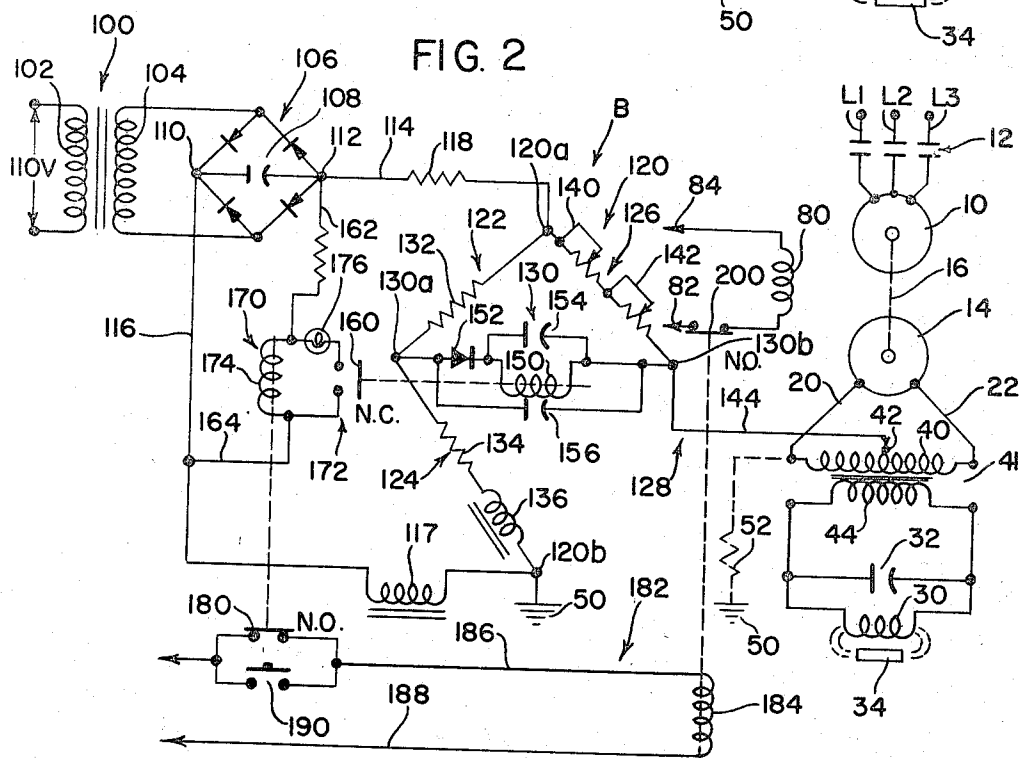
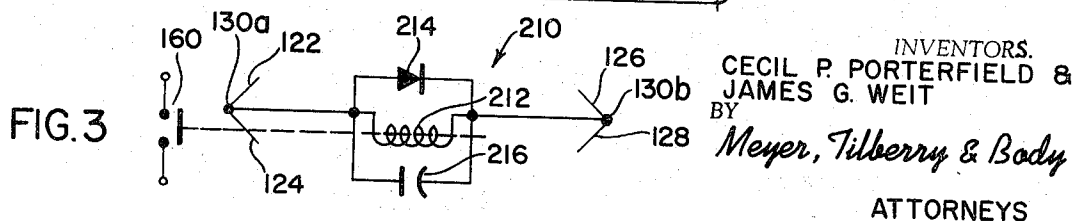


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GROUND DETECTOR FOR AN INDUCTION HEATING INSTALLATION

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GROUND DETECTOR FOR AN INDUCTION HEATING INSTALLATION

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This invention pertains to the art of induction heating and more particularly to a ground detector for an induction heating installation.

The invention is particularly applicable to a device for detecting a ground between the frame of a high frequency rotary generator and the primary winding of a transformer connected across the output terminals of the generator, and it will be described with particular reference thereto; however, it will be appreciated that the invention has much broader applications and may be used for detecting a ground at various locations in an electrical installation.

In operating an induction heating apparatus or installation, relatively high voltages are generated in the output circuit of the power supply being used. These voltages can present a substantial hazard to an operator and/or damage to the induction heating equipment if a ground or short is developed between high voltage points and the frame structure supporting the apparatus. To guard against these hazards, most induction heating equipment is provided with a ground detector which indicates when a ground or short exists between two selected elements of the equipment. These elements are generally the supporting frame structure and a selected portion of the output circuit of the generator. Many of these ground detectors also automatically shut down the power supply upon appearance of a ground or short in the equipment. The most common ground detector now in use includes a pulsating DC power supply connected in series with both a relay coil and two terminals across which the resistance changes upon the presence of a ground or short. This type of ground detector has various inherent disadvantages.

The most important shortcoming of these prior ground detectors is that the detector is inoperative if the DC power supply fails. Thus, an operator may believe that the ground detector is in operation, when due to a failure of the power supply it is not. Under these conditions, a ground or short can occur within the induction heating equipment without being indicated by the detector device. This may cause a serious hazard to the operator, and thus distract from the overall safety aspects surrounding the use of a ground detector.

In addition, these prior devices for detecting grounds or shorts within induction heating apparatus are affected by superimposed AC currents from the heating circuit being monitored. Consequently, the operation of prior ground detectors is adversely affected by changes in the loading of the apparatus into which the detector is incorporated. Also, these prior detectors have had a rather wide range of response. This made the devices somewhat less sensitive than desired for accurate protection of the equipment.

These and other disadvantages of prior ground detectors have been completely overcome by the present invention which is directed toward a ground detector for an induction heating installation which detector incorporates a novel circuit for responding to unwanted grounds or shorts between selected elements of the installation.

In accordance with the present invention there is provided a device for de-energizing the power supply of an induction heating installation upon the appearance of a

ground across two selected points in the installation. This device comprises: a bridge circuit having two output terminals adapted to be connected to a supply of DC voltage, four impedance legs and a null detecting intermediate branch spaced from the terminals by the legs; a resistor adjusted to have a resistance level corresponding to the minimum allowable resistance across the points, this resistor is connected within the first leg of the bridge circuit; and, the electrical circuit between the two selected points is connected within a second leg of the bridge circuit. Further, the first and second legs are arranged within the bridge circuit so that current will tend to flow through the branch in a first direction when the resistance of the second leg is substantially above the minimum allowable level, current will tend to flow through the branch in a second direction when the resistance of the second leg is substantially below the minimum allowable level, and no current will tend to flow through the branch when the resistance in the second leg is approximately at the minimum allowable level. Means are also provided in the null detecting branch for de-energizing the power supply of the induction heating installation when current flow through the branch approaches zero.

By incorporating the device described above, a null detecting bridge circuit is utilized for indicating when a short or ground exists between two selected points in an induction heating installation. The null detector allows a well defined operating point in response to a ground within the induction heating installation, and this point is maintained over large variations in the operating parameters.

The primary object of the present invention is the provision of a ground detector for an induction heating installation, which detector is relatively inexpensive, can be used without drastic reconstruction or redesign of existing equipment, is stable in operation, is sensitive and is fail safe.

Another object of the present invention is the provision of a ground detector for an induction heating installation, which detector is not affected by superimposed AC currents imposed upon the ground detector.

Still another object of the present invention is the provision of a ground detector for an induction heating installation, which detector utilizes a bridge type sensing circuit to provide response when a null occurs within the bridge circuit.

Still another object of the present invention is the provision of a ground detector for an induction heating installation, which detector is not drastically affected by changes in its power supply.

These and other objects and advantages will become apparent from the following description used to illustrate a preferred embodiment of the invention as read in connection with the accompanying drawing in which:

FIGURE 1 is a wiring diagram illustrating, somewhat schematically, the prior art of which the present invention is an improvement;

FIGURE 2 is a wiring diagram showing, somewhat schematically, the preferred embodiment of the present invention; and,

FIGURE 3 is a partial wiring diagram illustrating, somewhat schematically, a modification of the preferred embodiment as shown in FIGURE 2.

Referring now to the drawing wherein the showings are for the purpose of illustrating preferred embodiments of the invention only and not for the purpose of limiting same, FIGURE 1 shows the prior art to which the present invention is directed. A ground detector A is incorporated within an induction heating installation including a motor 10 powered by input leads L1, L2, and L3 upon closing of conventional circuit breakers 12. Motor 10 drives a

generator 14 through a connecting shaft 16. In accordance with normal practices, the output leads 20, 22 energize a heating inductor 30 having a parallel power factor correcting capacitor 32. A workpiece 34 is magnetically coupled with inductor 30 so that the workpiece is heated when current is directed from the generator to the output leads. It is appreciated that the present invention is applicable with various induction heating installations; therefore, the workpiece 34 may take a variety of forms.

To couple the generator with the inductor 30, a primary winding 40 of a matching transformer 41 is connected across leads 20, 22. The primary winding includes a center tap 42 which is used for the ground detector, in a manner to be hereinafter described. The secondary winding 44 of matching transformer 41 is connected across the inductor 30 to complete the output circuit of the generator. The frame of the heating apparatus is represented as a ground 50 connected with lead 20 by a circuit 52. During normal operation, the circuit 52 is open and no current flows therethrough. When a ground or short appears between the frame and lead 20, the resistance of circuit 52 decreases drastically to allow current flow through this circuit. This current flow actuates the ground detector A, in a manner to be described.

The ground detector A includes a power supply 60 having a primary winding 62 connected across a 110 volt lighting circuit and a second winding 64 connected between ground 50 and line 66. Within line 66 there is provided a half wave rectifying diode 68, a rheostat 70 for limiting the voltage within line 66 and a relay coil 72. The relay coil controls normally closed contacts or switch 74. Generator 14 includes a field winding 80 having input leads 82, 84. By providing the normally closed switch 74 within the field winding circuit of the generator, a substantial current flow through coil 72 opens the switch and de-energizes the field winding. This shuts down the generator 14.

In operation, a short or ground between lead 20 and frame 50 decreases the resistance within circuit 52. This causes a current flow through the coil 72, and generator 14 is shut down. It is appreciated that a failure of the power supply 60 disconnects the ground detector A from the induction heating installation. This is one hazard of the prior art ground detector shown in FIGURE 1. In addition, ground detector A is affected by superimposed AC currents caused by current flow in the installation and imposed on the detector. It is also noted that the half wave rectifier 68 creates a substantial amount of ripple through the line 66, and this affects the operating point at which the switch 74 is de-energized.

Referring now to FIGURE 2, the preferred embodiment of the present invention is illustrated. This embodiment includes a ground detector B having a power supply 100. This power supply includes a primary winding 102 connected across the lines of a 110 volt lighting circuit and a secondary 104 connected across the input terminals of a full wave rectifier 106. The rectifier includes a conventional filter capacitor 108 and output terminals 110, 112. Lines 114, 116 extend from the full wave rectifier and include a current limiting resistor 118 and an AC blocking choke 117, respectively. Also, lines 114, 116 are connected across a bridge circuit 120 having input terminals 120a, 120b. The bridge circuit includes legs 122, 124, 126 and 128 and a null detecting branch 130 having input terminals 130a, 130b.

Referring now to the bridge leg 122, there is provided a resistor 132. Leg 124 includes a resistor 134 and an AC blocking choke 136. The resistance of these two legs, in accordance with the preferred embodiment of the invention, is somewhat equal to provide a balancing operation to be described later. Leg 126 of the bridge circuit includes adjustable resistors 140, 142. In practice, the resistor 140 has a somewhat finer adjustment than the resistor 142. Finally, leg 128 is connected onto the heating equipment for detecting purposes. To accomplish con-

nection with the heating equipment, there is provided a line 144 connected onto the center tap 42 of the primary winding 40. The relative resistances of the four legs within the bridge circuit 120 determines current flow through the null detecting branch 130. This branch includes a relay coil 150, a diode 152, and by-pass capacitors 154, 156.

Relay coil 150 controls normally closed contacts 160 located within lines 162, 164 extending from the output terminals of the full wave rectifier 106. These lines actually extend to a pair of parallel branches 170, 172. The first branch 170 includes a second relay coil 174 while the second branch 172 includes an indicator light 176 and a normally closed contact 160.

Second relay coil 174 controls normally open contacts or switch 180 within a control circuit 182. This control circuit includes a third relay coil 184 and lines 186, 188. An override switch 190 is connected in parallel across the normally open contacts or switch 180. In a like manner, there is provided a normally open contact 200 controlled by the third relay coil 184 and adapted to control current flow within the field winding 80 of generator 14.

In operation, the resistance of leg 126 is adjusted to a value somewhat corresponding to the minimum allowable resistance in circuit 52 forming the major resistance within the control leg 128 of the bridge circuit 120. As long as the resistance in circuit 52 is above a preselected value, which exists when there is no ground or short to the frame 50, there is current flow through branch 130 in a direction allowed by the diode 152. This current flow actuates coil 150 to open contacts 160. Consequently, current flows through relay coil 174 so that normally open contacts 180 are closed. This establishes continuity in circuit 182 so that current flows in relay coil 184 and the normally open contacts 200 are closed. In this manner, the field winding 80 is energized.

When the resistance of circuit 52 decreases below a preselected minimum value determined primarily by the setting of resistors 140, 142, current flow through branch 130 drops to a relatively low value. This deactivates coil 150, and normally closed contacts 160 close. Relay coil 170 is shunted so that normally open contacts or switch 180 are opened. Relay coil 184 is de-energized and contacts 200 open. In this manner, the field winding 80 is de-energized and the generator 14 is shut down. At the same time, light 176 indicates a ground or short. If the resistance of circuit 52 were drastically below the preset minimum value, current would tend to flow through the branch 130 in a direction opposite to the direction of current flow when circuit 52 is open. Diode 152 prevents this reverse flow so that the coil 150 is not again energized at the lower impedance levels of circuit 52. The diode functions to cause a sharply defined cutoff of current flow through coil 150 when the voltage across branch 130 decreases to a given level. Further decrease in the voltage, which may be an opposite polarity, will not actuate the coil 150.

After the short has been corrected, the detector will automatically close switch 180 or, in the alternative, the override switch 190 is manually closed. This energizes the field winding 80 until the contacts 160 open. It is appreciated that the switch 190 is optional, since the power supply 100 is connected across a 110 volt lighting line. If the power supply 100 were connected onto a circuit controlled by the output of the generator 14, the reset switch would then be appropriate for starting the generator 14.

The chokes 117, 136 prevent AC currents from flowing within branch 130. Slight AC components within this branch are by-passed around the coil 150 by capacitors 154, 156. This substantially isolates the coil 150 from unwanted fluctuations due to AC components which are imposed on the ground detector by the current flow in the output of generator 14.

If the power supply 100 should fail, the device B disconnects the field winding 80 as if a short had occurred. This fail safe feature is obtained because current flow is required through the branch 130 during normal operation

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of the detector device B, and a discontinuation of this current flow by a power failure or short actuates the detector in the same manner. This fail safe feature is a substantial advance over prior devices wherein current flow is required to actuate the ground detecting device.

By providing a bridge circuit having a sharp null point when a minimum resistance occurs within circuit 52, the actuation of the device is quite sensitive. In addition, fluctuations in the output of the rectifier 106 do not substantially change the point of operation imparted by the parameters of the bridge circuit 120. These are all substantial advances over known ground detecting devices.

Referring now to FIGURE 3, a modification of the present invention is illustrated. In this modification, the bridge circuit 120 is provided with a null detecting branch 210. This branch includes a relay coil 212 and a diode 214 connected in parallel therewith. Current flow in one direction through the branch 210 actuates the relay coil to maintain the field winding 80 energized. Current flow in the opposite direction is by-passed around the relay coil 212 so that the relay is shorted and de-energized. This de-energizes the field winding 80 by the circuit shown in FIGURE 2. A capacitor 216 is connected in parallel across the coil 212 to by-pass the AC components introduced into the circuit by the heating installation.

Example A

A ground detector as shown in FIGURE 2 has been manufactured and the various components of this manufactured device have the following values:

Capacitor 108	-----μf-----	50
Choke 117	-----hy-----	16
Resistor 118	-----ohms-----	1000
Resistor 132	-----do-----	1000
Resistor 134	-----do-----	1000
Choke 136	-----hy-----	16
Resistor 140	-----ohms-----	0-750
Resistor 142	-----do-----	0-2500
Capacitor 154	-----μf-----	2
Capacitor 156	-----do-----	2

In using the above components, the coil 150 was dropped out at approximately 35 microamperes. This device has proven satisfactory in detecting a ground within a generator output circuit somewhat similar to the circuit illustrated in this application.

The present invention has been described in connection with two preferred embodiments; however, it should be appreciated that various changes may be made in these embodiments without departing from the intended spirit and scope of the present invention as defined in the appended claims.

Having thus described our invention, we claim:

1. A device for de-energizing the power supply of an induction heating installation upon the appearance of a ground across two selected points in said installation, said device comprising:

(a) a bridge circuit having two input terminals adapted to be connected to a supply of D.C. voltage, four impedance legs and a null detecting intermediate branch spaced from said terminals by said legs;

(b) a resistor adjusted to have a resistance level corresponding to the minimum allowable resistance across said two points, said resistor being connected in the first of said legs;

(c) the electrical circuit between said two selected points being connected within the second of said legs;

(d) said first and second legs being arranged within

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said bridge circuit so that current will tend to flow through said branch in a first direction when the resistance of said second leg is substantially above said minimum allowable level, current will tend to flow through said branch in a second direction when the resistance of said second leg is substantially below said minimum allowable level and no current will tend to flow through said branch when the resistance in said second leg is approximately at said minimum allowable level; and,

(e) means in said null detecting branch for de-energizing said power supply of said induction heating installation when current flow through said branch approaches zero.

2. A device as defined in claim 1 including means in said null detecting branch for preventing current flow in said second direction.

3. A device as defined in claim 2 wherein said preventing means is a diode polarized to prevent current flow in said second direction.

4. A device as defined in claim 1 wherein said de-energizing means includes a relay having a coil in said branch and normally closed contacts in a circuit for de-energizing said power supply when said contacts are closed, whereby current flow through said relay coil opens said contacts and allows operation of said power supply.

5. A device as defined in claim 4 including means in said null detecting branch for preventing current flow in said second direction.

6. A device as defined in claim 5 including a capacitor connected in parallel with said coil.

7. A device as defined in claim 6 wherein said means for preventing current flow in said second direction is in parallel with said coil.

8. A device as defined in claim 6 wherein said means for preventing current flow in said second direction is connected in series with said coil.

9. A device as defined in claim 4 wherein said de-energizing circuit includes a second relay with a coil and normally open contacts with said power supply being de-energized when said normally open contacts are open, and said second relay being de-energized upon closing of said normally closed contacts of said first-mentioned relay.

10. A device as defined in claim 9 including a second DC power supply with output terminals connected onto the input terminals of said bridge circuit and said second relay coil being connected across said output terminals, said normally closed contacts being in a shunt circuit around said second relay coil.

11. A device as defined in claim 4 including a capacitor in parallel with said coil.

12. A device as defined in claim 1 including a choke coil electrically associated with said bridge circuit to limit AC currents flowing in said branch.

13. A device as defined in claim 1 wherein said resistor in said first leg is adjustable.

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