United States Patent [19]

Kampf et al.

[11] **3,790,862**

[45] **Feb. 5, 1974**

[54] **EXCITATION CONTROL CIRCUIT FOR ELECTROMAGNET COIL**

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[22] Filed: **Dec. 21, 1972**

[21] Appl. No.: **317,448**

[52] **U.S. Cl.**..... **317/148.5 R**, 317/154, 317/DIG. 4, 317/DIG. 6

[51] **Int. Cl.** **H01h 47/32**

[58] **Field of Search**..... 317/DIG. 4, DIG. 6, 154, 317/148.5 R, 148.5 B

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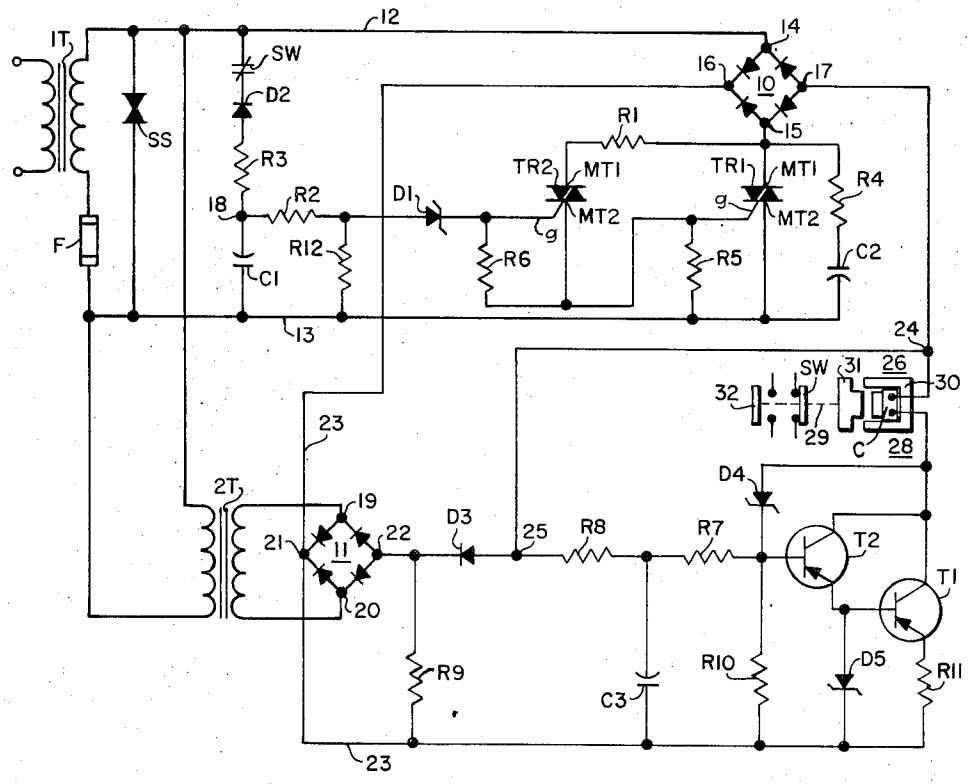
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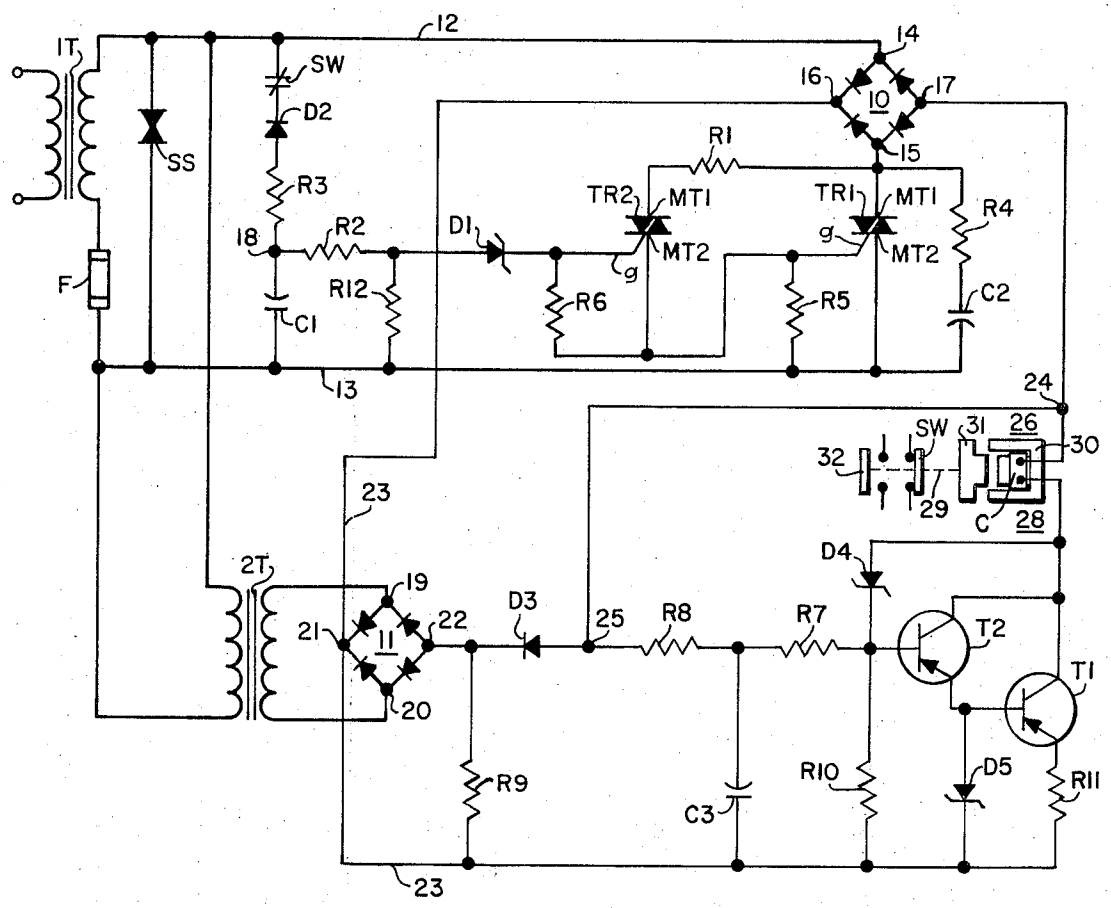
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[57] **ABSTRACT**

A circuit controlling the flow of direct current in a coil winding of a contactor from an alternating current source. The circuit includes a pair of full wave bridge rectifiers connected to be energized by the source so the rectifiers have unequal output voltages. The rectifiers have output terminals connected to the base, emitter and collector circuits of a transistor and the coil winding so the output of the higher voltage rectifier provides the base to emitter current for the transistor and energizes the coil when both rectifiers are energized and the transistor conducts current induced in the coil winding when the control circuit is de-energized to shorten the drop-out time of the contactor.

10 Claims, 1 Drawing Figure




1T
SS
SW
D2
R3
18
R2
F
C1
R12
12
13
14
16
10
17
15
R1
TR2
MT1
MT2
g
D1
R6
TR1
R5
R4
C2
24
SW
31
26
30
32
29
C
28
23
2T
19
21
11
22
20
D3
25
R8
R7
D4
T2
T1
R9
C3
R10
D5
R11
23

EXCITATION CONTROL CIRCUIT FOR ELECTROMAGNET COIL

This invention relates to an electric control circuit for an electromagnetically operated switching device and more particularly to a circuit that controls the flow of direct current in a coil winding of a contactor.

Electromagnetic switching devices, of the type with which the present invention is concerned, are commonly known as contactors and are furnished as switching units of various sizes, having ratings which are normally in accordance with the standards promulgated by the National Electrical Manufacturers Association, commonly known as NEMA. Among the commercial requirements which a contactor is required to satisfy are that the contactor must be constructed so it can be easily mounted and wired on a panel and that the parts of the contactor be arranged so it is easy to inspect and replace the various components, such as the switching contacts and coil of the contactor while the contactor is wired on the panel.

A contactor satisfying the above requirements is disclosed in U.S. Pat. No. 3,643,188 which was granted to the inventors Jordan F. Puetz and James E. Stallmann on Feb. 15, 1972. The contactor structure as disclosed in the Puetz et al patent is rated as a NEMA Size 5 and includes a magnet structure which, when energized by alternating current, is capable of exerting the force required to move and cause a proper engagement between the movable and stationary contacts of the contactor to permit the contactor to carry 300 amperes. A NEMA Size 6 contactor is required to carry 600 amperes and has contacts and contact springs of a considerably greater mass and exert a greater force respectively than the contacts and springs of a Size 5 contactor. Thus the magnet of a Size 6 is required to exert more force than the magnet of a Size 5.

The control circuit according to the present invention will permit the magnet structure disclosed in the Puetz et al patent to be used in a contactor having twice the current carrying capacity of the contactor shown in the Puetz et al patent. This result is accomplished by energizing the magnet coil winding in the Puetz et al structure with a controlled direct current.

The 1971 National Electric Code and NEMA standards require that a Size 5 contactor be used to control currents through motors ranging from 100 to 200 horsepower and a Size 6 contactor be used in circuits for motors ranging from 200 to 400 horsepower. As installations requiring motors have 200 horsepower are uncommon, the market requirement for Size 6 contactors is small and appreciably less than the market requirements for Size 5 contactors. Thus if an electromagnet, which is correctly sized to operate in a NEMA Size 5 contactor, can be used in a NEMA Size 6 contactor, economy in the manufacture as well as a reduction in the size and weight of the Size 6 contactor will result.

It is well known that the current required to cause the electromagnet to pick up greatly exceeds the current required to cause the electromagnet to remain in its sealed condition where the armature engages the stationary magnet. Also, it is well known that an electromagnet, when energized with alternating current, will require less current to pick up and more current to remain sealed than when the electromagnet is energized with direct current. Attempts have been made to increase the flux output of coil windings of electromagnets to cause an armature to pick up and move from its dropped out position, where it is spaced from a stationary magnet, to its sealed position, where it engages the magnet, and to decrease the flux output of the coil winding when the armature engages the magnet. These attempts have included arrangements requiring tapped or multiple wound coils, coils which were energized by alternating current before the armature is at the sealed position and with direct current after the armature is in the sealed position and systems which reduce the current flow through the coil after the armature is at its sealed position. These prior art systems are objectionable in that they are either expensive, are limited in their ability to reduce the current flow through the coil after the armature is at the sealed position, or incapable of quickly discharging the energy stored in the magnet after the magnet is de-energized.

It is an object of the present invention to provide a circuit for controlling the energization of a device having an electromagnet with said circuit including a pair of bridge-type rectifying networks having unequal output voltages and a transistor having an emitter and collector connected in series with a coil winding of the electromagnet and the networks so the winding of a coil is energized by the outputs of either of the networks and a base connected to the outputs of both networks so the transistor is biased into saturation by the output of the higher output voltage network when both networks are energized and by the lower output voltage network when the higher voltage network is de-energized, and when both networks are de-energized, the transistor is switched into an active state by current induced in the coil by the magnet energy stored in the electromagnet.

An additional object is to provide a circuit for controlling the energization of an electromagnet in an electromagnetically operated device with said electromagnet including a stationary magnet, an armature and a coil positioned to induce magnet flux in the magnet and armature for causing the armature to move from a de-energized position to an energized position and engage the magnet when the coil is energized by current flowing through a transistor from a first direct current voltage source and to cause the armature to be maintained in its energized position when the coil is energized by a reduced current flowing through the transistor from a second direct current voltage source that has an output voltage that is less than the output voltage of the first source and with said circuit including a diode connected between like polarity output terminals of both sources for preventing current flow from the first source through the second source, a Zener diode connected between the base of the transistor and the coil to limit the voltage bias across the transistor when both sources are deenergized and the transistor is biased toward conduction by a voltage caused by the inductive energy in the electromagnet, and a Zener diode connected between the base and the emitter of the transistor to limit the voltage bias between the base and the emitter and the conduction of the transistor to a predetermined value when the first source is energized.

A further object is to provide a circuit for controlling the energization of an electromagnet in an electromagnetically operated device with said electromagnet including a stationary magnet, an armature, and a coil positioned to induce magnet flux in the magnet and armature for causing the armature to move from a de-

energized position to an energized position and engage the magnet when the coil is energized by current flowing through a transistor from a first direct current voltage source and to cause the armature to be maintained in its energized position when the coil is energized by a reduced current flowing through the transistor from a second direct current voltage source that has an output voltage that is less than the output voltage of the first source and with the first direct current source including a full wave rectifying bridge network, a transformer having a primary winding connected to be energized by an alternating current source and a secondary winding connected through a triac to supply an alternating current input to the bridge network and a firing circuit controlling the conduction of the triac, said firing circuit including a normally closed switch that is opened when the armature is at the energized position and a capacitor that is charged through the switch and connected to maintain the triac in a conductive state a brief period after the switch opens and the second direct current source including a full wave rectifying bridge network and a transformer having a primary winding connected to be energized by the output of the secondary winding of the first direct current source and a secondary winding connected to supply an alternating current input to the bridge network of the second direct current source.

Further objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawing illustrating a preferred embodiment in which a schematic diagram of a circuit controlling the energization of a coil winding according to the present invention is shown.

The control circuit shown in the drawing includes a transformer 1T, a transformer 2T, a full wave rectifier bridge network **10**, and a full wave rectifier bridge network **11**. The transformer 1T has a primary winding connected through a conventional start-stop control circuit to an alternating current source, not shown. A secondary winding of the transformer 1T has its output terminals connected to supply alternating current to a pair of leads **12** and **13** and a primary winding of the transformer 2T. The rectifier bridge **10** has a pair of input terminals **14** and **15**, a pair of output terminals **16** and **17**, and diodes polarized so the output terminal **16** is positive relative to the terminal **17** when the bridge **10** is energized with alternating current at its input terminals **14** and **15**. The terminal **14** is connected to the lead **12** and the terminal **15** is connected through a triac TR1 to the lead **13**.

The term "triac" is an acronym that has been coined to identify the triode (three-electrode) AC semiconductor switch which is triggered into conduction by a gate signal in a manner similar to the action of an SCR. The triac, generically called a bidirectional triode thyristor, first developed by General Electric, (U.S. Pat. No. 3,275,909 and others applied for) differs from the SCR in that it can conduct in both directions of current flow in response to a positive or negative gate signal.

The triac TR1 has a main terminal MT1 connected to the output terminal **15**, a main terminal MT2 connected to the lead **13**, and a gate *g* connected to the main terminal MT2 of a triac TR2. The triac TR2 has a main terminal MT1 connected through a resistor R1 to the terminal **15** and a gate *g* connected through a Zener diode D1 and a resistor R2 to a junction **18**. A capacitor C1 is connected between the junction **18** and the lead **13**. A charging circuit for the capacitor C1 includes a switch having normally closed contacts SW, a diode D2 and a resistor R3 connected in series between the lead **12** and the junction **18**. The diode D2 is polarized so the side of the capacitor connected to the lead **13** is positive in polarity when the capacitor C1 is charged. A resistor R4 and a capacitor C2 are connected in series between the main terminals MT1 and MT2 of the triac TR1 and a resistor R5 is connected between the gate *g* and the main terminal MT2 of the triac TR1. A resistor R6 is connected between the gate *g* and the main terminal MT2 of the triac TR2.

The rectifier bridge **11** has a pair of input terminals **19** and **20** connected to the output terminals of the secondary winding of the transformer 2T, a pair of output terminals **21** and **22** and diodes polarized so the output terminal **21** is positive in polarity relative to the terminal **22** when the bridge **11** is energized by the output of the transformer 2T.

The positive output terminals **16** and **21** are connected to each other by a common lead **23** and the negative terminals **17** and **22** are connected together by a series circuit that includes a junction **24**, a junction **25** and a diode D3. The diode D3 is polarized to block current from the terminal **22** to the terminal **17**. A transistor T1 and a coil C are connected in series between the junction **24** and the common lead **23**. The transistor T1 is of the pnp type and has an emitter connected to the common lead **23**, a collector connected through the coil C to the junction **24**, and a base connected to the emitter of an pnp type transistor T2. The transistor T2 is of the pnp type and has a collector connected to the collector of the transistor T1 and a base connected through series connected resistors R7 and R8 to the junction **25**. A capacitor C3 is connected between the lead **23** and a junction located between the resistors R7 and R8. A resistor R9 is connected between the terminal **22** and the lead **23** and a resistor R10 is connected between the base of the transistor T2 and the lead **23**. A Zener diode D4 is connected between the base of the transistor T2 and the collector of the transistor T1. If desired, a resistor R11 and a Zener diode D5 may be connected between the emitter and the base respectively of the transistor T2 and the lead **23**.

The coil C is part of an electromagnet **26** as may be used in an electromagnetically operated device **28** disclosed in the Puetz et al patent supra, and is schematically illustrated in the drawing. The device **28** in addition to the electromagnet **26** includes a movable contact carrier **29** illustrated by a broken line. The electromagnet in addition to the coil C includes a stationary magnet **30** and an armature **31**. The armature **31** is moved to a dropped out position where it is spaced from the magnet **30** when the coil C is deenergized. The coil C, when energized by sufficient current, will induce a magnet flux in the magnet **30** and the armature **31** which causes the armature **31** to move to a sealed position where it engages the magnet **30**. The carrier **29** is moved by the armature **31** and causes a set of contacts **32** to be open and the contacts SW to be closed when the armature is at its dropped out position. When the coil C is energized and the armature **31** is at its sealed position, the carrier **29** will cause the contacts **32** to be closed and the contacts SW to be open. The contacts **32** are the power switching contacts of the contactor shown in the Puetz et al patent which open and close a load circuit. The contacts SW in the

preferred form of the invention are provided by a separate switch that is mounted adjacent the side wall of the Puetz et al. contactor, as disclosed in U.S. Pat. No. 3,322,910 which was granted to Allin W. Schubring on May 30, 1967.

The transformer 1T, when de-energized, will cause the circuit to be in its quiescent state and the coil C to be de-energized, the contacts SW to be closed, and the capacitor C1 to be discharged. The transformer 1T, when energized by alternating current, will cause an alternating voltage to be present between the leads 12 and 13 and cause the transformer 2T to supply an alternating voltage to the terminals 19 and 20. In the preferred embodiment, the transformers 1T and 2T are wound so the alternating voltage between the leads 12 and 13 is approximately ten times the voltage between the terminals 19 and 20.

The alternating voltage between leads 12 and 13 will charge the capacitor C1 through the charging circuit that includes the resistor R3, the diode D2 and the contacts SW. When the charge across the capacitor C1 exceeds the breakdown voltage of the Zener diode D1, current will flow through the gates of the triacs TR1 and TR2 through a circuit that includes the lead 13, the terminal MT2 and the gate *g* of the triac TR1, the terminal MT2 and the gate *g* of the triac TR2, the Zener diode D1, the resistor R2 and the junction 18. The gate current through the triacs TR1 and TR2 causes the triacs to switch to a conductive state and a direct current voltage to be present between the terminals 16 and 17. The emitter of the transistor T1 is connected by the lead 23 to the terminal 16 and the base of the transistor T1 is connected to the terminal 17 by a circuit that includes the emitter to base of the transistor T2, the resistor R7 and R8, and the junctions 25 and 24. The collector of the transistor T1 is connected through the coil C to the terminal 17. Thus the direct current voltage between the terminals 16 and 17 switches the transistor T1 to a saturated state and causes the coil C to be energized.

The coil C, when energized by the output of the rectifier bridge 10, induces a magnet flux in the armature 31 and the magnet 30 which causes the armature to move from its dropped out position to the sealed position with the magnet 30. The contacts SW are opened just prior to the engagement between the armature 31 and the magnet 30 and interrupt the charging circuit for the capacitor C1. The triacs TR1 and TR2 continue to be conductive for a brief period after the contacts SW are opened by the decaying charge on the capacitor C1 as the charge on the capacitor decays to a potential which permits the Zener diode D1 to block gate current through the triacs TR1 and TR2. The continued conduction of the triacs TR1 and TR2 after the contacts SW are opened assures that the armature 31 will move to its sealed position. Any charge remaining on the capacitor C1 after the triacs TR1 and TR2 are switched to a nonconductive state is dissipated through the resistors R12 and R2. The switching of the triacs TR1 and TR2 to their nonconducting or OFF states permits the rectifier bridge 11 to supply the coil C with the necessary current to maintain the armature 31 in its sealed position with the magnet 30. The output terminals 21 and 22 of the rectifier bridge 11 are connected in a series circuit with the coil C that includes the lead 23, the emitter to collector of the transistor T1, the coil C, the junctions 24 and 25, and the diode D3. The output terminals 21 and 22 of the rectifier are also connected in a series circuit with the emitter and base of the transistor T1 that includes the lead 23, the emitter to base of the transistor T1, the emitter to base of the transistor T2, the resistors R7 and R8, the junction 25, and the diode D3. Thus during periods when the rectifier bridge 10 is de-energized, because of the nonconducting triacs TR1 and TR2, the potential at the terminals 21 and 22 will cause the transistor T1 to continue to conduct at a rate dependent upon the voltage between the terminals 21 and 22. The components of the circuit are selected so the transistor T1 will conduct at a maximum when the bridge 10 is energized and conduct at a reduced rate when the bridge 10 is de-energized and the bridge 11 is energized. Thus after the armature 31 is at the sealed position, the coil C will be energized by current supplied by the rectifier bridge 11 which is sufficient to maintain the armature 31 in its sealed position without overheating the coil C which would occur if the rectifier bridge 10 was permitted to supply energizing current to the coil C after the armature 31 was in its sealed position.

The circuit is de-energized when the alternating current input to the primary winding of the transformer 1T is removed. The de-energization of the circuit will cause the magnet energy stored in the armature 31 and magnet 30 to induce a reverse voltage in the coil C and cause the junction 24 side of the coil C to become positive in polarity. The positive potential at the junction 24 causes a current flow through both rectifying bridges 10 and 11 and the lead 23 and causes a positive to negative potential to appear between the emitter and collector of the transistor T1 which is limited by the Zener diode D4. The Zener diode D4 conducts the emitter to base current of the transistors T1 and T2 when the potential between the emitter and collector of the transistor T1 exceeds the break-down voltage of the Zener diode D4 which causes the transistor T1 to provide a relatively constant voltage to the induced current output of the coil C to rapidly dissipate the energy stored in the electromagnet 26.

The components in the circuit function and provide the advantages as follows. The transformer 1T supplies power directly to the coil C during pick-up of the armature 31 and indirectly through the transformer 2T when the armature 31 is in the sealed position. Thus if the transformer 1T is provided with a multitaped primary winding, the circuit can be used without modification with a range of different alternating current sources.

It is apparent that the triac TR2 may be omitted from the circuit and the triac TR1 may be fired directly in response to the charge on the capacitor C1. However, the use of the pilot triac TR2 to control the gate current through the main power triac TR1 permits the resistance of the resistor R2 to be increased and the capacitance of the capacitor C1 to be decreased. The pilot triac TR2 is selected to have a high rate sensitivity and thus permits the capacitor C1 to be of the mylar type, rather than of the electrolytic type, which is required when the triac TR1 gate current is directly furnished by the capacitor C1.

The transistors T1 and T2 are connected in a commonly known Darlington connection and, if desired, the Zener diode D4 may be connected between the emitter and collector of the transistor T1 to dissipate the stored energy in the coil C when the circuit is initially de-energized. Also, the transistor T1 may be re-

placed by a jumper wire. However, when the transistor T1 is eliminated from the circuit, the drop-out time of the armature becomes prohibitively long because the induced coil current "freewheels" through the full wave bridges **10** and **11.** The placement of the Zener diode D4 between the base and collector of the transistor T2, instead of between the emitter and collector of the transistor T1, allows the use of a low power, rather than a high power, Zener diode. The higher power transistor T1 that is required to conduct high current during pick-up is also used to dissipate the stored energy in the coil during the drop-out of the armature. This allows for economy in design since the transistor T1 has to be a high power transistor to handle the in-rush current to the coil C.

Another important feature of the circuit is that the drive for the power transistor T1 is provided by the bridge **10** during pick-up and from the bridge **11** during sealed conditions of the armature. Thus the transformer 2T is not required to provide power for the coil during sealed conditions plus the drive for the transistor T1 during pick-up conditions of the armature which would increase the power requirements of the transformer 2T.

The presence of the diode D3 in the circuit isolates the rectifier bridge **11** from the high voltage output of the rectifier bridge **10** during pick-up. The rectifier bridge **10** is required to have a voltage and current rating sufficient to tolerate the high pick-up voltage and current. The diode D3 has the same voltage rating as the bridge **10.** However, its current carrying capability is compatible with the current rating of the rectifier bridge **11.** Thus the diode D3 permits the bridge **11** to be of the low voltage, low current type, since the diode D3 isolates the bridge **11** from the bridge **10** during pick-up of the armature **31.** The resistor R9 provides a sufficiently low impedance path to ensure that the reverse leakage current of the diode D3 will not cause the high reverse voltage to be impressed across the rectifier bridge **11.**

The addition of the Zener diode D5 between the base of the transistor T1 and the lead **23** in conjunction with the resistor R11 between the emitter of the transistor T1 and the lead **23** limit the current flow through the transistor T1 during the pick-up of the armature **31.** The Zener diode D5 and the resistor R11 are selected so that the current through the coil C is limited to an amount sufficient to ensure pick-up of the armature **31** during low voltage conditions of the source to the transformer 1T. During normal and high voltage conditions, the pick-up current through the coil C is regulated at the current limit level. The limitation of current flow through the coil C will provide a uniform pick-up of the armature and provide a mechanical life of the device that is independent of high and low voltage conditions of the alternating current supply to the system.

The Zener diode D1 is included in the circuit to the gate of the triac TR2 to establish uniform time during which the triacs TR1 and TR2 remain conducting after the contacts SW are opened and causes the circuit to be less sensitive to variations in the gate sensitivities of the triacs TR1 and TR2.

The resistors R7 and R8 control the amount of base drive current to the transistor T2. The capacitor C3 acts as a filter and prevents the base drive current in the transistor T2 from falling to zero between the half cycles of the applied voltage.

A surge suppressor SS may be included in the circuit to protect the circuit from damage caused by voltage transients from the source to the primary winding of the transformer 1T and a fuse F is included in the output circuit of the secondary winding of the transformer 1T. Preferably, the fuse F is rated so that if a component in the circuit fails so that the bridge rectifier **10** is energized after the armature **31** is at the sealed position, the fuse F will blow and cause the control circuit to be de-energized.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. A circuit for controlling the energization of an electromagnetically operated device, said device including a stationary magnet, an armature and a coil positioned to induce magnet flux in the magnet and the armature for causing the armature to move from a first position where the armature is spaced from the magnet to a second position where the armature engages the magnet when the coil is energized by direct current, said circuit comprising: a pair of rectifying bridge networks each having a pair of input terminals and a pair of output terminals, circuit means connecting the input terminals of the pair of networks to an alternating current source for causing a direct current potential between the output terminals of a first of said pair of networks to have a magnitude greater than a direct current potential between the output terminals of a second of the networks when said networks are energized by the source, a transistor having an emitter and a collector connected in series with the coil in a circuit connected between the output terminals of both networks and the emitter and a base connected between the output terminals of both networks in a direction to cause the transistor to conduct and cause the coil to be energized by an output current from the first network when both of said networks are energized and to conduct and cause the coil to be energized by an output current from the second network when the second network is energized and the first network is de-energized, and switching means in the circuit connecting the input terminals of the first network to the alternating current source for causing the first network to be de-energized when the armature is at the second position.

2. A circuit for controlling the energization of an electromagnetically operated device, said device including a stationary magnet, an armature and a coil positioned to induce magnet flux in the magnet and the armature for causing the armature to move from a first position where the armature is spaced from the magnet to a second position where the armature engages the magnet when the coil is energized by direct current, said circuit comprising: a first rectifying bridge network having a positive polarity output terminal, a negative polarity output terminal and a pair of input terminals, circuit means connecting the input terminals to an alternating current source for energizing the network and causing a direct current potential between the positive and negative terminals, a transistor having a pair of main electrodes and a base electrode, circuit means connecting the main electrodes and the coil in series with the positive and negative terminals and connecting

the base to one of the output terminals for causing the transistor to conduct and the coil to be energized with a current flow having a magnitude sufficient to maintain the engagement between the armature and the magnet when the first network is energized, a second rectifying bridge network having a positive polarity output terminal, a negative polarity output terminal and a pair of input terminals, means including a circuit connecting the input terminals of the second network to an alternating current source for energizing the second network and causing a direct current potential to be present between the output terminals of the second network that has a magnitude greater than the potential between output terminals of the first network, circuit means connecting the main electrodes and the coil in series with the positive and negative terminals of the second network and connecting the base to one of the output terminals of the second network for causing the transistor to conduct and the coil to be energized with current flow from the second network having a magnitude sufficient to cause the armature to move from the first position to the second position and for blocking current flow through the base of the transistor from the first network when the first and the second networks are energized, and switching means connected in the circuit between the source and the input terminals of the second rectifier for causing the second network to be de-energized when the armature is at the second position.

3. The circuit as recited in claim 1 including a diode connected in the circuit between like polarity output terminals of both networks for preventing current flow from the output terminals of the first network through the second network whereby the rectifying components of the second network may have a lower voltage rating than the rectifying components of the first network.

4. The circuit as recited in claim 1 including a Zener diode having a first side connected to the series circuit at a junction between the coil and the transistor and a second side connected through a circuit to the base of the transistor for limiting the voltage across the transistor to a predetermined value when both of the networks are de-energized and the transistor is biased toward conduction by a voltage caused by inductive energy in the device.

5. The circuit as recited in claim 1 including a Zener diode connected between the base and the emitter of the transistor and a resistor connected in the emitter circuit of the transistor to limit conduction of the transistor to a predetermined value.

6. The circuit as recited in claim 1 wherein the switching means in the circuit connecting the input terminals of the first network to the alternating current source includes a triac and a circuit for switching the triac to a conductive state, said switch circuit comprising a capacitor connected in a circuit between a gate and a main electrode of the triac and a charging circuit for the capacitor including a rectifying diode and normally closed switching contacts that are moved to a circuit opening position when the armature is at the second position.

7. The circuit as recited in claim 6 wherein the circuit connecting the capacitor to the gate and main electrode of the triac includes a Zener diode connected to prevent current flow in the circuit when the charge on the capacitor is less than a predetermined value.

8. The circuit as recited in claim 6 including a second triac having main electrodes connected between one of the input terminals of the first network and one side of the source and one main electrode and a gate electrode connected to a circuit including a main electrode of the first mentioned triac.

9. The circuit as recited in claim 1 wherein the alternating current source for the first network includes a first transformer having a secondary winding having a pair of output terminals connected to the pair of input terminals of the first network respectively and the alternating current source for the second network includes a transformer having a primary winding connected to be energized by the output of the secondary winding of the first transformer.

10. The circuit as recited in claim 1 including a diode connected in the circuit between like polarity output terminals of both networks for preventing current flow from the output terminals of the first network through the second network whereby the rectifying components of the second network may have a lower voltage rating than the rectifying components of the first network, a Zener diode having a first side connected to the series circuit at a junction between the coil and the transistor and a second side connected through a circuit to the base of the transistor for limiting the voltage drop across the transistor to a predetermined value when both of the networks are de-energized and the transistor is conducting current caused by inductive energy in the device.

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