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SATURABLE TRANSFORMER SYSTEM

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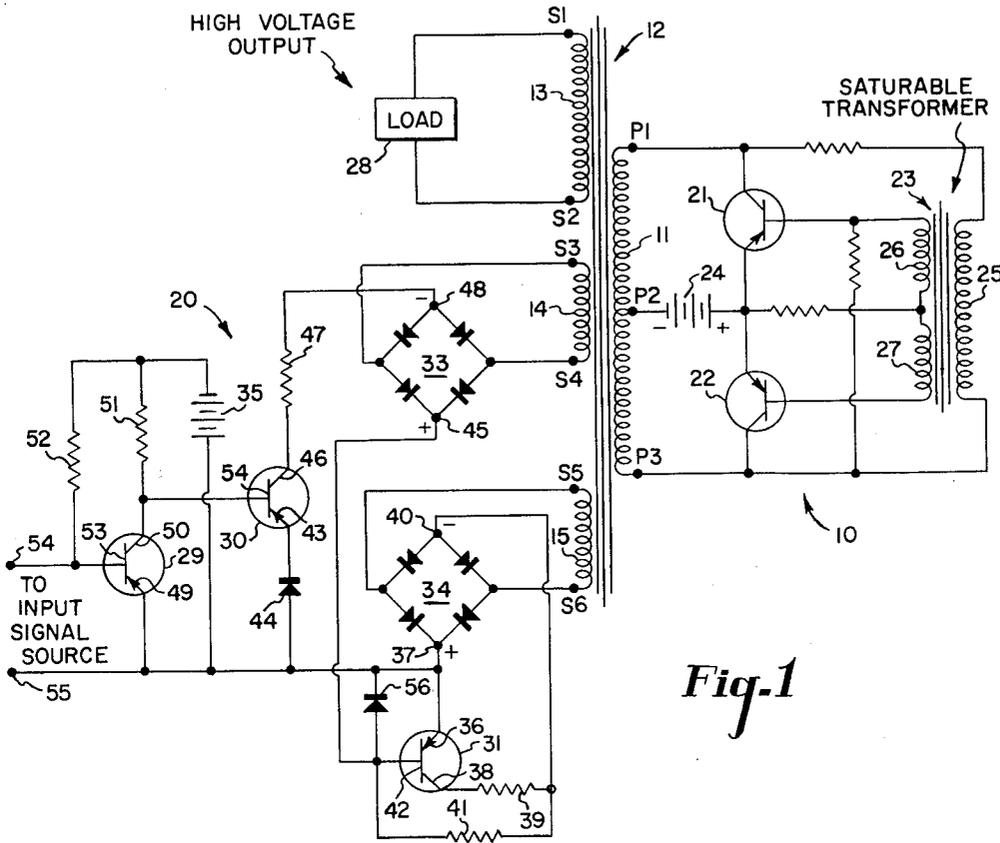


Fig. 1

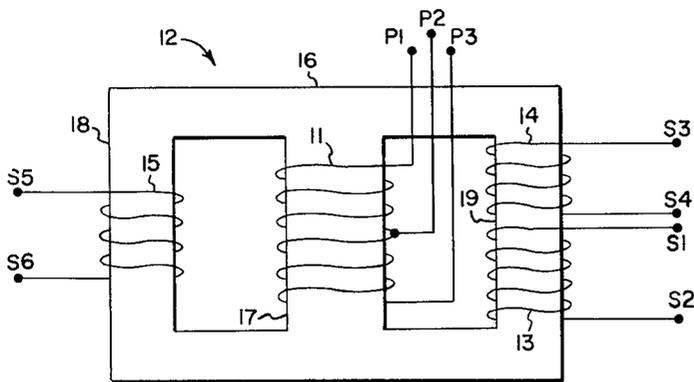


Fig. 2

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## SATURABLE TRANSFORMER SYSTEM

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This invention is concerned with an improved electrical apparatus and particularly with an electrical apparatus for use in energizing a high voltage load from a low voltage source under the control of a semiconductor type network.

Specifically, the present invention utilizes a low magnitude source of alternating voltage which is connected to the low voltage primary winding of the transformer. The transformer is provided with a high voltage output winding, adapted to be connected with a high voltage load, and is also provided with control windings which are connected to be controlled by a transistor network. By the use of such construction, low voltage transistors can be utilized to control the energization of a high voltage load.

Referring now to the drawings;

FIGURE 1 is a schematic representation of the preferred modification of the present invention,

FIGURE 2 is a schematic type representation of the transformer of FIGURE 1, and

FIGURE 3 is a schematic representation of the present invention as applied to control the operating voltage applied to non-selfquenching Geiger tube.

Referring specifically to FIGURE 1, the reference number 10 designates generally a low magnitude source of alternating voltage. Specifically, source 10 may comprise a square wave generator of the type shown in the James L. Jensen Patent 2,774,878, which issued on December 18, 1956.

The low voltage output obtained from square wave generator 10 is applied to the low voltage primary winding 11 of a transformer 12. Transformer 12 is provided with a high voltage secondary winding 13 and a pair of low voltage secondary windings 14 and 15. The terminal connections of the various windings of transformer 12 have been designated by the letter P to indicate primary winding terminals and by the letter S to designate secondary winding terminals. FIGURE 2 is a representation of transformer 12 in which the various windings are shown wound about the iron core or magnetic flux path of the transformer.

Transformer 12, as shown in the FIGURE 2, is provided with a shell type or three-legged iron core which is designated by the reference numeral 16. Primary winding 11 is wound about a portion 17 of the iron core. The magnetic flux produced by winding 11 flows through leg 17 and a pair of separate flux paths defined by the legs 18 and 19. As is well known, the magnetic flux generated by alternating voltage which is applied to the terminals P1, P2 and P3 of primary winding 11 flows through the magnetic flux paths defined by the legs 18 and 19 in inverse relation to the reluctance of these flux paths. The reluctance of the legs 18 and 19 is in turn controlled by the loading of secondary windings 14 and 15. In other words, the greater the loading on the particular secondary winding, the higher the reluctance of the associated flux path.

This principle is utilized in the present invention to control the flux which flows through the leg 19 and thereby control the voltage induced in secondary winding 13. When it is desired to de-energize winding 13, the flux produced by winding 11 is caused to flow through leg 18

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and thereby effectively de-energize the secondary winding 13.

Referring again to FIGURE 1, the reference number 20 designates a semiconductor type network which is connected to receive its operating voltage from the secondary windings 14 and 15 and which has an input which is adapted to be connected to a signal source. This signal source controls the network 20 to in turn control the state of energization of the high voltage secondary winding 13.

Describing the apparatus of FIGURE 1 in greater detail, the source of alternating voltage 10 comprises a square wave generator or oscillator including transistors 21 and 22. A saturable transformer 23 is connected in circuit with transistors 21 and 22 and this saturable transformer's function is to provide a feedback so long as the transformer is not saturated. By way of example, consider that portion of the cycle of source 10 in which transistor 21 is conductive. Electrical current flows from the battery 24 through the emitter and collector electrodes of transistor 21, terminal P1 of primary winding 11, the upper portion of the primary winding 11, and terminal P2 battery 24. A voltage is therefore present across the terminals P1 and P3 of primary winding 11 and this voltage causes a current to flow in a first direction through the primary winding 25 of saturable transformer 23. A voltage is thereby induced in the secondary winding 26, which voltage is of a forward biasing direction for transistor 21 and which maintains this transistor conductive. The voltage induced in secondary winding 27 of transformer 23 maintains transistor 22 non-conductive.

Upon transformer 23 saturating, the forward biasing voltage induced in secondary winding 26 suddenly decreases and transistor 21 becomes less conductive. The current flow, above traced, through the upper portion of the primary winding 11 therefore decreases and due to the inductive effect of winding 11, the voltage present across terminals P1 and P3 of this primary winding reverses polarity in an attempt to maintain this current flowing. When this occurs, the voltage applied to the primary winding 25 of the saturable transformer 23 reverses and, in turn, the voltage present in the secondary windings 26 and 27 also reverses. The result is that the voltage induced in secondary winding 26 turns transistor 21 to a non-conductive condition. Furthermore, the voltage induced in the secondary winding 27 is effective to place transistor 22 in a conductive condition. In this way, the source 10 functions as a square wave generator and applies a relatively low magnitude alternating voltage to the primary winding 11 of transformer 12.

The operation of the square wave generator 10 thereby causes magnetic flux to be produced by winding 11 which is wound about portion 17 of the iron path 16. This magnetic flux divides between the two flux paths 18 and 19 to thereby inductively link the secondary windings 13, 14 and 15 with the primary winding 11.

The high voltage secondary winding 13 is provided with a pair of terminals S1 and S2 which are adapted to be connected to a high voltage load identified by the reference numeral 28 of FIGURE 1. The secondary windings 14 and 15 are low voltage windings which are connected to network 20 and which function to control the flux flow through paths 18 and 19.

Network 20 includes three transistors 29, 30, and 31. The reference numerals 33 and 34 designate bridge rectifiers which are connected to the secondary windings 14 and 15 respectively and which provide a D.C. operating voltage for transistors 30 and 31 respectively. The reference numeral 35 designates a battery which supplies D.C. operating voltage for transistor 29.

Considering the transistor network 20 in greater detail, the emitter electrode 36 of transistor 31 is directly con-

ected to the positive output terminal 37 of bridge rectifier 34. The collector 33 of this transistor is connected through a resistor 39 to negative terminal 40 of bridge rectifier 34. Transistor 31 is biased to be normally conductive by means of a circuit including resistor 41 which is connected from the base electrode 42 of transistor 31 to the negative terminal 40 of bridge rectifier 34. By means of this circuit connection, a biasing current flow circuit can be traced from terminal 37 through the emitter 36, base 42 and resistor 41 to the negative terminal 40. Therefore, in the absence of an input signal to transistor 31 which tends to render this transistor non-conductive, transistor 31 is normally conductive and the secondary winding 15 is in a loaded condition. Since this secondary winding is associated with the flux path identified by the reference numeral 18 of FIGURE 2, this particular flux path has a relatively high magnetic reluctance and the major portion of the flux produced by winding 11 is caused to flow through the flux path identified by the reference numeral 19. As will be apparent later, with this condition existing, the high voltage secondary winding 13 is effectively energized to energize the load 28 of FIGURE 1.

Considering now transistor 30, this transistor has its emitter 43 connected through a diode 44 and a diode 56 to the positive terminal 45 of bridge rectifier 33. The collector 46 of transistor 30 is connected through a resistor 47 to the negative terminal 48 of bridge rectifier 33. From this circuit it can be seen that the output circuit of transistor 30, that is the circuit that can be traced from the terminals 45 and 48 of bridge rectifier 33 through the emitter to collector circuit of transistor 30, includes diode 56, which diode is also connected to the emitter to base circuit of transistor 31. The voltage drop across diode 56, when transistor 30 is conductive is of a polarity to bias transistor 31 to be non-conductive. Transistor 30 is however normally in a non-conducting condition and therefore is not effective to control transistor 31, which is therefore normally in a conducting condition.

Since transistor 30 is normally non-conducting, the secondary winding 14 of transformer 12 is normally in an unloaded condition and therefore has relatively little effect on the magnetic reluctance of the flux path 19. It will be noted that secondary winding 14, which supplies operating voltage for transistor 30, is located on the same flux path leg as high voltage secondary winding 13 which supplies high voltage to the load 28.

Considering now transistor 29, this transistor has its emitter 49 connected directly to the positive terminal of battery 35. Its collector 50 is connected through a resistor 51 to the negative terminal of battery 35. Transistor 29 is biased to be normally in a conducting condition by means of a circuit including resistor 52. The biasing current flow circuit, including resistor 52, can be traced from the positive terminal of battery 35 through emitter 49, base electrode 53 and resistor 52 to the negative terminal of battery 35. This current flow circuit normally maintains transistor 29 in a conducting condition. So long as transistor 29 remains in this conducting condition, an emitter to collector current flows from battery 35 through resistor 51. As is well known, the voltage drop from the emitter to the collector of this transistor is relatively low. This low magnitude voltage is applied between the base and emitter electrodes of transistor 30 by means of a circuit including diode 44. Since diode 44 is effectively connected in series with a further diode consisting of emitter 43 and base 54, this low magnitude voltage present between the emitter and collector of transistor 29 is insufficient to cause an emitter to base current to flow through transistor 30 therefore the stable non-conducting condition for transistor 30 is established.

The above description of apparatus of FIGURE 1 has been concerned with the condition wherein it is desired

to apply a high operating voltage to load 28. In this condition, transistor 31 is conductive to load secondary winding 15, and transistor 30 is non-conductive, so that secondary winding 14 is not loaded. Transistor 29 is conductive and so long as this transistor remains conductive, the transistor 30 remains non-conductive. If it is desired to operatively de-energize load 28, input signal is applied to the input terminals 54 and 55, these input terminals being connected respectively to the base 53 and the emitter 49 of transistor 29. This input signal must be of a polarity to apply a positive voltage to the base 54 and thereby render transistor 29 non-conductive.

With transistor 29 non-conductive, the emitter to collector impedance of this transistor becomes relatively large and therefore a high negative voltage is applied to the base electrode 54 of transistor 30. This voltage causes an emitter to base current to flow which can be traced from the positive terminal of battery 35 through diode 44, emitter 43 and base 54, and resistor 51 to the negative terminal of battery 35. Transistor 30 is thereby rendered conductive.

With transistor 30 conductive, an emitter to collector current flows which can be traced from the positive terminal 45 of bridge rectifier 33 through diode 56, diode 44, emitter 43 and collector 46, and resistor 47 to the negative terminal 48. This current flow causes a voltage to exist across diode 56. The polarity of this voltage is such as to apply a positive voltage to base 42 and a negative voltage to emitter 36 of transistor 31. This voltage is effective to bias transistor 31 to a non-conducting condition.

The input signal to terminals 54 and 55 is therefore effective to render transistor 29 non-conductive, render transistor 30 conductive, and render transistor 31 non-conductive. Therefore, the load is effectively removed from secondary winding 15 while secondary winding 14 is now loaded.

Referring now to FIGURE 2, it can be seen that secondary winding 14, which is now in a loaded condition, is wound on the same flux path leg 19 as is the high voltage secondary winding 13 which supplies energizing voltage for load 28. Also, it can be seen that the secondary winding 15, which is no longer loaded, is wound on the flux path 18. As a result, the magnetic reluctance of leg 19 increases while the magnetic reluctance of leg 18 is appreciably reduced. The major portion of the flux produced by the primary winding 11 now flows through the leg 18 which has a low reluctance. In other words, the major portion of the magnetic flux generated by the primary winding 11 now links or couples the secondary winding 15 while only a small portion of this flux links secondary windings 13 and 14. As a result, load 28, which is connected to the high voltage secondary winding 13 is effectively de-energized.

From the above description it can be seen that we have provided an improved electrical apparatus for energizing a high voltage load 28 from a low voltage source 24 under the control of a transistor network. This has been accomplished in part by providing a transformer having a first leg 17 including primary winding 11, having a second leg 18 including secondary winding 15 connected to the output circuit of transistor 31, and having a third transformer leg 19 including high voltage winding 13 which is adapted to be connected to the high voltage load 28. By means including transistor 31, the reluctance of leg 18 is controlled to control the magnetic flux path and in turn control the state of energization of output load 28. The further secondary winding 14, located on the same transformer leg as secondary 13, is connected to a further network including transistor 30 and this network is also effective to control the magnetic flux path.

Referring now to FIGURE 3, this figure shows an arrangement for utilizing the apparatus of FIGURE 1. Specifically, the apparatus of FIGURE 3, discloses a circuit which supplies operating voltage to a Geiger tube

70 and also functions to quench this Geiger tube. Geiger tube 70 is the type known as the non-self quenching tube which requires external means to de-ionize the Geiger tube once it is ionized by radiation to which the tube is sensitive. The reference numeral 71 of FIGURE 3 identifies a source of alternating voltage, and specifically the square generator identified by the reference number 10 of FIGURE 1. The reference numeral 72 designates a transformer similar to that shown in FIGURE 2 wherein the high voltage winding 73 is connected to supply operating voltage for Geiger tube 70 and wherein secondary windings 74 and 75, corresponding to secondary windings 14 and 15 FIGURE 1, are connected to supply operating voltage to transistors 76 and 77 respectively. The transistors 76 and 77 correspond to transistors 30 and 31 of FIGURE 1 and, as with the transistors of FIGURE 1, transistor 77 is normally conductive and transistor 76 is normally non-conductive.

Transistor 76 is controlled by a further transistor network including transistors 78 and 79. The operating voltage for transistors 78 and 79 is derived from a battery 80.

Transistor 78 is normally conductive, this normal condition being established by the series connected resistors 81 and 82 which are connected across battery 80 to establish a voltage across resistor 81 such that its lower terminal is positive with respect to its upper terminal. The lower terminal of resistor 81 is connected directly to the emitter 83 of transistor 78 and its base 84 is connected to the upper or negative terminal of resistor 81. Therefore, transistor 78 is normally conductive and a current flow circuit can be traced from the lower positive terminal of battery 80, through emitter 83, collector 85, and resistor 86 to the negative terminal of battery 80.

Since transistor 78 is conductive, the emitter to collector impedance of this transistor is relatively low. The emitter 89 of transistor 79 is connected through diode 88 and resistor 87 to emitter 83 of transistor 78. The base electrode 90 of this transistor is connected directly to the collector of transistor 78. Since the voltage necessary to cause a current to flow through the series connection of diode 88 and the diode consisting of emitter 89 and base 90 is relatively high, compared to the voltage between the emitter and collector of transistor 78 when this transistor is conductive, transistor 79 is maintained in a normally non-conductive condition. Since transistor 79 is normally non-conductive, there is no voltage drop across resistor 87 and transistor 76 is thereby maintained non-conductive.

This then is the standby or normal operating condition of the apparatus of FIGURE 3. Upon an ionizing event passing through Geiger tube 70, this tube becomes conductive and a pulse of current flows in a circuit which can be traced from the upper terminal of resistor 91 through Geiger tube 70, and resistor 81 to the lower terminal of resistor 91. This current flow causes positive pulse of voltage to be applied to the base electrode 84 of transistor 78. As a result, transistor 78 becomes non-conductive and in turn causes transistor 79 to become conductive.

An input voltage is now applied to the transistor network including transistors 76 and 77, and as a result transistor 76 is rendered conductive and transistor 77 is rendered non-conductive, as above described in connection with FIGURE 1. The secondary winding 74 is thereby loaded and the load is removed from secondary winding 75. In the manner above described, the magnetic flux paths of transformer 72 are thereby controlled to operatively de-energize secondary winding 73 and as a result remove the operating voltage from Geiger tube 70. As a result, Geiger tube 70 is quenched. As will be appreciated, the signal current pulse derived from Geiger tube 70 is of a relatively short time duration and the apparatus of FIGURE 3 provides means including ca-

pacitor 95, resistor 96 and diode 97 which functions to cause the transistors 78 and 79 to function as a pulse stretching network. In its normal or standby condition, diode 97 is effective to charge capacitor 95 from battery 80 to the polarity indicated, such that the lower plate thereof is positive with respect to the upper plate. Upon the signal current pulse being received from Geiger tube 70, to thereby cause transistor 78 to become non-conductive and transistor 79 to become conductive, capacitor 95 discharges through a circuit which can be traced from its lower plate through resistor 96, resistor 81, resistor 87, diode 88, emitter 89, and collector 98 to the upper terminal of capacitor 95. As capacitor 95 discharges, a voltage is maintained across resistor 81 which maintains transistor 78 non-conductive. However, once capacitor 95 has discharged to a given value, the transistor network including transistors 78 and 79 again reverts to its normal condition whereas transistor 78 is conductive and transistor 79 is non-conductive.

This in turn causes transistors 76 and 77 to return to their normal condition wherein transistor 76 is non-conductive and transistor 77 is conductive. As a result, secondary 75 is again loaded and the load is removed from secondary winding 74. As above described, the flux path of transformer 72 is thereby controlled to operatively energize secondary winding 73 and again applying an operating voltage to Geiger tube 70. The Geiger tube is now again sensitive to a further ionizing condition and is effective to produce a further discharge or count upon being subjected to such a further ionizing condition.

While FIGURE 1, in conjunction with FIGURE 2, discloses the preferred embodiment of the present invention, it is readily appreciated that other modifications of the present invention will be apparent to those skilled in the art and it is therefore intended that the scope of the present invention be limited solely by the scope of the appended claims.

We claim as our invention:

1. Electrical apparatus comprising; a transformer having first, second and third legs, a primary winding wound on said first leg and adapted to be connected to a source of alternating voltage to thereby produce a magnetic flux which flows through said second and third legs in inverse relation to the relative magnetic reluctance thereof, an output winding wound on said second leg adapted to be connected to a load, a first control winding wound on said second leg, a second control winding wound on said third leg, a first transistor having its output connected to said second control winding to be energized therefrom, biasing means connected to render said first transistor normally conductive and thereby cause said third leg to present a high reluctance to flux flow, a second transistor having its output connected to said first control winding to be energized therefrom, means connected to render said second transistor normally non-conductive, means connecting said second transistor in controlling relation to said first transistor, and means including the input of said second transistor adapted to receive a control signal which is effective to render said second transistor conductive and thereby render said first transistor non-conductive to cause the major portion of the magnetic flux to flow through said third leg and thereby effectively de-energize the load.

2. Electrical apparatus for use in energizing a high voltage load from a low voltage source by means of low voltage transistors, comprising; a transformer having a magnetic path including a leg having a primary winding connected to a source of low magnitude alternating voltage to thereby produce magnetic flux which flows through said magnetic path, said magnetic path including a first leg having a first low voltage winding and having a high voltage output winding adapted to be connected to a high voltage load, said magnetic path including a second leg having a second low voltage winding; a first transistor having its emitter and collector connected to said second low voltage

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winding to receive operating voltage therefrom, means biasing said first transistor to be conductive to thereby load said second low voltage winding and cause a major portion of the flux to flow through said first leg and operatively energize the load; a second transistor having its emitter and collector connected in circuit with the base and emitter of said first transistor to said first low voltage winding to receive operating voltage therefrom, said second transistor being normally non-conducting; and control signal means including the base and emitter of said second transistor adapted to render said second transistor conductive and thereby render said first transistor non-conductive, said control signal means thereby being effective to load said first low voltage winding and to unload said second low voltage winding with the effect that a major portion of the flux flows through said second leg and the load is operatively de-energized.

3. Electrical apparatus as defined in claim 2 wherein said source of low magnitude alternating voltage consists of a square wave generator having its output connected to said primary winding.

4. Electrical apparatus for use in energizing a high resistance high voltage device from a low voltage source under the control of low voltage transistor means, comprising; a transformer having a leg including a low voltage primary winding, a first leg including a first low voltage secondary winding, and a second leg including a second low voltage secondary winding and a high voltage secondary winding; a high voltage, high resistance device connected to said high voltage secondary winding to be energized therefrom; a first transistor having its output connected to be energized from said first low voltage winding, means connected to the input of said first transistor to render said first transistor normally conductive and thereby load said first low voltage winding and thereby cause said device to be energized; a second transistor having a normal non-conductive condition, said second transistor having its output connected to be energized from said second low voltage winding and also connected to the input of said first transistor so as to render said first transistor non-conductive upon said second transistor being rendered

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conductive; and control means including the input of said second transistor adapted to render said second transistor conductive to in turn de-energize said device.

5. Electrical apparatus comprising; a transformer having first, second and third legs, a primary winding wound on the first leg and adapted to be connected to a source of alternating voltage to thereby produce a magnetic flux which flows through said second and third legs in inverse relation to the relative magnetic reluctance thereof, an output winding wound on said second leg adapted to be connected to a load, a first control winding wound on said second leg, a second control winding wound on said third leg, a first controllable current conducting device having its output connected to said second control winding to be energized therefrom, means connected in controlling relation to said first controllable current conducting device to render said first device normally conductive and thereby cause said third leg to present a high reluctance to flux flow, a second controllable current conducting device having its output connected to said first control winding to be energized therefrom, means connected to render said second controllable current conducting device normally non-conductive, means connecting said second controllable current conducting device in controlling relation to said first controllable current conducting device, and means including the input of said second controllable current conducting device adapted to receive a control signal which is effective to render said controllable current conducting device conductive and thereby render said first controllable current conducting device nonconductive to cause the major portion of the magnetic flux to flow through said third leg and thereby effectively deenergize the load.

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