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CIRCUIT FOR CONTROLLING ELECTROMECHANICAL LOAD

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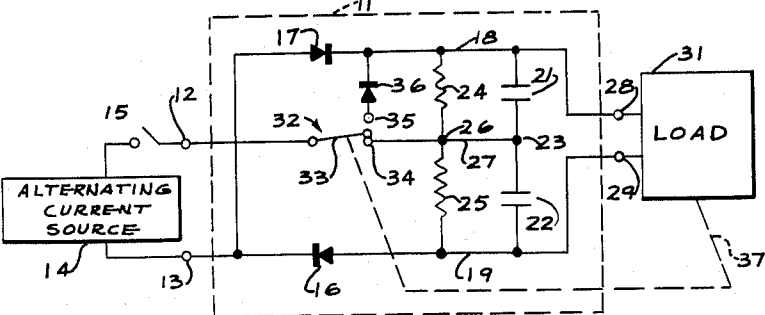


FIG. 1

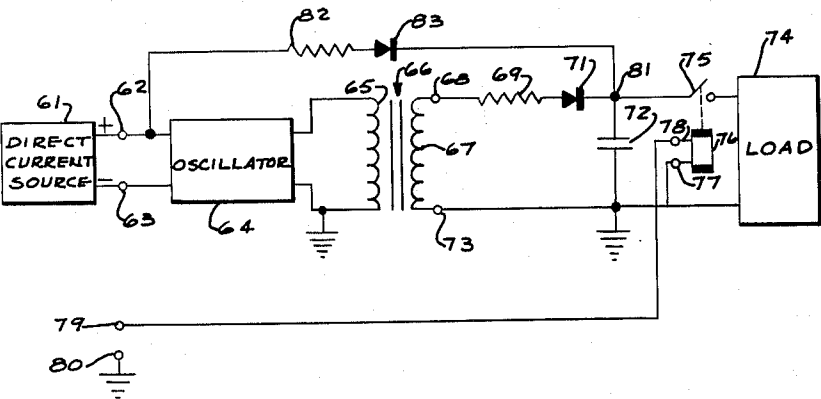


FIG. 3

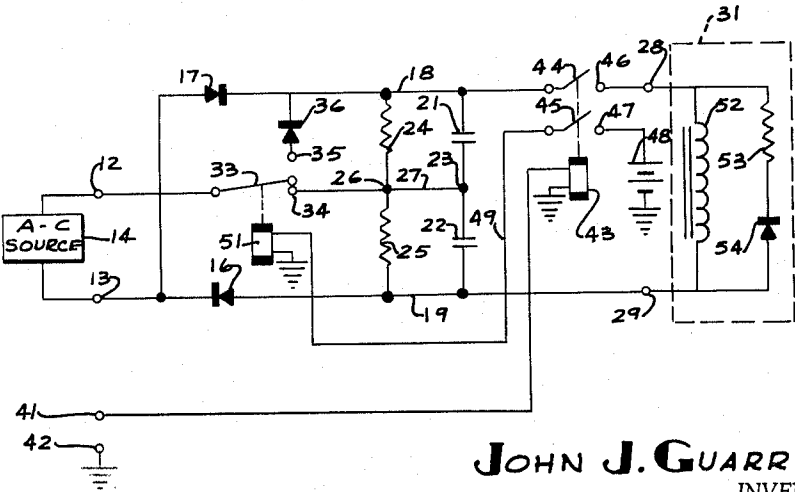


FIG. 2

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CIRCUIT FOR CONTROLLING ELECTRO-MECHANICAL LOAD

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This invention relates generally to a circuit for controlling electromechanical loads and more particularly for such loads that require one potential level for actuation thereof and another potential level for maintaining the load in its actuated position.

There are many instances wherein it becomes desirable to cause a particular device to operate very quickly and to maintain the device in an operated condition for long periods of time. One example of such a device is a microwave switch which is utilized to transfer microwave energy from one position or apparatus to another. Typically such devices are actuated or switched by a solenoid type apparatus. To obtain the very fast initial switching action a level of potential much higher than the normal operating level is applied to the solenoid. If the high level of potential is maintained upon the solenoid the actuating coils contained therein will ultimately become damaged as a result of the overload thereon. The solenoid can, however, very readily withstand short duration high potential applied thereto. It therefore becomes necessary to reduce the potential level after the switch has been actuated so that it can be maintained in the actuated position as desired.

In the prior art this reduction of potential has been accomplished after the switch has actuated by inserting a series dropping resistor into the circuit. Although the series dropping resistor does accomplish the purpose of reducing the potential level applied to the solenoid large amounts of heat are generated thereby. The generation of these large amounts of heat not only is a direct waste of electrical energy but at the same time the temperature increase resulting from the heat generation causes the lifetime of various components housed within the general vicinity of the series dropping resistor to be shortened.

Accordingly it is an object of the present invention to provide an actuating circuit for applying two potential levels to a load device which circuit is positive and fast acting, which does not utilize electrical energy beyond that required to operate the desired load, and which does not generate large amounts of heat.

It is another object of the present invention to provide an actuating circuit for applying two potential levels to a load device which circuit is simple, rugged and has an exceedingly long lifetime.

Other objects and advantages of the present invention will become apparent from a consideration of the following description taken in conjunction with the accompanying drawing which is presented by way of example only and is not intended as a limitation upon the scope of the present invention as defined in the appended claims and in which:

FIG. 1 is a schematic circuit diagram of one embodiment of a circuit in accordance with the present invention;

FIG. 2 is a schematic circuit diagram illustrating an addition to the circuit as illustrated in FIG. 1; and

FIG. 3 is an alternative embodiment of a circuit in accordance with the present invention.

A circuit in accordance with the present invention includes first means for establishing a first potential level which is sufficient to actuate the desired load. Second means is provided for establishing a second potential level which is sufficient to maintain the desired load in an actuated state once it has been placed therein. Switch means is included for enabling the second means and

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disenabling the first means after the load device has been actuated.

Referring now to the drawing and more particularly to FIG. 1 there is illustrated an actuating circuit contained within the dotted block 11. The circuit includes input terminals 12 and 13, across which there is connected a source of alternating current voltage 14. A switch 15 is interposed between the alternating current voltage source and terminal 12 to control the application of the alternating current voltage to the circuit 11. The cathode of a diode 16 and the anode of a diode 17 are interconnected and returned to the input terminal 13 of the circuit 11. The cathode of the diode 17 is connected to a lead 18 while the anode of the diode 16 is connected to a lead 19. Charge storage means such as capacitors 21 and 22 are connected in series providing a common point 23 therebetween, and in turn are connected between the leads 18 and 19. A pair of resistors 24 and 25 are connected in series thus providing a common terminal 26 therebetween and in turn are connected between the leads 18 and 19 in parallel with the capacitors 21 and 22. A lead 27 is interconnected between the common points 23 and 26. Output terminals 28 and 29 of the circuit 11 are connected to the leads 18 and 19 respectively and a load 31 is connected to the output terminals 28, 29. The load 31 may be any load which is desired and which requires for actuation thereof a first level of potential and, for maintenance of the actuated state, a second level of potential as will be described more fully below.

A single pole double throw switch 32 has the movable arm 33 thereof connected to the input terminal 12. Stationary contact 34 of the switch 32 is connected to the common point 26 while stationary contact 35 of the switch 32 is connected to the anode of a diode 36. The cathode of the diode 36 is connected to the lead 18. The movable arm 33 of the switch 32 may be actuated in any manner which is desired, that is electrically, mechanically, or electromechanically, and for example may be mechanically actuated as a result of the actuation of the load device 31. Such mechanical actuation of the switch 32 is indicated in FIG. 1 by the dashed line 37 interconnecting the load and movable arm 33 of the switch 32.

The operation of the circuit illustrated in FIG. 1 will now be described. At some predetermined signal or time switch 15 is closed thus applying voltage from the alternating current source 14 to the input terminals 12 and 13 of the circuit 11. Assume for purposes of description that the instantaneous polarity of the potential applied to the terminals 12 and 13 is such that terminal 13 is positive going with respect to terminal 12. Under these operating conditions a positive potential is applied to the cathode of the diode 16 thus causing it to become back-biased and therefore non-conducting. A positive potential is also applied to the anode of the diode 17 thus causing it to become forward biased and therefore conducting. Current therefore flows from source 14 through input terminal 13, through the forward biased diode 17 through lead 18, through capacitor 21 applying a charge thereon which is positive at lead 18. Since the diode 16 is back-biased and therefore non-conducting, current cannot flow through capacitor 22. Therefore, current flows from common point 23, through lead 27, through the normally closed contacts 33, 34 of the switch 32, to input terminal 12 and back to the alternating current source 14. Thus a unidirectional current flow path is provided as above indicated.

Assuming next that the instantaneous polarity of the alternating current source voltage has changed such that the input terminal 12 is positive going with respect to input terminal 13 under such conditions diode 16 has a negative potential applied to the cathode thereof and is therefore forward biased while diode 17 has a negative

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potential applied to the anode thereof and is therefore reverse biased. Under these conditions current flows from source A through input terminal 12, through the normally closed contacts 33, 34 of the switch 32, through lead 27, through capacitor 22 charging it positive at the common terminal 23, through lead 19, through the forward biased diode 16, to input terminal 13, and back to the alternating current source 14. The current cannot flow through the capacitor 21 since diode 17 is back biased and therefore non-conductive. Thus there is established a second unidirectional current flow path as above indicated.

From the foregoing it is seen that capacitors 21 and 22 have a charge applied to them in such a manner that lead 18 is positive with respect to lead 19. The circuit as indicated essentially doubles the voltage which is available from alternating current source 14. The resistors 24 and 25 are in parallel with capacitors 21 and 22 respectively to operate as a simple smoothing circuit. When the charge across the capacitors 21 and 22 reaches the desired level load 31 is actuated. Upon the actuation of the load it is desired to maintain it in the actuated state. Obviously if current continued to flow in the manner above described, the potential level developed across the capacitors 21 and 22 is such that the load would be maintained in its actuated state. However, the potential level is quite high compared to the normal design rating for the load and would in a very short period of time cause damage to the load. It is therefore desirable to reduce the potential level once the load has become actuated. This is accomplished in the following manner.

Upon the actuation of the load 31 the movable arm 33 of the switch 32 is transferred from contact 34 to contact 35. Under these operating conditions circuit 11 functions as follows: Assuming that the potential at input terminal 13 is positive with respect to input terminal 12 it is seen that as before diode 16 is reverse biased and diode 17 is forward biased. However, since the return circuit from the common points 23 and 26 through the switch 32 is now open, current cannot flow through diode 17. Since input terminal 13 is positive going with respect to terminal 12, diode 36 is reverse biased. Therefore during the period of time that the input terminal 13 is positive going with respect to input terminal 12 there is no current flow through the circuit 11.

Reversing the situation now such that the input terminal 12 is positive going with respect to the input terminal 13, the following operation will occur. Under these conditions diode 16 is forward biased as is diode 36. Diode 36 being forward biased by the positive potential appearing at terminal 12 current flows from source A, through the diode 36, through capacitors 21 and 22 in series, through the forward biased diode 16, to input terminal 13, and back to the alternating current source 14. It is thus seen that under these operating conditions capacitors 21 and 22 along with the remainder of circuit operate as a simple half-wave rectifier.

As a simple half-wave rectifier a much lower potential is provided across leads 18 and 19 and thus at output terminals 28 and 29 which is in turn applied to the load 31 than was the case during the period of time that the capacitors 21 and 22 with the remainder of the circuit operated as a voltage doubling circuit. Under these operating conditions the load 31 is maintained in its actuated state for an indefinite period of time without in any way imparting damage thereto or to the circuit 11. When it is desired to have the load 31 returned to its non-actuated state switch 15 may be opened, thus permitting this to occur. When the load 31 returns to its non-actuated state the movable arm 33 of the switch 32 returns to its normally closed position such that it is in contact with the stationary terminal 34.

From a consideration of the circuit as illustrated in FIG. 1 and its description given above, it is seen that there is some time delay although small after the closing

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of switch 15 before the potential across leads 18 and 19 can rise to a level sufficient to quickly actuate the load 31. Under some operating conditions it is desirable to more quickly operate load 31 upon the application of the desired signal to the actuating circuit.

A circuit for accomplishing almost instantaneous actuation upon the application of a command signal thereto is indicated in FIG. 2 to which reference is hereby made. The voltage doubling and half-wave rectifier circuits are identical to that illustrated and described in FIG. 1. Such is indicated by the use of the same reference numerals in FIG. 2 for the same or similar parts as illustrated in FIG. 1. Since the circuit and its operation as above described is essentially the same as for FIG. 2 additional description of the circuit in FIG. 2 will not be given with the exception of reference to the various additions thereto.

It should be noted that there is no switch interposed between the alternating current source 14 and input terminal 12. Under these conditions the potential from the alternating current source is applied at all times to the circuit. Under these operating conditions capacitors 21 and 22 operating as a voltage doubler maintain a relatively high potential level across leads 18 and 19.

As is illustrated in FIG. 2 the circuit is provided with an additional pair of input terminals 41, 42, 42 being returned to a point of fixed potential such as ground. Input terminal 41 is connected to one side of a relay 43, the remaining side of which is connected to a point of fixed potential such as ground. The relay 43 actuates two movable contacts 44 and 45. The stationary contact 46 which operates in conjunction with movable contact 44 is connected to output terminal 28 while the stationary contact 47 which operates in conjunction with movable contact 45 is connected to the positive terminal of a source of potential such as battery 48, the negative terminal of which is returned to a point of fixed potential such as ground. The movable contact 45 is connected by way of lead 49 to one side of an additional relay 51, the opposite side of which is returned to ground. Relay 51 operates the movable arm 33 which operates in conjunction with stationary terminals 34 and 35 to convert the circuit from a voltage doubler to a half-wave rectifier. Output terminals 28 and 29 of the circuit are connected to the load 31 which in this particular illustration is represented as being the coil 52 of a solenoid which has connected in parallel therewith a resistor 53 and a diode 54. The function of the resistor 53 and diode 54 is to eliminate the spike of voltage generated when current is removed from the coil 52 upon de-actuation of the load.

In operation the circuit as illustrated in FIG. 2 functions as follows. As above indicated the alternating current source voltage 14 is applied to the circuit input terminals 12 and 13 at all times. Under these operating conditions the leads 18 and 19 have applied thereto the high level of potential developed by charging the capacitors 21 and 22 in such a manner that they function as a voltage doubler. However, since the relay 43 is not actuated no potential is applied to the load 31. When it becomes desirable to actuate the load 31 a common signal is applied across input terminals 41 and 42. The command signal energizes relay 43 causing the movable contacts 44, 45 thereof to close and contact the stationary contacts 46, 47 respectively. Upon this occurring the high level of potential is applied to the load 31 thus causing the solenoid 52 to become energized and to immediately actuate the load. Simultaneously the potential from battery 48 is applied to the relay 51 causing it to become energized thus causing the movable arm 33 to move from stationary contact 34 to stationary contact 35. The potential stored in capacitors 21, 22 is sufficient to completely actuate the load 31 even though the voltage doubling circuit has thus been interrupted. After the actuation of relay 51 the potential applied to the load 31 through the now closed contacts 44, 46 of the relay 43 is reduced to a level sufficient to maintain the load in an

actuated condition but such that it will do no damage to the load.

Alternatively and if such is desired relay 51 can be made a time delay type relay to thereby completely assure under all circumstances that load 31 has fully actuated before reducing the potential level that is applied thereto.

Under some operating environments a source of alternating current potential is not available for actuation or energization of circuits such as those illustrated in FIGS. 1 and 2. Under these circumstances a circuit of the type illustrated in FIG. 3 to which reference is hereby made can be utilized to accomplish the same purpose as above described. As is illustrated in FIG. 3 there is provided a source of direct current voltage 61 which is connected to a pair of input terminals 62 and 63. The input terminals in turn are connected to an oscillator 64 which may be a conventional direct current to alternating current converter of the type well known in the prior art. The output of the oscillator 64 is a primary winding 65 of a transformer 66. As is illustrated one portion of the winding 65 may be returned to a point of fixed potential such as ground. The transformer 66 also includes a secondary winding 67. Connected in series with terminal 68 of the secondary windings 67 is a current limiting resistor 69 to which is connected the anode of diode 71. The cathode of diode 71 is connected to charge storage means such as capacitor 72. The opposite terminal 73 of secondary winding 67 is connected also to capacitor 72 and may if such is desired be returned to a point of fixed potential such as ground, as is illustrated. Connected between the cathode of the diode 71 and a load 74 is the contact 75 of a relay 76. The relay 76 has one terminal 77 thereof returned to ground while the other terminal 78 thereof is connected to an input terminal 79, the co-operating terminal 80 thereof also being connected to a point of fixed potential such as ground.

Connected between input terminal 62 and the common point 81 between diode 71 and capacitor 72 is the series connected combination of a resistor 82 and a diode 83, the cathode of the diode 83 being connected to the common terminal 81, the resistor 82 functioning as a current limiting resistor.

The operation of the circuit as illustrated in FIG. 3 is as follows. The direct current source is applied by way of terminals 62 and 63 to the oscillator 64. The oscillator functions at the design frequency thereof in the normally understood manner to thereby apply an alternating current voltage across the primary winding 65 of the transformer 66. The secondary winding 67 of the transformer 66 then applies the voltage generated therein to the terminals 68, 73 thereof. Assuming that the terminal 68 of the secondary winding 67 is positive going with respect to the terminal 73 diode 71 is forward biased thus causing current to flow therethrough. Current thus flows from the terminal 68 of the secondary winding 67 through resistor 69, diode 71, the capacitor 72 and back to the terminal 73 of secondary winding. This flow of current applies a charge across capacitor 72 which is positive at the common point 81. Since the switch 75 is open no potential is applied to the load 74. When the terminal 68 of the secondary winding 67 is negative going with respect to the terminal 73 the diode 71 is reverse biased and no current flows through the circuit. The level of potential across capacitor 72 is such that diode 83 is maintained in a reverse biased and thus non-conducting condition. Thus no current can flow from the direct current source through the diode 83 and into the remainder of the circuit. Capacitor 72 is thus charged and will remain charged until such a time as it is desirable to actuate the load 74.

When such becomes desirable a command signal is applied to input terminals 79, 80 thus energizing the relay 76. When the relay 76 is energized contact 75 thereof is closed, thus applying the potential charge contained on the capacitor 72 directly to the load 74, causing it to become actuated. Upon the actuation of the load 74 the charge upon the capacitor 72 is applied thereto and is thus reduced to substantially zero. At this point diode 83 the anode of which is connected to the direct current source in such a manner that the positive terminal thereof is connected to the input terminal 62, as illustrated by the polarity signals, becomes forward biased. Under these conditions current then flows from the direct current source through the diode 83 through the closed contact 75 into the load 74 and returns back through ground to the negative terminal of the direct current source. This reduced potential, being the direct current source, maintains the load 74 in an actuated condition for the time desired.

There has thus been disclosed three embodiments of an actuating circuit which applies a high level of potential to a load to obtain actuation thereof and upon the actuation of the load applies a reduced potential thereto to maintain the load in the actuated state for the time desired.

Although several embodiments of the circuit in accordance with the present invention have been disclosed, it should be understood that such embodiments are illustrative only and are not intended as a limitation upon the scope of the appended claims.

What is claimed is:

1. A circuit for operating a load requiring a first potential level for actuation and a second potential level for maintaining said load in an actuated state, said circuit comprising: a source of alternating current voltage having two terminals; a first series connected diode and capacitor connected across said source; a second series connected diode and capacitor connected across said source, said diodes being interconnected and poled in opposite directions and connected to one terminal of said source; switch means, having first and second positions; said capacitors being interconnected at a common point and connected through said switch means to the other terminal of said source, thereby providing a common current flow path connected to each of said capacitors only when said switch means is in said first position; a third diode connected between said switch means and said first capacitor, said third diode being poled the same as said first diode and operable only when said switch means is in said second position, whereby said capacitors are charged separately when said switch means is in said first position and together when said switch means is in said second position.

2. A circuit as defined in claim 1 further including load means, means including second switch means connecting said load means across said capacitors, and actuating means for operating said second switch means.

3. A circuit as defined in claim 2 in which said actuating means is a relay and which further includes a second relay responsive only to actuation of said relay for actuating said switch means.

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