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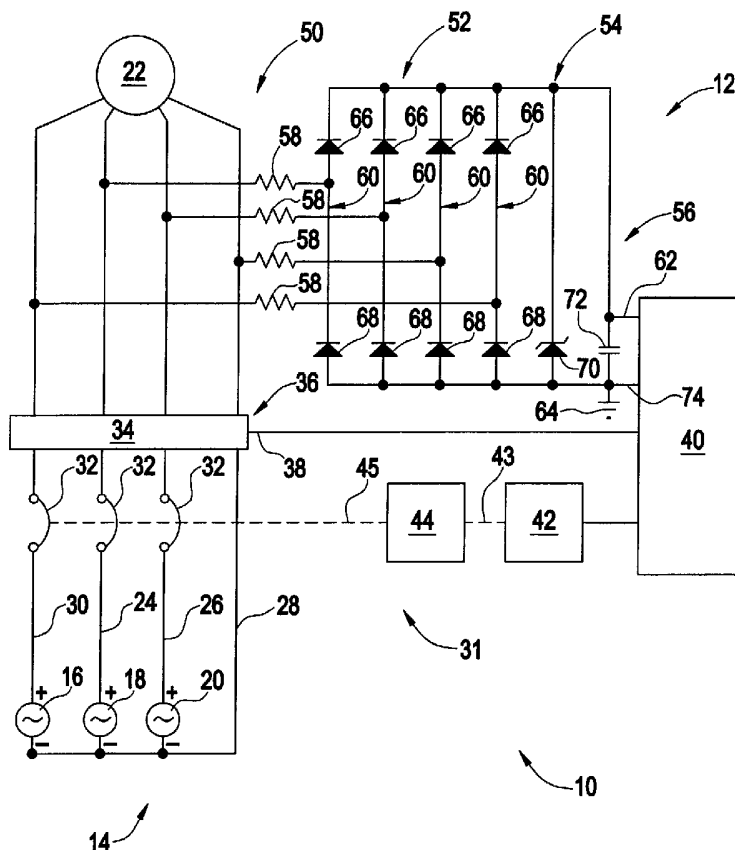
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(54) Title: NEUTRAL POLE LOCATION INDEPENDENT EARTH LEAKAGE DETECTION CIRCUIT



(57) Abstract: A neutral pole location independent power supply circuit includes: a first leg including a first diode and a second diode, the first leg is configured for electrical connection to a first phase of the power distribution circuit at a point between the first diode and the second diode; a second leg including a third diode and a fourth diode, the second leg is configured for electrical connection to a second phase of the power distribution circuit at a point between the third diode and the fourth diode; a third leg including a fifth diode and a sixth diode, the third leg is configured for electrical connection to a third phase of the power distribution circuit at a point between the fifth diode and the sixth diode; a fourth leg including a seventh diode and an eighth diode, the fourth leg is configured for electrical connection to a neutral line of the power distribution circuit at a point between the seventh diode and the eighth diode.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

NEUTRAL POLE LOCATION INDEPENDENT EARTH LEAKAGE DETECTION CIRCUIT

BACKGROUND OF THE INVENTION

An earth leakage detection device is generally installed in an electrical power distribution circuit in conjunction with a circuit breaker. The earth leakage detection device detects the existence of certain predefined earth leakage current levels. If such current levels exist, the earth leakage detection device causes the circuit breaker to trip, thus stopping current flow to the protected circuit. Together, the earth leakage detection device and the circuit breaker provide overcurrent and earth leakage protection to the distribution circuit (generally known as a differential circuit breaker).

A conventional earth leakage detection device generally comprises a housing in which different mechanical, electrical and electronic elements are enclosed. This housing can be separate from, or integral to, the housing for the associated circuit breaker. Within the housing, the earth leakage detection device includes a plurality of conductive straps, one strap being provided for each pole of the electrical distribution circuit. Each of these straps passes through a torous-shaped, ferrous core mounted within the housing. The straps passing through the toroidal core form the primary winding of a current transformer. A secondary winding of the current transformer is electrically connected to earth leakage detection electronics (control circuitry) mounted within the housing. The current induced in the secondary winding is sensed by the earth leakage detection circuitry, which determines the level of current leakage to earth. If detected current level is greater than a predetermined current threshold setting, the earth leakage detection circuitry will provide a trip signal to an electromechanical trip/reset mechanism located within the

earth leakage detection device housing. In response to the trip signal, the trip/reset mechanism will trip an operating mechanism within the circuit breaker to stop current flow in the protected circuit.

5 The electronic detection circuitry receives its operating power from a power supply circuit. In an earth leakage detection device designed for a four-pole power distribution circuit (three phases and a neutral line), the power supply circuit includes three leads, with
10 each lead attached to a different phase. However, for four-pole power distribution circuits, it is well known that some countries prefer the neutral connection on the left pole while others prefer the neutral connection on the right pole. If an earth leakage detection device
15 designed for a left pole neutral connection is used in a distribution system with a right pole neutral, or vice-versa, the response time of the power supply circuit is almost doubled. A delay in the response time of the power supply circuit will delay the protective capability of the
20 earth leakage detection device during start-up of the power distribution circuit. To prevent this start-up delay, manufacturers of earth leakage detection devices produce devices with different power supply circuits for use in different countries. However, the manufacturing
25 and logistics costs required for such products are greater than the manufacturing and logistics costs required for a single device that can be used in any country.

BRIEF DESCRIPTION OF THE INVENTION

30 The above described and other drawbacks and deficiencies of the prior art are overcome or alleviated by a neutral pole location independent power supply circuit. The neutral pole location independent power supply circuit includes: a first leg including a first diode and a second diode, the first leg is configured for
35 electrical connection to a first phase of the power

distribution circuit at a point between the first diode and the second diode; a second leg including a third diode and a fourth diode, the second leg is configured for electrical connection to a second phase of the power distribution circuit at a point between the third diode and the fourth diode; a third leg including a fifth diode and a sixth diode, the third leg is configured for electrical connection to a third phase of the power distribution circuit at a point between the fifth diode and the sixth diode; a fourth leg including a seventh diode and an eighth diode, the fourth leg is configured for electrical connection to a neutral line of the power distribution circuit at a point between the seventh diode and the eighth diode.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings wherein like items are numbered alike:

Figure 1 is a schematic diagram of an earth leakage detection device including a neutral pole location independent power supply circuit connected to a distribution circuit having a right side neutral pole location;

Figure 2 is a schematic diagram of an earth leakage detection device including the neutral pole location independent power supply circuit connected to a distribution circuit having a left side neutral pole location; and

Figure 3 is a graph depicting voltage as a function of time during the startup of the neutral pole location independent power supply circuit of Figure 1 and Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 1, a schematic diagram of an earth leakage detection device 10 including a neutral pole location independent power supply circuit 12 is

shown. Earth leakage detection device 10 is electrically connected to a four-pole power distribution circuit 14, between power sources 16, 18, 20 and a load 22. Four-pole power distribution circuit 14 includes three phases 24, 26, 30 and a neutral line 28, which is located to the right side of phases 24, 26 and 30 in Figure 1.

Earth leakage detection device 10 includes a housing (not shown), which can be separate from, or integral to, a housing (not shown) for an associated circuit breaker 31. Within earth leakage detection device 10, each pole 24, 26, 30 and 28 of the electrical distribution circuit 14 passes through a ferrous core 34 of a current transformer 36, thereby forming the primary windings of current transformer 36. A secondary winding 38 of the current transformer is electrically connected to control circuitry 40.

Control circuitry 40 is an analog circuit, a digital circuit, a microprocessor, an electronic circuit, or the like. Control circuitry 40 is powered by power supply circuit 12, and is configured to receive from current transformer 36 a sensed signal indicating an electrical property (e.g., voltage, current, resistance, and the like) in phases 24, 26 and 30 and neutral 28 of distribution circuit 14. Control circuitry 40 monitors the sensed signal to detect earth leakage in the power distribution circuit 14. If control circuitry 40 senses earth leakage, control circuitry 40 provides a trip signal to a trip/reset mechanism 42.

Trip/reset mechanism 42 is an electromechanical device, such as a solenoid or a solenoid actuated, spring driven latch, which is mechanically coupled to a trip lever 43. Trip/reset mechanism 42 is configured to receive a trip signal from control circuitry 40 and, in response to receiving the trip signal, unlatch an operating mechanism 44 in circuit breaker 31 via trip

lever 43. Operating mechanism 44 is a spring-driven device that is mechanically coupled to contacts 32 in circuit breaker 31 via a breaker mechanism 45 (e.g., one or more movable contact arms). In a latched state, operating mechanism 44 and breaker mechanism 45 maintain contacts 32 in a closed circuit condition. In a closed circuit condition, contacts 32 conduct electrical current between power sources 16, 18 and 20 and load 22. When operating mechanism 44 is unlatched by trip lever 43, operating mechanism 44 and breaker mechanism 45 force contacts 32 into an open circuit condition in which the flow of electrical current between power sources 16, 18 and 20 and load 22 is stopped.

Power supply circuit 12 includes a resistor network 50, a full wave bridge rectifier 52, a voltage regulator 54, and a smoothing circuit 56. Resistor network 50 includes four equivalent resistances 58, each of which is connected in series between a leg 60 of full wave bridge rectifier 52 and phase 24, 26 or 30 or neutral line 28 of electrical distribution circuit 14.

Full wave bridge rectifier 52 includes legs 60, which are electrically connected across an input lead 62 of control circuitry 40 and a voltage reference 64 (e.g., ground). Each leg 60 includes diodes 66 and 68, with a cathode of diode 66 connected to input lead 62 of control circuit 40, an anode of diode 66 connected to a cathode of diode 68, and an anode of diode 68 connected to reference voltage 64. In each leg 60, resistance 58 is electrically connected to the anode of diode 66 and the cathode of diode 68. Voltage regulator 54 includes a zener diode 70 electrically connected at its cathode to input lead 62 of control circuitry 40 and electrically connected at its anode to voltage reference 64. Smoothing circuit 56 includes a capacitance 72 electrically connected across input lead 62 of control circuitry 40 and

voltage reference 64. A second input lead 74 of control circuitry 40 is connected to voltage reference 64.

In operation, control circuitry 40 receives operating power from power supply circuit 12. In addition, control circuitry 40 receives a sensed signal indicating the electrical property in phases 24, 26 and 30 and neutral 28 from current transformer 36. Control circuitry 40 monitors the sensed signal to detect earth leakage. For example, control circuitry 40 may determine the existence of earth leakage by measuring the sum of the electric currents flowing simultaneously in each phase 24, 26 and 30 and neutral 28 of the distribution circuit 14. When the distribution circuit 14 down-line of the earth leakage detection device 10 functions normally, the sum of the electric current that flows simultaneously through the phases 24, 26 and 30 and neutral 28 is essentially equal to zero. If there is earth leakage, the sum of the electric currents that flow simultaneously through the phases 24, 26 and 30 and neutral 28 will not be equal to zero and an electric current will be induced in secondary winding 38 of transformer 36. The current induced in secondary winding 38 is sensed by control circuitry 40, which determines the level of current leakage to earth. If detected current level is greater than a predetermined current threshold setting, control circuitry 40 will provide a trip signal to trip/reset mechanism 42. In response to receiving the trip signal, trip/reset mechanism 42 will mechanically actuate operating mechanism 44, which mechanically separates contacts 32 to stop the flow of electrical current in phases 24, 26 and 30.

Referring to Figure 2, earth leakage detection device 10 is connected to a four-pole power distribution circuit 114 having a left side neutral pole location. Four-pole power distribution circuit includes three phases 124, 126 and 128, and a neutral line 130 that

connect power sources 116, 118 and 120 to load 122. Neutral line 130 is located to the left side of phases 124, 126 and 128. Because legs 60 are similar to each other and resistances 58 are equivalent to each other,
5 power supply circuit 12 will function in the manner described herein above whether it is installed in a right side neutral pole location, as shown in Figure 1 or a left side neutral pole location, as shown in Figure 2.

To provide earth leakage protection
10 immediately after contacts 32 are closed, power supply circuitry 12 must quickly provide operating power to control circuitry 40. Figure 3 is a graph depicting voltage as a function of time during the startup of the neutral pole location independent power supply circuit 12
15 of Figures 1 and 2. Power supply circuit 12 will provide a similar response time whether the neutral line 30 is on the right pole, as shown in Figure 1, or the neutral line 30 is on the left pole, as shown in Figure 2.

Unlike earth leakage detection devices of the
20 prior art, in which response time can be greatly decreased if the device is connected to a power distribution circuit having a left side neutral pole location or a right side neutral pole location, an earth leakage detection device including neutral pole location independent power supply
25 circuit 12 ensures a fast response time regardless of whether it is used in a power distribution circuit having a left side neutral pole location or a right side neutral pole location. Because neutral pole location independent power supply circuit 12 can be used with any neutral pole
30 configuration, power supply circuit 12 reduces the manufacturing and logistics costs below that possible for power supply circuits of the prior art, which require a manufacturer to manufacture, store, and supply a different power supply for each different neutral pole
35 configuration.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

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CLAIMS

1. A neutral pole location independent power supply circuit for conducting operating power from a power distribution circuit to control circuitry, said neutral pole independent power supply circuit comprising:
- 5 a first leg including a first diode and a second diode, said first leg is configured for electrical connection to a first phase of the power distribution circuit at a point between said first diode and said second diode;
- 10 a second leg including a third diode and a fourth diode, said second leg is configured for electrical connection to a second phase of the power distribution circuit at a point between said third diode and said fourth diode;
- 15 a third leg including a fifth diode and a sixth diode, said third leg is configured for electrical connection to a third phase of the power distribution circuit at a point between said fifth diode and said sixth diode;
- 20 a fourth leg including a seventh diode and an eighth diode, said fourth leg is configured for electrical connection to a neutral line of the power distribution circuit at a point between said seventh diode and said eighth diode.
- 25
2. The neutral pole location independent power supply circuit of claim 1, wherein an anode of said first diode is electrically connected to a power input lead of the control circuitry, an anode of said third diode is electrically connected to said power input lead of the control circuitry, an anode of said fifth diode is electrically connected to said power input lead of the control circuitry, and an anode of said seventh diode is electrically connected to said power input lead of the control circuitry.
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3. The neutral pole location independent power supply circuit of claim 2, wherein a cathode of said second diode is electrically connected to a voltage reference, a cathode of said fourth diode is electrically connected to said voltage reference, a cathode of said sixth diode is electrically connected to said voltage reference, and a cathode of said eighth diode is electrically connected to said voltage reference.

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4. The neutral pole location independent power supply circuit of claim 3, further comprising:
a first resistance electrically connected to said point between said first diode and said second diode, said first resistance is configured for electrical connection to said first phase of the power distribution circuit;
a second resistance electrically connected to said point between said third diode and said fourth diode, said second resistance is configured for electrical connection to said second phase of the power distribution circuit;
a third resistance electrically connected to said point between said fifth diode and said sixth diode, said third resistance is configured for electrical connection to said third phase of the power distribution circuit; and
a fourth resistance electrically connected to said point between said seventh diode and said eighth diode, said fourth resistance is configured for electrical connection to said neutral line of the power distribution circuit.

5. The neutral pole location independent power supply circuit of claim 3, further comprising:

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a voltage regulator electrically connected between said power input lead of the control circuitry and said voltage reference.

5 6. The neutral pole location independent power supply circuit of claim 5, wherein said voltage regulator comprises a zener diode.

7. The neutral pole location independent power
10 supply circuit of claim 3, further comprising:
a smoothing circuit electrically connected between said power input lead of the control circuitry and said voltage reference.

15 8. The neutral pole location independent power supply circuit of claim 7, wherein said smoothing circuit is a capacitor.

9. An earth leakage detection device for a power
20 distribution circuit, the power distribution circuit including a first phase, a second phase, a third phase, and a neutral line, said earth leakage detection device comprising:

a core disposed around the first phase, the second
25 phase, the third phase, and the neutral line of the power distribution circuit;

a secondary winding wrapped around said core;
control circuitry electrically connected to said secondary winding;

30 a full wave bridge rectifier electrically connected between said control circuitry and said four pole power distribution circuit, said full wave bridge rectifier including

a first leg including a first diode and a second
35 diode, said first leg is electrically connected to

the first phase of the power distribution circuit at a point between said first diode and said second diode,

5 a second leg including a third diode and a fourth diode, said second leg is electrically connected to the second phase of the power distribution circuit at a point between said third diode and said fourth diode,

10 a third leg including a fifth diode and a sixth diode, said third leg is electrically connected to the third phase of the power distribution circuit at a point between said fifth diode and said sixth diode, and

15 a fourth leg including a seventh diode and an eighth diode, said fourth leg is electrically connected to the neutral line of the power distribution circuit at a point between said seventh diode and said eighth diode.

20 10. The earth leakage detection device of claim 9, wherein an anode of said first diode is electrically connected to a power input lead of said control circuitry, an anode of said third diode is electrically connected to said power input lead of said control circuitry, an anode
25 of said fifth diode is electrically connected to said power input lead of said control circuitry, and an anode of said seventh diode is electrically connected to said power input lead of said control circuitry.

30 11. The earth leakage detection device of claim 10, wherein a cathode of said second diode is electrically connected to a voltage reference, a cathode of said fourth diode is electrically connected to said voltage reference, a cathode of said sixth diode is electrically connected to
35 said voltage reference, and a cathode of said eighth diode

is electrically connected to said voltage reference.

12. The earth leakage detection device of claim 9, further comprising:

- 5 a first resistance electrically connected between said point between said first diode and said second diode and said first phase of the power distribution circuit;
- a second resistance electrically connected between said
10 point between said third diode and said fourth diode and said second phase of the power distribution circuit;
- a third resistance electrically connected between said point between said fifth diode and said sixth diode
15 and said third phase of the power distribution circuit; and
- a fourth resistance electrically connected between said point between said seventh diode and said eighth diode and said neutral line of the power distribution
20 circuit.

13. The earth leakage detection device of claim 11, further comprising:

- 25 a voltage regulator electrically connected between said power input lead of said control circuitry and said voltage reference.

14. The earth leakage detection device of claim 13, wherein said voltage regulator comprises a zener
30 diode.

15. The earth leakage detection device of claim 11, further comprising:

- 35 a smoothing circuit electrically connected between said power input lead of said control circuitry and said

voltage reference.

16. The earth leakage detection device of claim 15, wherein said smoothing circuit is a capacitor.

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17. A neutral pole location independent power supply circuit for conducting operating power from a power distribution circuit to control circuitry, said neutral pole independent power supply circuit comprising:

- 10 a first leg including a first diode and a second diode, an anode of said first diode is electrically connected to a power input lead of the control circuitry, a cathode of said second diode is electrically connected to a voltage reference;
- 15 a second leg including a third diode and a fourth diode, an anode of said third diode is electrically connected to said power input lead of the control circuitry, a cathode of said fourth diode is electrically connected to said voltage reference;
- 20 a third leg including a fifth diode and a sixth diode, an anode of said fifth diode is electrically connected to said power input lead of the control circuitry, a cathode of said sixth diode is electrically connected to said voltage reference;
- 25 a fourth leg including a seventh diode and an eighth diode, an anode of said seventh diode is electrically connected to said power input lead of the control circuitry, a cathode of said eighth diode is electrically connected to said voltage reference;
- 30 a first resistance electrically connected to a point between said first diode and said second diode, said first resistance is configured for electrical connection to a first phase of the power distribution circuit;
- 35 a second resistance electrically connected to a point

between said third diode and said fourth diode, said second resistance is configured for electrical connection to a second phase of the power distribution circuit;

- 5 a third resistance electrically connected to a point between said fifth diode and said sixth diode, said third resistance is configured for electrical connection to a third phase of the power distribution circuit; and
- 10 a fourth resistance electrically connected to a point between said seventh diode and said eighth diode, said fourth resistance is configured for electrical connection to a neutral line of the power distribution circuit.

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18. The neutral pole location independent power supply circuit of claim 17, further comprising:

- a voltage regulator electrically connected between said power input lead of the control circuitry and said
- 20 voltage reference.

19. The neutral pole location independent power supply circuit of claim 18, further comprising:

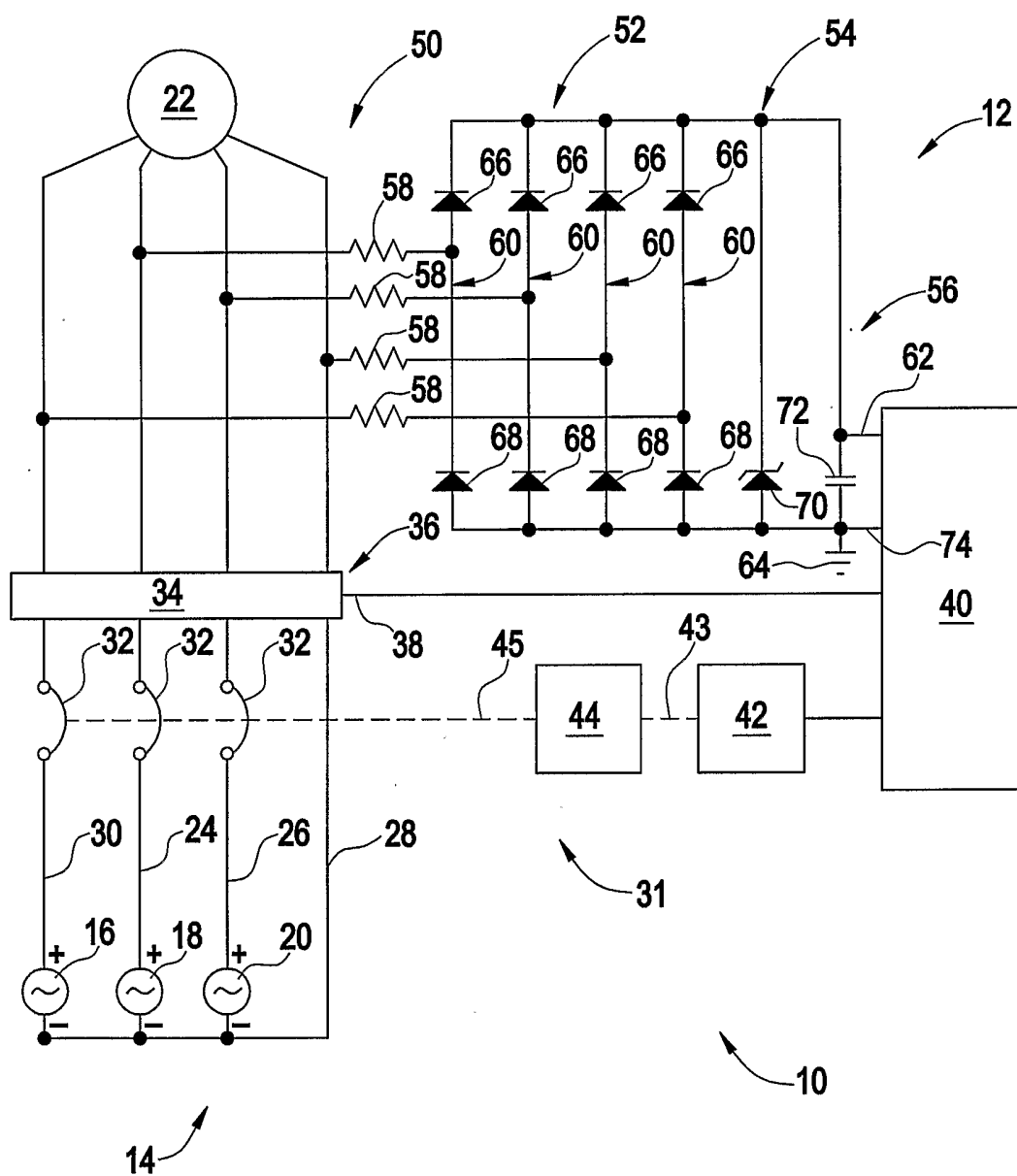
- a smoothing circuit electrically connected between said
- 25 power input lead of the control circuitry and said voltage reference.

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FIG. 1



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FIG. 2

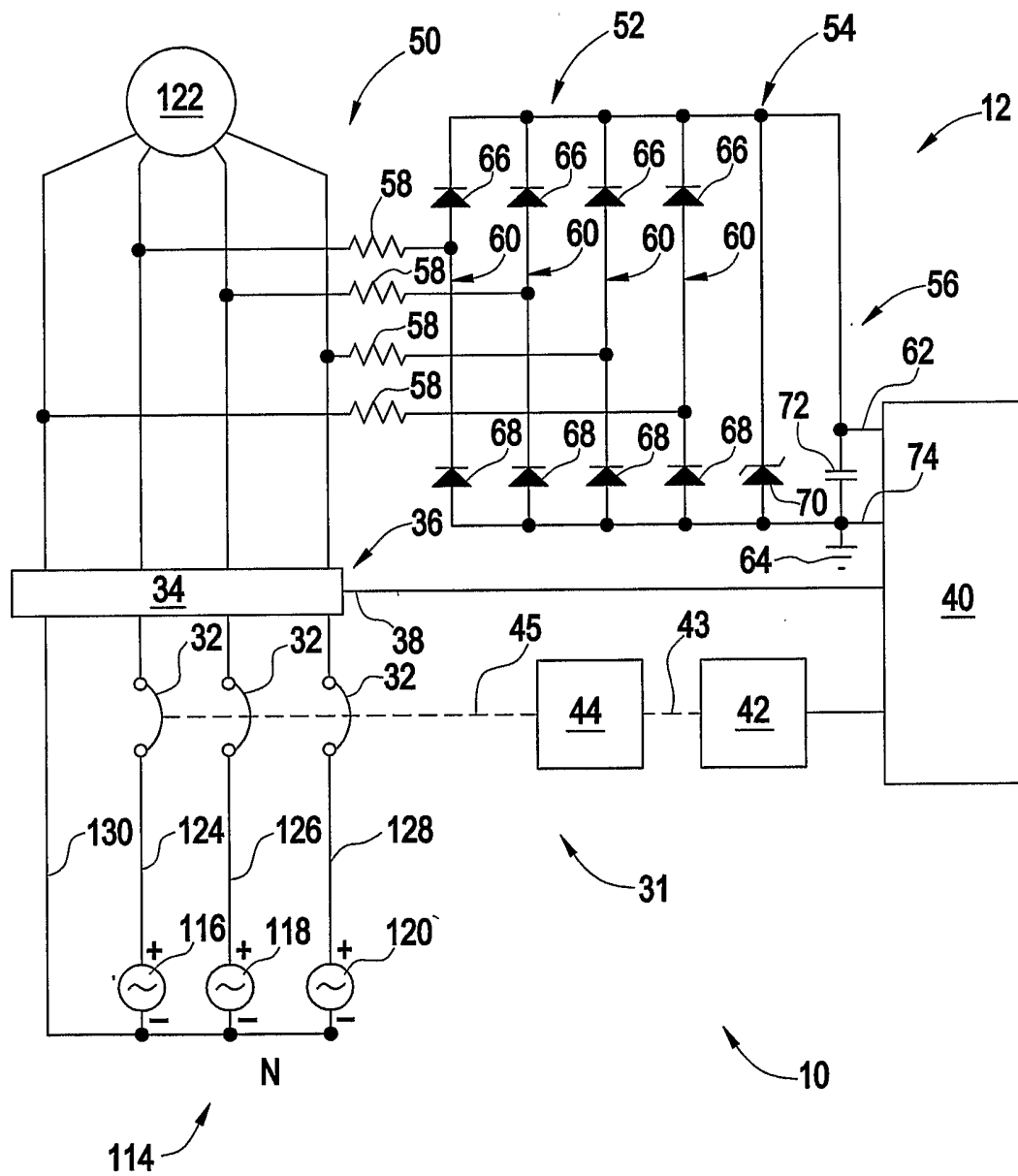
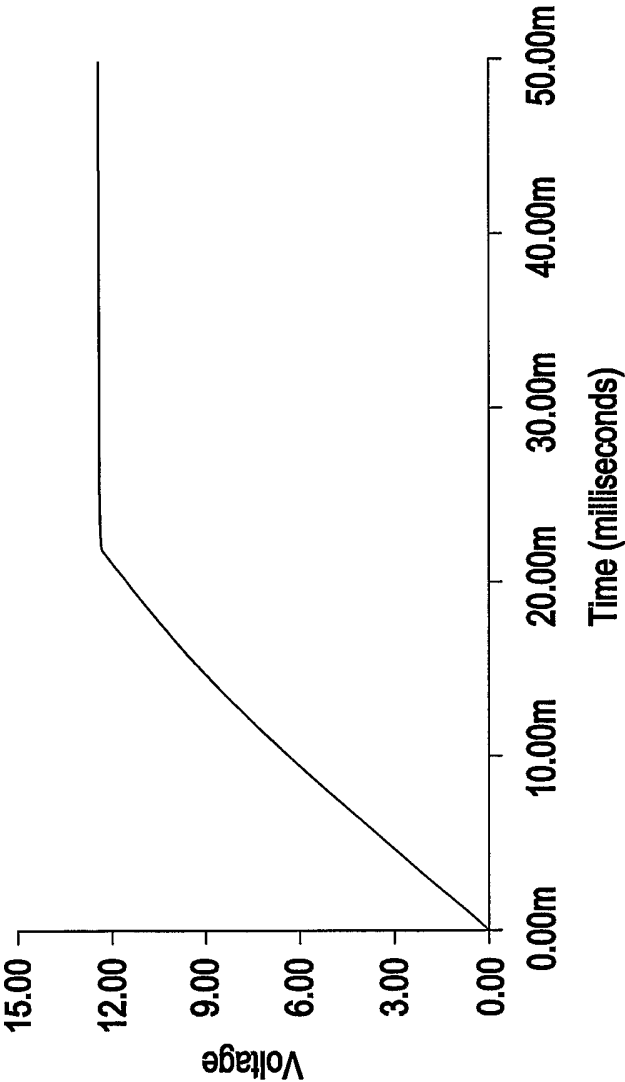


FIG. 3



INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 02/08629

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02M7/06 H02H3/34

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)

IPC 7 H02M H02H

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 practical, search terms used)

WPI Data, EPO-Internal, PAJ, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	EP 0 326 281 A (MITSUBISHI ELECTRIC CORP) 2 August 1989 (1989-08-02) figure 3 ---	1-3
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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