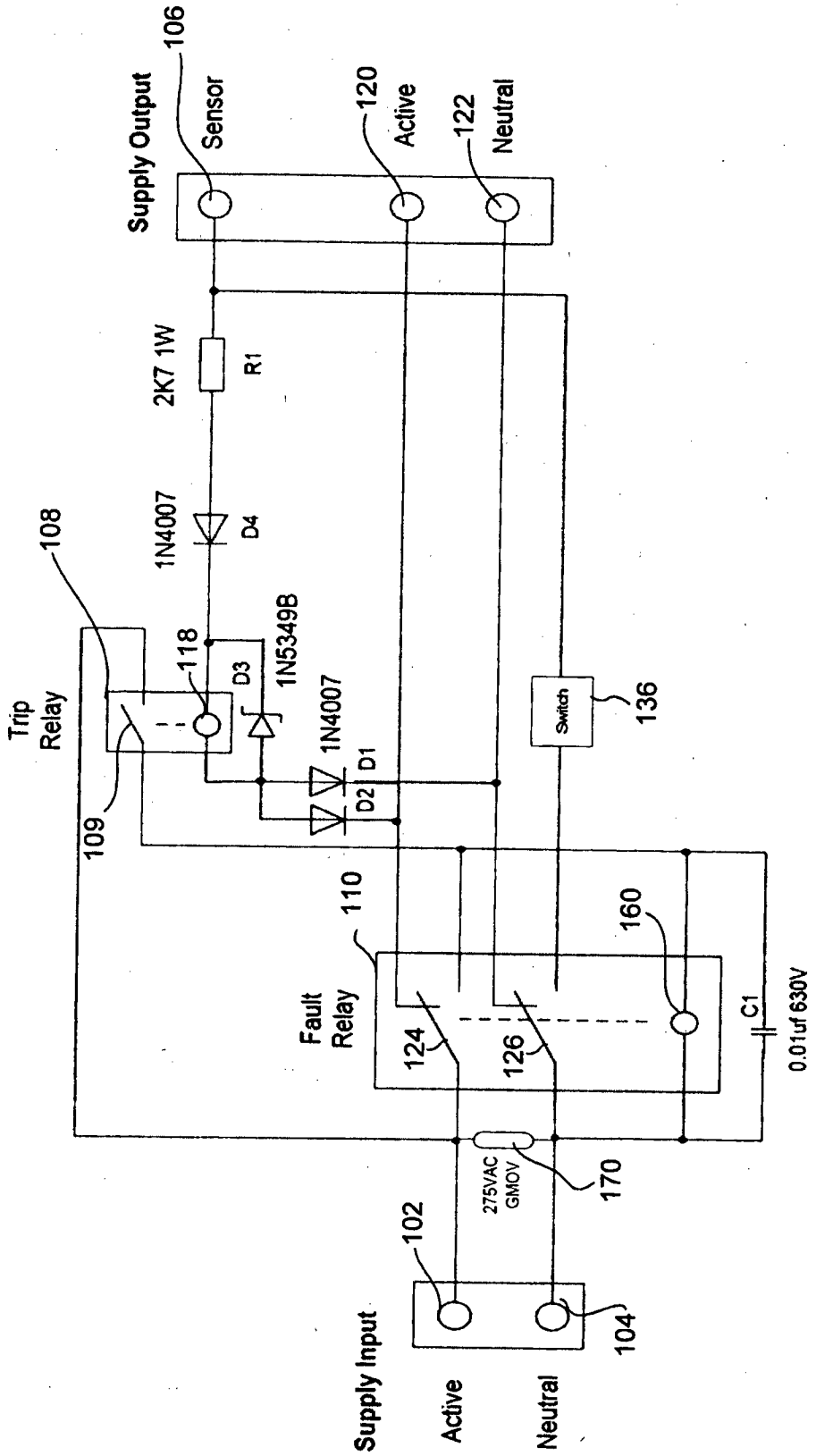
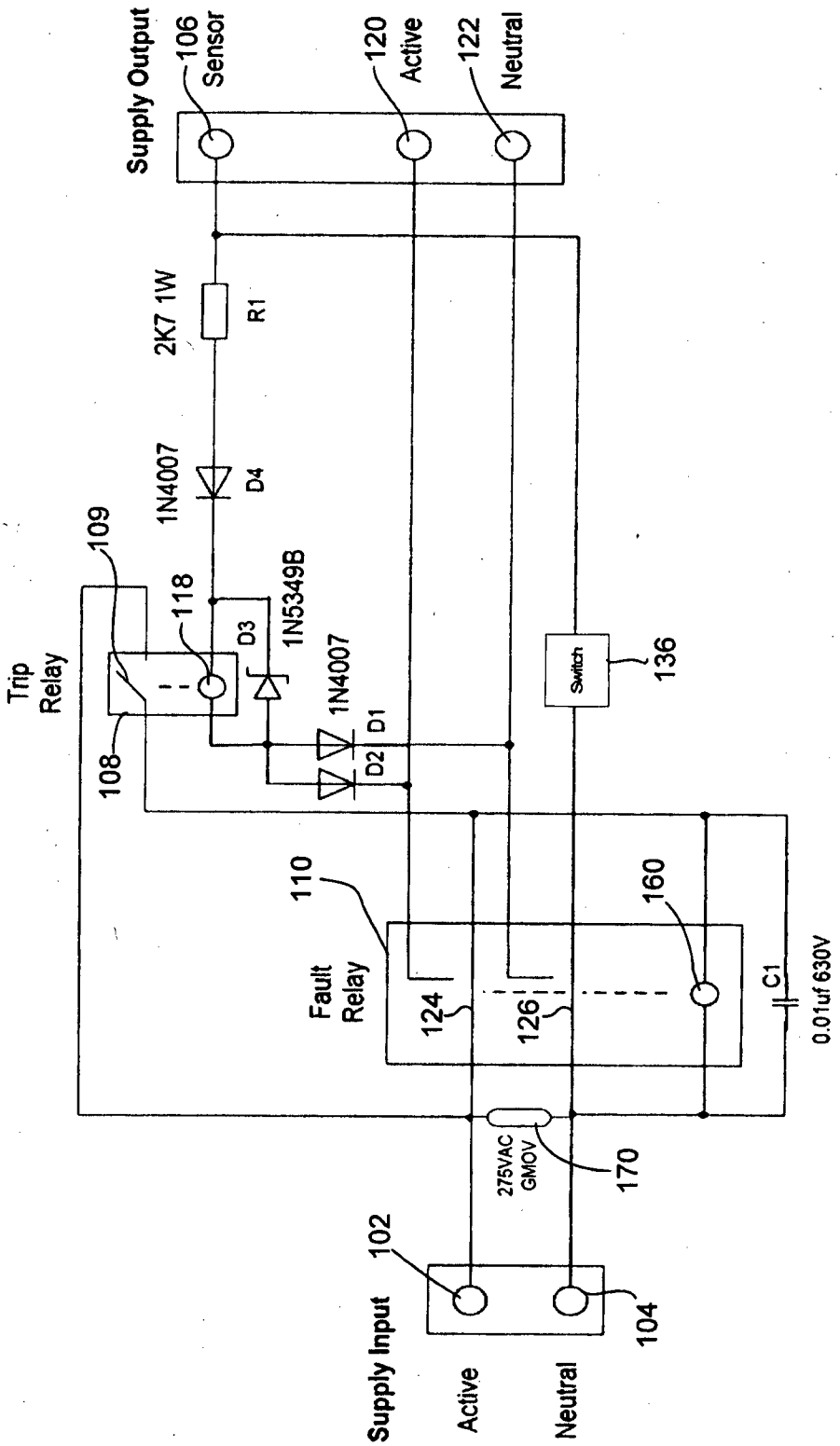

Supply Output
106
Sensor
120
Active
122
Neutral
2K7 1W
R1
1N4007
D4
108
Trip
Relay
118
D3
1N5349B
1N4007
D1
D2
109
Switch
136
110
Fault
Relay
160
124
126
C1
0.01uf 630V
275VAC
GMOV
170
102
Supply Input
Active
Neutral
104

FIGURE 1A


Supply Output
106
Sensor
120
Active
122
Neutral
2K7 1W
R1
1N4007
D4
109
118
D3
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Trip
Relay
1N4007
D1
D2
108
Switch
136
110
160
Fault
Relay
124
126
C1
0.01uf 630V
275VAC
GMOV
170
102
Supply Input
Active
Neutral
104

FIGURE 1B

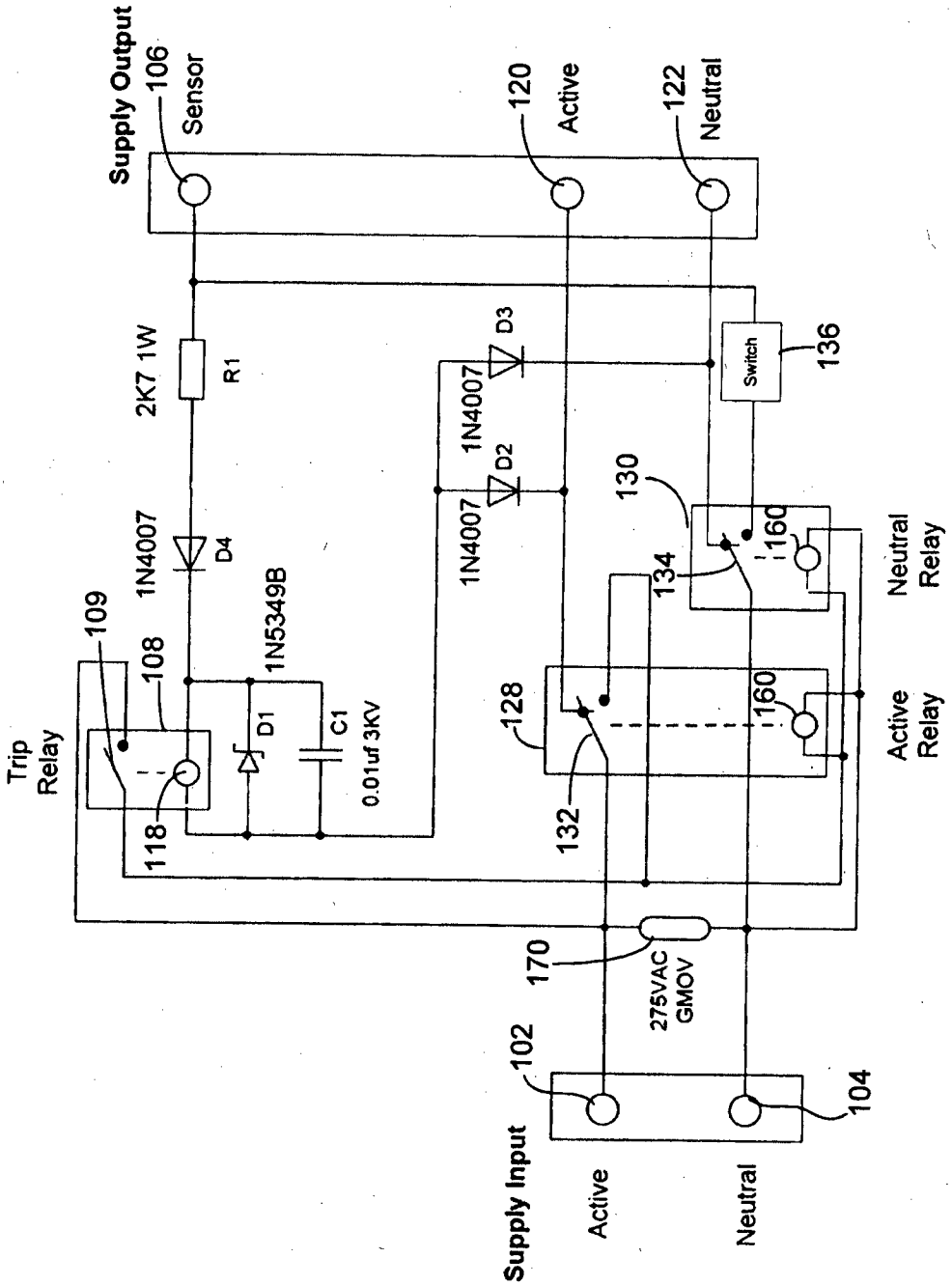
Supply Output
106
Sensor
120
Active
122
Neutral
2K7 1W
R1
D3
1N4007
D2
1N4007
Switch
136
1N4007
D4
1N5349B
D1
C1
0.01uf 3KV
130
134
160
Neutral Relay
109
108
Trip Relay
118
128
132
160
Active Relay
170
275VAC GMOV
102
Supply Input
Active
Neutral
104

FIGURE 2A

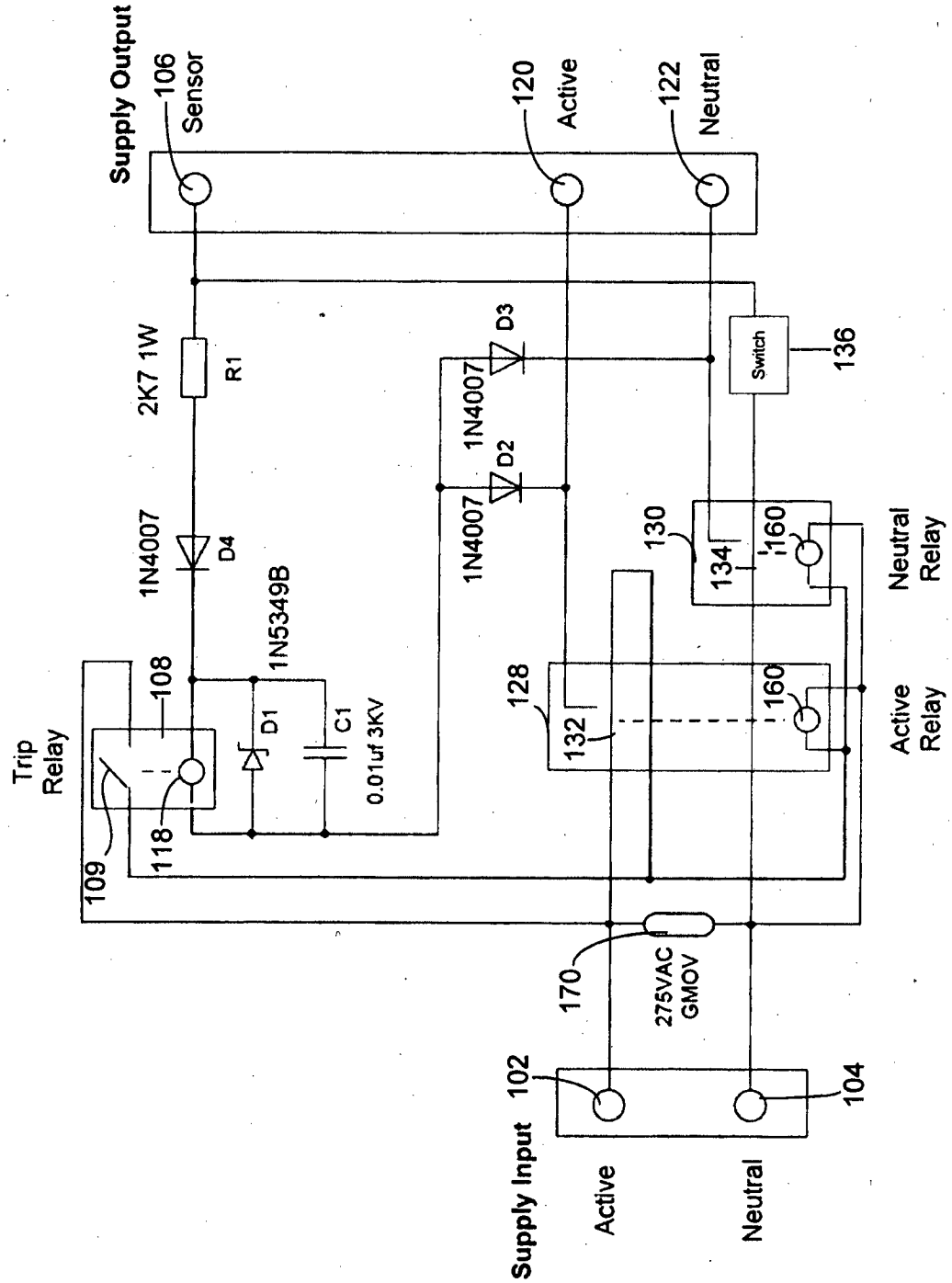
Supply Output
106
Sensor
120
Active
122
Neutral
2K7 1W
R1
D3
1N4007
Switch
136
D2
1N4007
1N4007
D4
130
134
160
Neutral
Relay
1N5349B
108
D1
C1
0.01uf 3KV
128
132
160
Trip
Relay
Active
Relay
109
118
170
275VAC
GMOV
102
104
Supply Input
Active
Neutral

FIGURE 2B

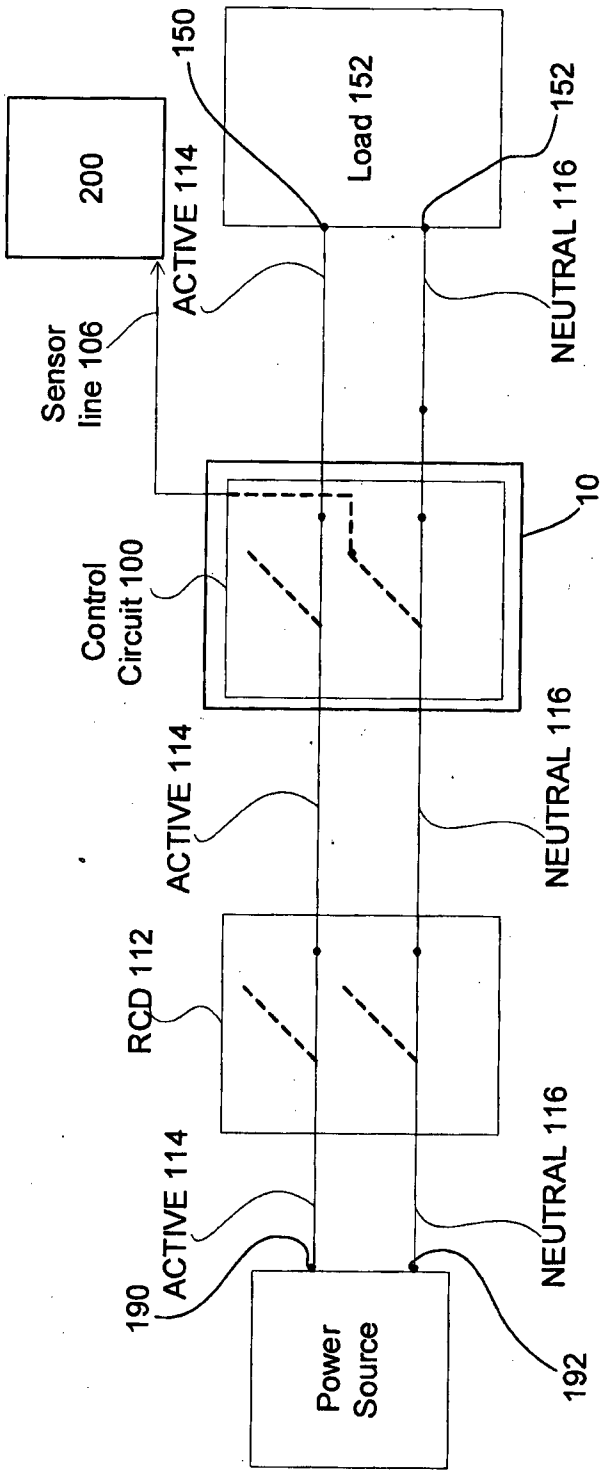
200
150
Load 152
152
ACTIVE 114
NEUTRAL 116
Sensor line 106
10
Control Circuit 100
ACTIVE 114
NEUTRAL 116
RCD 112
ACTIVE 114
NEUTRAL 116
190
Power Source
192

FIGURE 3

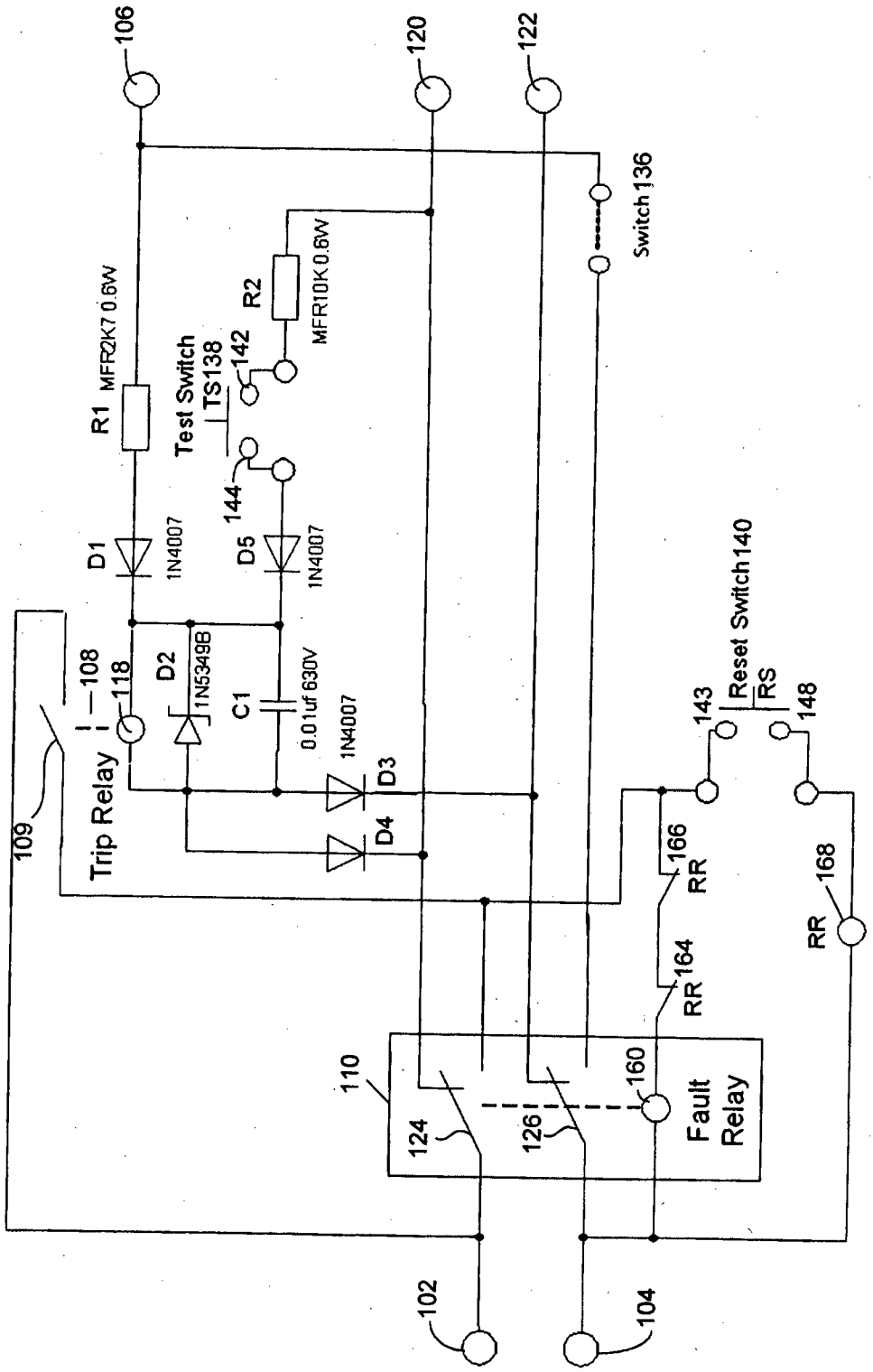
106
120
122
Switch 136
R1 MFR2K7 0.6W
R2 MFR10K 0.6W
Test Switch TS138
142
144
D1 1N4007
D5 1N4007
D2 1N5349B
C1 0.01uf 630V
1N4007
D3
D4
108
118
Trip Relay
109
Reset Switch 140
RS
143
148
166
RR
164
RR
168
RR
Reset Relay 162
110
124
126
160
Fault Relay
102
104

FIGURE 4A

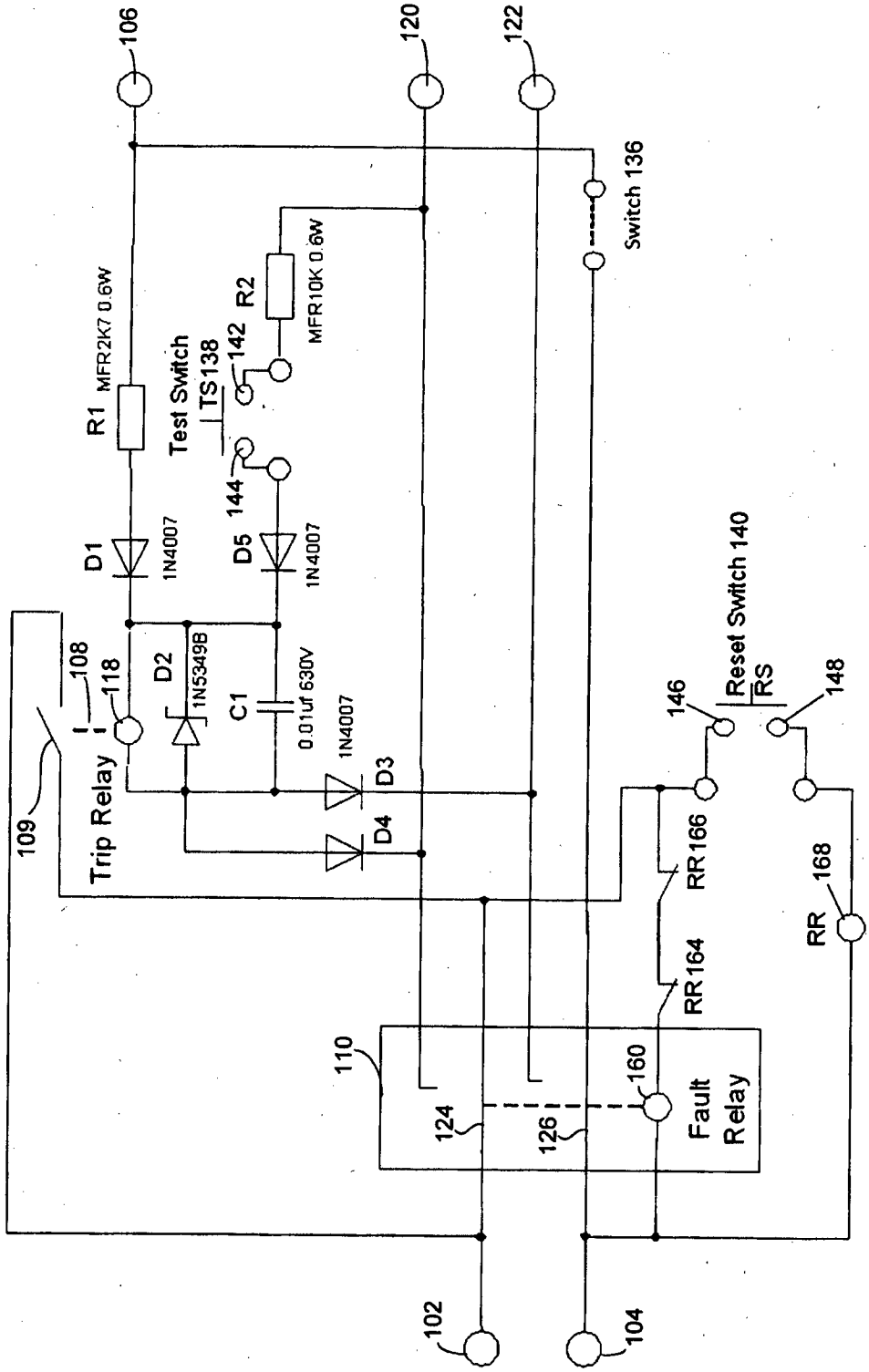
106
120
122
Switch 136
R1 MFR2K7 0.6W
Test Switch TS138
142
R2 MFR10K 0.6W
144
D1 1N4007
D5 1N4007
D2 1N5349B
C1 0.01uf 630V
1N4007
D3
D4
108
118
Trip Relay
109
Reset Switch 140
RS
146
148
RR166
RR164
RR 168
Reset Relay 162
110
124
126
160
Fault Relay
102
104

FIGURE 4B

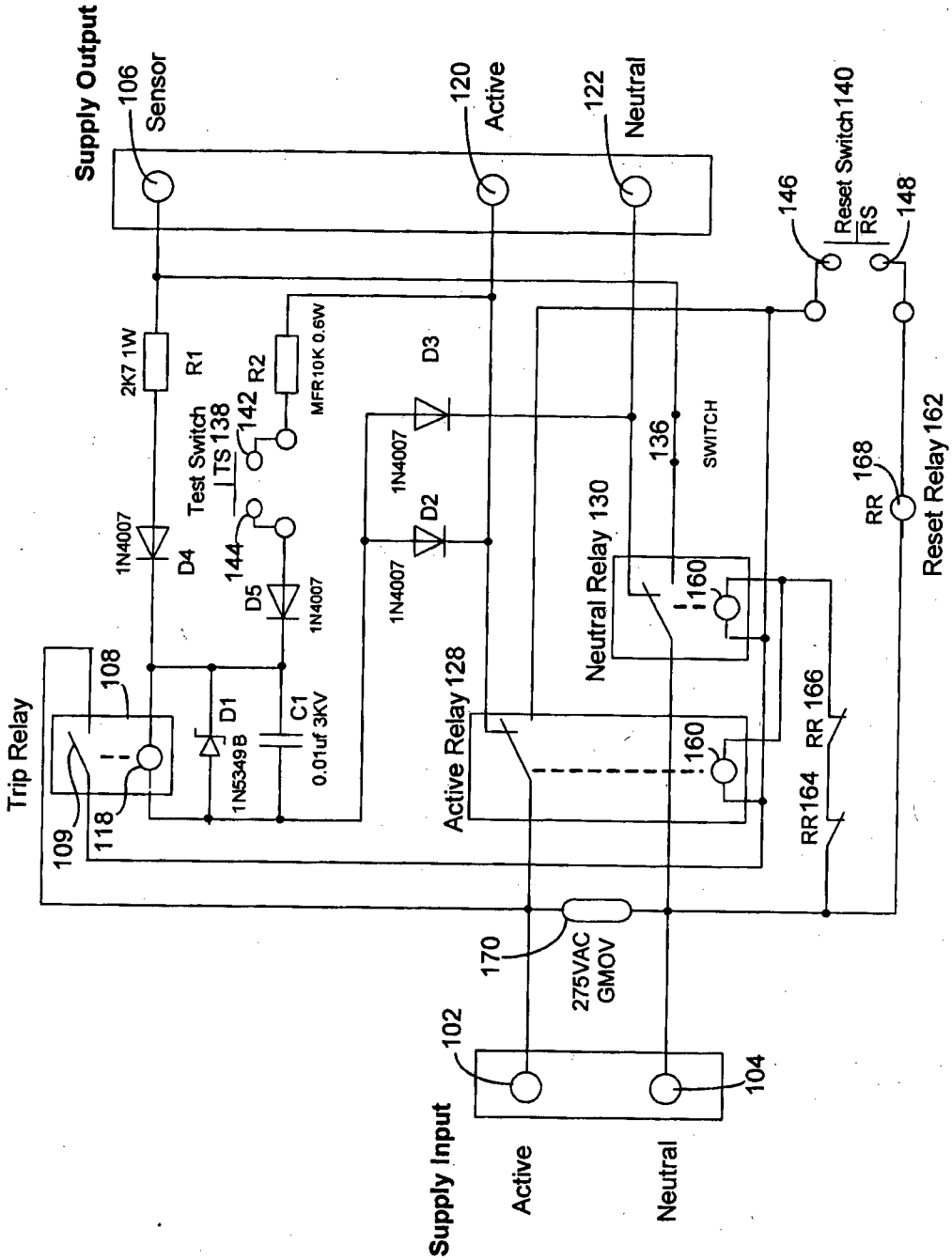
Supply Output
106
Sensor
120
Active
122
Neutral
146
Reset Switch 140
RS
148
2K7 1W
R1
R2
MFR10K 0.6W
D3
1N4007
D2
1N4007
1N4007
D4
Test Switch
TS 138
142
144
D5
1N4007
136
SWITCH
RR 168
Reset Relay 162
Neutral Relay 130
160
Trip Relay
108
D1
1N5349B
C1
0.01uf 3KV
Active Relay 128
160
RR 166
RR164
109
118
170
275VAC
GMOV
102
104
Supply Input
Active
Neutral

FIGURE 5A

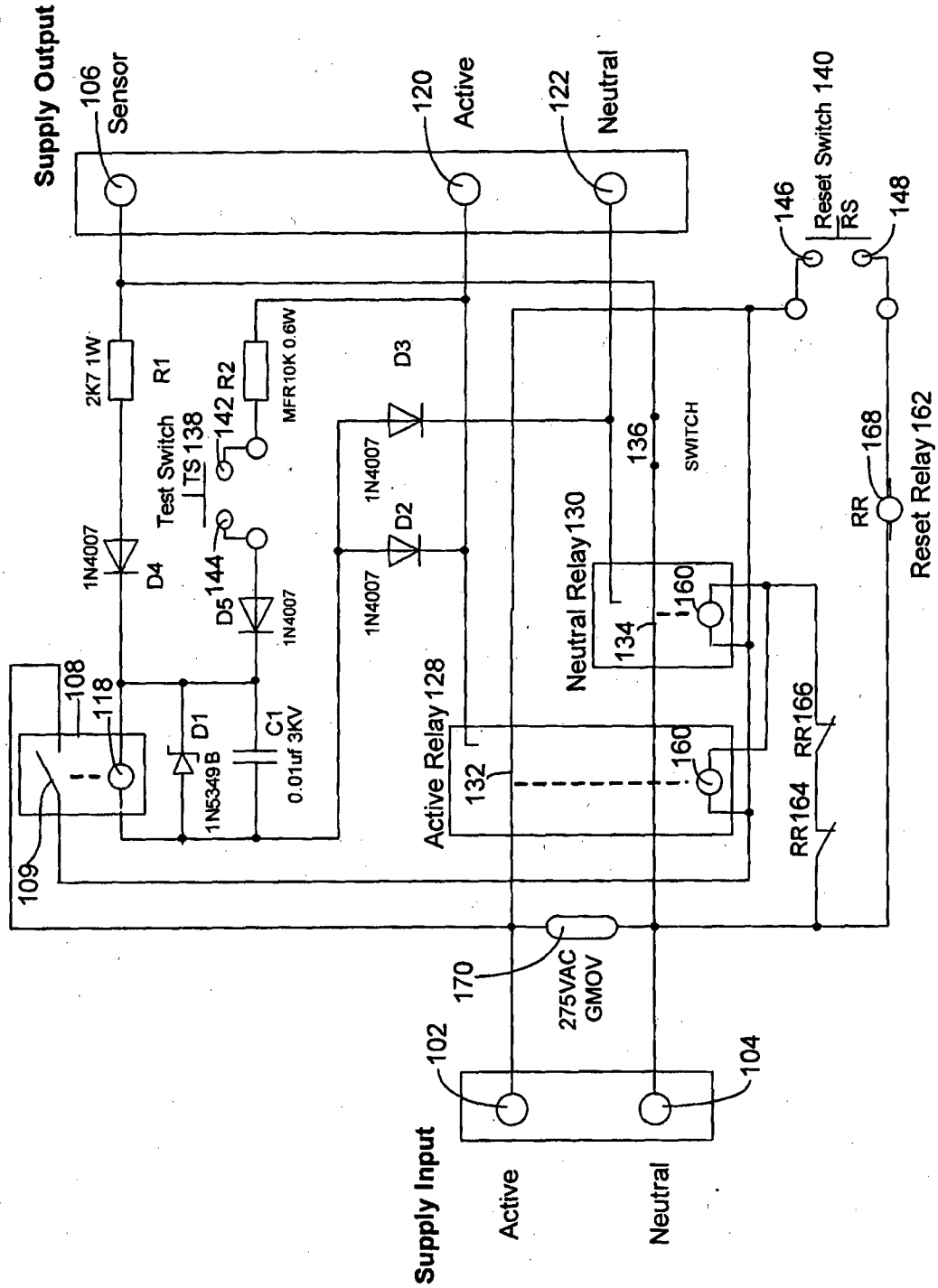
Supply Output
106
Sensor
120
Active
122
Neutral
146
Reset Switch 140
RS
148
2K7 1W
R1
142 R2
MFR10K 0.6W
D3
1N4007
Test Switch
TS 138
136
SWITCH
1N4007
D4
D2
144
D5
1N4007
1N4007
Neutral Relay 130
160
134
RR
168
Reset Relay 162
108
118
D1
1N5349B
C1
0.01uf 3KV
Active Relay 128
132
160
RR166
RR164
109
170
275VAC
GMOV
102
104
Supply Input
Active
Neutral

FIGURE 5B

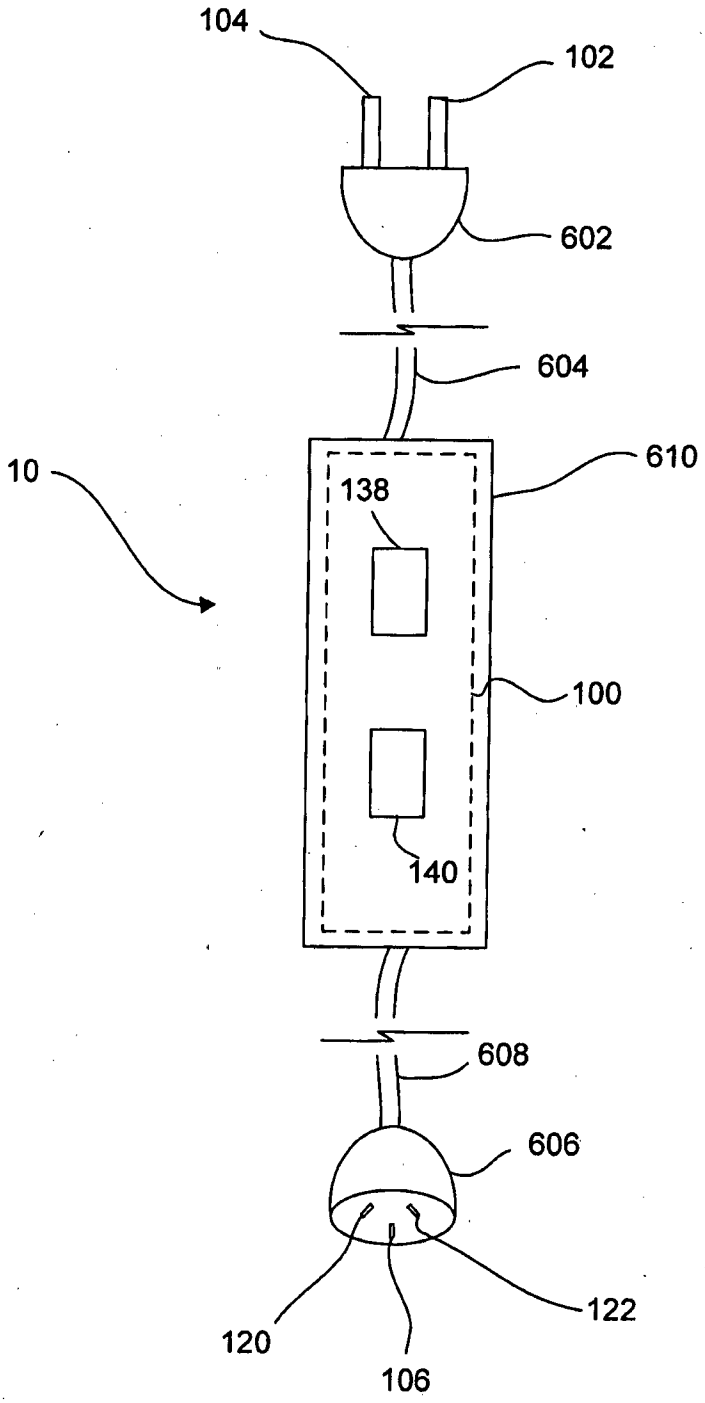

FIGURE 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2013/000504

A. CLASSIFICATION OF SUBJECT MATTER

H02H 3/00 (2006.01) H02H 1/06 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI: IPC H02H, H01H & Keywords: (electrical, overload, surge, protect, circuit w breaker, isolate, earth, ground, residual w current w device, toroid, RCD, sensor, detector, fault, leakage, current, threshold, limit, difference, discriminate) and similar terms.

Google Patents, Esp@ce. Keywords: (electrical, protection device, safety device, overload, surge detect, circuit breaker, isolate, control circuit, residual current device, RCD, power supply, electrical load, sensor, detector, actuator, fault relay, switch, reset, mode, state, operable, disconnect, trip relay, low voltage, test switch, reset relay, energized or de-energized mode, current imbalance, current threshold, leakage) and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 July 2013	08 July 2013

Name and mailing address of the ISA/AU

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Authorised officer

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AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No. 0262832833

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2013/000504**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/0221600 A1 (KINSEL et al.) 15 September 2011 abstract; paragraphs 8, 24, 38-44, 49 and 71; FIGs. 1 and 10-12	1-25
P,X	WO 2012/065224 A1 (GATO et al.) 24 May 2012 whole document, in particular, abstract; pages 1-5, 7-11 and 17-18; FIGs. 1-4 and 8-9	1-25

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2013/000504**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 2011/0221600 A1	15 Sep 2011	CN 102792538 A	21 Nov 2012
		EP 2548273 A1	23 Jan 2013
		MX 2012010639 A	29 Nov 2012
		US 2011221600 A1	15 Sep 2011
		WO 2011115863 A1	22 Sep 2011
WO 2012/065224 A1	24 May 2012	WO 2012065224 A1	24 May 2012

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.