

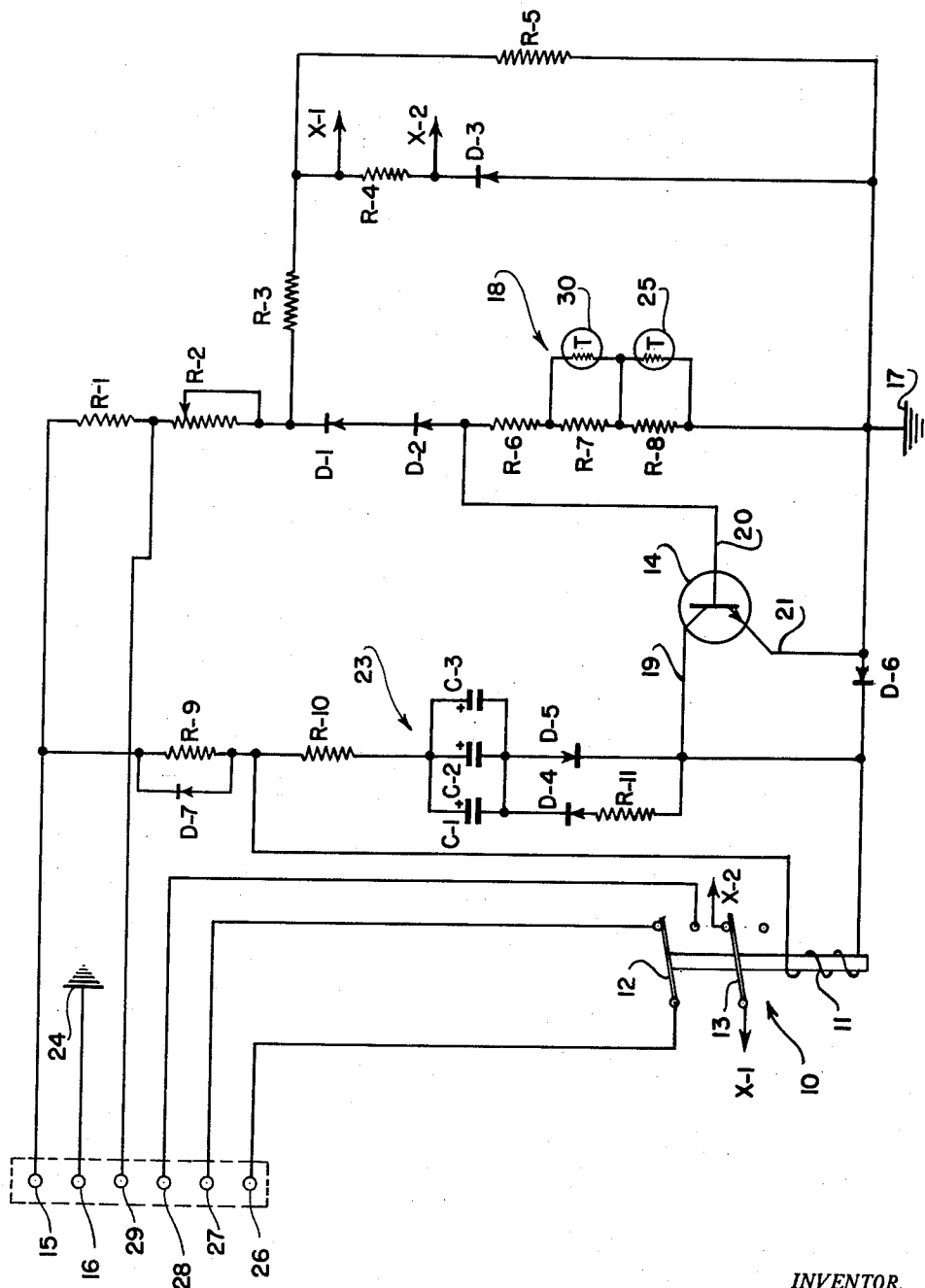
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OVER VOLTAGE RELAY

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OVER VOLTAGE RELAY

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The present invention relates to voltage responsive switches or relays and, more particularly, to a voltage responsive switch relay employing semi-conductors suitable for use as an over voltage relay in electric current generating systems.

Over voltage relays are commonly used in alternating and direct current generating systems to perform a switching function resulting in shutting off a generator causing the over voltage. A relay for use in this type of system requires a time delay in its operation upon the currents of an over voltage so as not to be operated by unobjectionable transients in the system. The relay should also have an inverse time characteristic so that the delay in the operation of the contact decreases as the magnitude of the over voltage increases.

One of the important objects of the present invention is to provide a new and improved over voltage relay in which the over voltage is determined by the attainment of a predetermined threshold voltage and in which there is a time delay in the operation of the relay upon the occurrence of an over voltage, the duration of the time delay normally decreasing as the magnitude of the over voltage increases.

Another object of the present invention is to provide an over voltage relay or switch for aircraft electrical systems, for example, which is substantially unaffected by the wide range of operating temperatures to which aircraft components are sometimes subjected.

Another object of the present invention is to provide a new and improved over voltage circuit which produces a signal that is substantially non-linear with respect to variations of input voltage. The device of the present invention provides a reference diode network in which the associated non-linear signal is used as the basic sensing element for the over voltage.

Still a further object of the present invention is to provide a non-linear diode circuit responsive to an over voltage for generating a controlling signal which operates a relay. The relay is voltage sensitive rather than current sensitive.

With reference to the accompanying schematic drawing, there is shown a direct current over voltage operated relay in accordance with the present invention. Basically, the relay circuit of the present invention comprises a relay 10 having a solenoid 11 which when energized closes a plurality of relay contacts such as the contacts 12 and 13, a transistor 14 coupled to the solenoid for current amplification and supplying the solenoid with operating current and a network of semi-conductors such as diodes D1, D2 and D3 arranged in a cascade relationship which supplied the transistor with operating current proportional to the value of over voltage, the value of over voltage being the voltage above the normal voltage. The diodes are characterized by their ability to pass current in their reverse direction when a specified voltage is applied. This current is a signal current which when applied to the transistor and amplified causes the solenoid to energize and the relay contacts to pull in. The characteristics of the diodes and the transistor amplification characteristics provide a relay solenoid current varying from zero to a "pull in" level of the relay for an input voltage variation of 1.4 volts. That is, if the relay is set to operate at a positive 32 volts, for example, no voltage is applied to the solenoid until 30.60 volts have been reached. For purposes of clarification and

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convenience of description, the present invention will be described according to various functions of the circuit.

Diode Network

Assuming that the normal voltage placed across a pair of input terminals 15 and 16 is 32 volts and that relay 10 will energize at 33 volts. The path to a ground connection 17 from input terminal 15 is via resistors R1, R2 diode D1 and D2, and resistors R6, R7 and R8. A portion of this path is shunted by resistors R3 and R5 which divide the 32 volt input. Selection of proper values for the resistors and the diodes should be made so that approximately 12 volts appear at the top of diode D1. For clarification, the top of a diode or the top of a resistor is that point of highest voltage for that particular diode or resistor. When there are 12 volts at the top of diode D1, there is no current flowing through diode D1 in either its forward or reverse direction. This arrangement provides that there be an approximate 20 volts drop across resistors R1 and R2 and if variable resistor R2 is set at 500 ohms, which is recommended, then a current of 20 milliamperes will flow through these two resistors since current flow is prohibited through diodes D1 and D2. Therefore, the current must go through resistor R3 and then divide between diode D3 and resistor R5.

The value of diode D3 is chosen so that approximately a 6 volt drop will appear across the diode and so that approximately a 6 volt drop appears across resistor R5 having 6 milliamperes passing therethrough. The remaining 14 milliamperes passing through will pass through diode D3. This current is well within the rating of diode D3 and yet it is high enough so that a small change in current will not affect the 6 volt drop across the diode and the voltage at the top of diode D3 will remain at 6 volts.

When the D.C. voltage across input terminals 15 and 16 changes from 32 volts to 33 volts, solenoid 11 of relay 10 will be energized. Energization is accomplished as follows: Inasmuch as the combination of diode D1 and diode D2 produced a voltage drop of 12 volts, the voltage across resistor R3 will not appreciably change so that the current through diode D3 and resistor R5 does not change. However, the increased voltage causes a larger drop across resistor R1 and R2 when considering diode D1 and D2 theoretically. The voltage drop remains constant at 12 volts and the one volt increase is sensed across resistor R1 and resistor R2 whereby the current passing therethrough increases proportionately. Since no more current goes through resistor R3, the one milliamperes increase passes through diodes D1 and D2 and through the temperature compensating circuit 18 comprising resistors R6, R7, and R8. This one milliamperes of current will produce a voltage drop of about one volt across the temperature compensation circuit and this voltage is sufficient to pass current through base circuit 20 of transistor 14.

The circuit of the present invention is designed so that there is approximately 12 volts at the top of diode D1; however, inasmuch as commercially available diodes are not theoretically perfect, the non-conductance point could be 11½ or 12½ or vary anywhere in between. The purpose of resistor R2 is to correct for these variations so that the diodes will not have to be selectively assembled and chosen and therefore R2 can be adjusted to compensate for all the required voltage drops at a voltage just below the solenoid energizing voltage.

Transistor and Relay Operation

Current normally passing through solenoid 11 of relay 10 passes from input terminal 15 to the relay solenoid via resistor R9 and then to but not through diode D6 to a collector circuit 19 of transistor 14 and then through

transistor emitter circuit 21 to ground 17. The amount of current that passes through the relay is controlled by the impedance of the transistor which in turn is determined by the transistor base current flowing in the base circuit 20. Thus, the one volt at the top of resistor R6 causes relay current to flow and causes solenoid 11 to be energized. Once the solenoid commences to be energized, relay contacts X-1 and X-2 open which couples resistor R4 in the diode network. This results in a voltage rise at diode D1 and eliminates the possibility of relay contact chatter.

When the relay is not energized, contact 13 shorts out resistor R4 through leads X-1 and X-2. When the solenoid commences to energize due to a reduced transistor impedance, resistor R4 is no longer shorted but it is placed in the diode network in series with diode D3. Inasmuch as about 14 milliamperes are passing through the diode, there is a voltage drop of more than one volt across resistor R4. This increases the voltage at diode D1 by about one volt and increases the current through diodes D1 and D2 by approximately a ratio of 5 to 1. The effect is to cause more transistor base current to flow and thus more relay current will be present which will positively eliminate relay chatter.

Time Delay Network

A time delaying network is provided which comprises R9, R10, and R11 and capacitors C1, C2 and C3 and diodes D4 and D5. Assuming a condition before relay energization when no current is flowing in the relay coil, the entire 32 volts applied across input terminals 15 and 16 are across the transistor and there is no voltage drop across the time delay network. When the input voltage is increased to 33 volts or more, the transistor impedance decreases and there is a voltage drop across the relay. Thus, the voltage of collector circuit 21 of the transistor is somewhat below 32 volts and a voltage drop exists across the time delay network and current will flow through the capacitors. This current is required to pass through resistor R9 causing a voltage drop to exist momentarily which decreases the voltage drop across the relay. This is the time delay in the circuit and it lasts until capacitors C1, C2 and C3 are charged to the equivalent time delay at various input voltages. Obviously, the limits of time delay depend on the values of the various resistors and capacitors in the delay network. The particular delay employed in the present embodiment was designed for a particular application and it is to be understood that the delay can be varied for any particular time required by other applications. A feature exists in employing this time delay network wherein the voltage drop across the time delay network is the same whether the input voltage between input terminals 11 and 12 is 0 volt or 32 volts. Thus, the capacity of the delay network to absorb a charge is the same regardless whether the starting voltage is 0 or 32 volts.

Temperature Compensation

Inasmuch as the parameters of transistors vary considerably at various ambient temperatures, the resultant difference is that a different base current is required for an equivalent change of impedance. Thus, at low ambient temperatures more base current is required, and at high ambient temperatures less base current is required than for an equivalent operation at normal or room temperature. The method to provide this higher base current is to employ a higher voltage at the top of resistor R6. This is accomplished by employing the temperature compensation circuit 18 between resistor R6 and ground 17. The temperature compensating circuit comprises a pair of thermistors 30 and 25 coupled across resistors R7 and R8 which provide a proper voltage drop. The temperature compensation circuit represents approximately 1,000 ohms of resistance at 25° centigrade.

Reverse Voltage Operation

The present invention further includes a reverse voltage network so that when a reverse voltage between input terminals 15 and 16 is present, the relay will operate. This means that if input terminal 16 is positive and input terminal 15 is negative, the relay will be energized. The relay should be fully energized at a lower voltage than if input terminal 15 were positive. The relay should close at approximately 18 to 20 volts and this is accomplished by shunting across transistor 14 with diode D6 and shunting resistor R9 with diode D7. Thus, if ground 24 is positive, current will flow directly from this ground point through ground 17 and relay solenoid 11 and through diode D7 to input terminal 15. The capacitors C1, C2 and C3 are protected from the reverse voltage by diode D5 which will not permit current to flow through the capacitors in a reverse direction. However, since the capacitors will have to discharge in a reverse direction across diode D5, means are provided which allow the capacitors to discharge even through diode D5 is in the circuit. This means comprises diode D4 and resistor R11 wherein resistor R11 should be of sufficient value so that reverse voltage will not damage the capacitors and yet low enough value so that the capacitors will discharge in the direction from capacitor C2 to resistor R10 via relay solenoid 11 and then to resistor R11, diode D4 and back to capacitance C2.

Remarks

In put terminal 29 is connected between resistors R1 and R2 which serves as a test circuit for the over voltage relay. The relay should close at about 22 to 25 volts D.C. and the test circuit may be employed to determine if the over voltage relay is functioning properly and if the circuitry which the over voltage relay controls is also functioning properly. Terminals 26 and 27 comprise a normally closed circuit which when opened can be used to disrupt the generator power source (not shown) which the relay protects while a terminal 28 in combination with terminal 26 can be used to disrupt the generator power source when closed.

The relay employed on one embodiment of the present invention is a sigma-type 21-RJCC with a 5,000 ohm coil. The high coil resistance is required because this resistance must be high in relation to the lowest impedance sensed across the transistor. The transistor impedance generally drops to about 1,000 to 1,500 ohms and the 5,000 ohm coil resistance is reasonably high with respect to that impedance. For illustrative purposes, a transistor manufactured by the Texas Instrument Company, catalogue number 951, has been employed and appears to have sufficient sensitivity.

Features in the present invention reside in the fact that the relay will not energize until the input D.C. voltage is within approximately one volt of relay energization and furthermore the relay is not fully energized until the exact "pull-in point" at one-half volt below pull in of the relay network has been achieved.

For convenience of actual construction, the following values are recommended for the various components of the system:

Resistors and Capacitors Plus or Minus 10% Unless Noted

R1	500 ohms.
R2	1,000 ohms
R3	potentiometer.
	340 ohms, plus or minus 5%.
R4	100 ohms.
R5	1,000 ohms.
R6	200 ohms.
R7	1,500 ohms.
R8	1,500 ohms.
R9	2,000 ohms.
R10	600 ohms.

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R11	-----	5,000 ohms.
C1, C2, C3	-----	100 μ fd.
D1, D2	-----	1N429, National Semi- Conductor Products.
D3	-----	1N468.
D4, D5, D6, D7	-----	1N91.

Having described only typical forms of the invention I do not wish to be limited to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims.

I claim:

1. An automatically operating D.C. over voltage protecting device for controlling an electrical apparatus by switching off power to said apparatus in response to over voltages occurring in said apparatus comprising in combination:

I. a switching relay circuit containing the following elements in series with one another between input voltage terminals;

A. the coil of a normally de-energized switching relay having first and second sets of contacts,
B. a controlling transistor connected by collector and emitter for controlling current through said relay coil,

C. a unidirectional conducting diode in reverse position with respect to normal current direction and connected across said collector and emitter of said transistor,

II. a transistor base controlling circuit connected in parallel to the total circuit of said switching relay circuit and containing in series;

A. at least one variable resistive element,
B. a temperature compensating diode circuit having unidirectional conducting diodes arranged in reverse position with respect to normal current direction and having a connection to the base of said transistor extended from the reverse side of the last of said diodes,

C. said temperature compensating diode circuit containing in series after said transistor base connection at least one resistor and at least one thermistor in parallel with said resistor,

D. a by-pass circuit for by-passing current around and in parallel with said diode circuit when normal operating voltage is impressed from said apparatus load and containing a normally shunted out resistive element,

III. a time delay circuit arranged in parallel with said switching relay circuit for momentarily by-passing current around said relay coil to provide for a time lapse in said relay actuation containing;

A. a plurality of capacitors arranged in parallel,
B. unidirectional conducting diodes arranged in reverse relationship to one another in separate parallel legs both in series with said plurality of capacitors,

IV. all of said unidirectional conducting diodes having the characteristic of passing current freely in one direction and passing current in the opposite direction only after a predetermined voltage is impressed thereupon without destruction,

V. said first set of relay contacts controlling the power to said apparatus, and

VI. said shunted out resistive element controlled by said second set of relay contacts for adding said shunted out resistive element to said by-pass circuit simultaneously with controlling of power to said apparatus so that greater current is impressed upon said transistor base which in turn increases relay current through said transistor which controls chattering of said relay contacts.

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2. An automatically operating D.C. over voltage protecting device for controlling an electrical apparatus by controlling power to said apparatus in response to over voltages occurring in said apparatus comprising in combination:

5. bination:

I. a switching relay circuit containing the following elements in series with one another between input voltage terminals;

A. the coil of a normally de-energized switching relay having at least one set of contacts,

B. a controlling transistor connected by collector and emitter for controlling current through said relay coil,

C. a unidirectional conducting diode in reverse position with respect to normal current direction and connected across said collector and emitter of said transistor,

II. a transistor base controlling circuit connected in parallel to the total circuit of said switching relay circuit and containing in series;

A. at least one variable resistive element,

B. a temperature compensating diode circuit having unidirectional conducting diodes in reverse position with respect to normal current direction and having a connection to the base of said transistor extended from the reverse side of the last of said diodes.

C. said temperature compensating diode circuit containing in series after said transistor base connection at least one resistor and at least one thermistor in parallel with said resistor,

D. a by-pass circuit for by-passing current around and in parallel with said diode circuit when normal operating voltage is impressed from said apparatus load and containing a resistive element which is balanced with respect to said diode of said diode circuit so that voltage greater than a predetermined value will allow said diode to conduct current and thereby control said transistor amplification and in turn said relay for controlling power to said load,

III. a time delay circuit arranged in parallel with said relay circuit for momentarily by-passing current around said relay coil to provide for a time lapse in said relay actuation and containing a plurality of capacitors arranged in parallel.

IV. all of said unidirectional conducting diodes having the characteristic of passing current freely in one direction and passing current in the opposite direction only after a predetermined voltage is impressed thereupon without destruction, and

V. said first set of relay contacts controlling the power to said apparatus.

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