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ELECTRICAL CONTROL DEVICE

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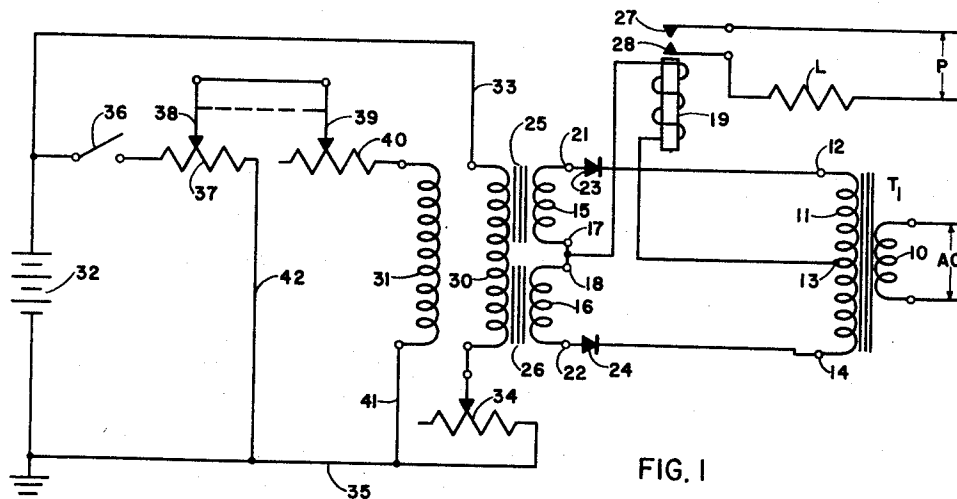


FIG. 1

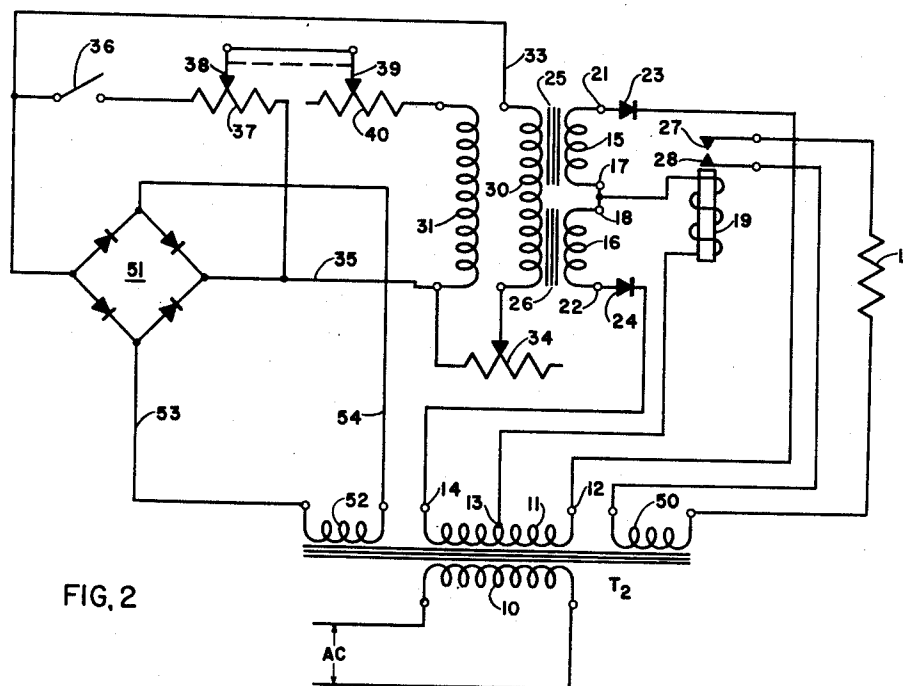


FIG. 2

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ELECTRICAL CONTROL DEVICE

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My invention relates to a magnetic relay circuit and has particular reference to a relay circuit wherein relatively small actuating currents can be used to control actuation of relatively large out-put currents after a lapse of discrete intervals of time. The particular feature of my invention relates to a circuit having certain novel flux linkages and means for varying the voltage in the control windings whereby substantially any desired time delay may be obtained between the completion of the actuating circuit and the response of an out-put circuit.

It is one of the objects of my invention to provide a relay circuit having an out-put which responds to a control circuit at a predetermined and appreciable period of time after the actuation of such control circuit.

In a great many installations it is necessary to actuate an electrically responsive device and to follow the actuation by the energization of a second electrically responsive device with the lapse of a discrete and predetermined period of time. For example, in night time aerial photography, a flare is dropped and after the lapse of a predetermined time interval, the camera shutter is opened.

A further object of my invention is to provide a simple, reliable electrical circuit by which a camera shutter can be actuated within a given interval of time after the dropping of a flare.

Also, in modern bombing technique, salvo bombing is quite frequently employed; that is, a group of bombs are dropped from a plane in sequence, which said sequence varies in its time interval, depending upon the target and the altitude of the plane. By connecting a plurality of circuits embodying the principles of my invention, an efficient intervalometer can be obtained which will salvo bombs in series at any interval desired.

In a relay circuit embodying the principles of my invention it is possible and is one of the objects of my invention to provide a relay circuit wherein the control current may be relatively weak and yet control the actuation of a load circuit requiring relatively large currents.

Other and further objects and advantages of my invention will become apparent from the drawings and specifications relative thereto.

Figure 1 is a schematic electrical diagram of a circuit embodying the principles of my invention.

Figure 2 is a schematic diagram of a modified form illustrating the adaptability of the circuit to A. C. operation.

In an electrical circuit embodying an induct-

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ance there are two quantitative measurements for current flowing in such circuit. As is well known, there is a steady-state current which is readily determined by Ohms law. There is also a transient current; that is, the current flowing at any given interval of time after completion of the circuit and before the steady-state current is reached. The transient current in a given inductive circuit having a fixed inductance and a fixed resistance depends upon the E. M. F. applied across the inductance. By holding all variables constant except the applied E. M. F., the time interval required for the transient current to reach a given or operative quantity that may be controlled.

Referring to the schematic diagram, it will be apparent that this embodiment of my invention comprises essentially three circuits, that is, a relay circuit, a control circuit and a load circuit.

The relay circuit comprises a transformer T₁ having a primary coil 10, a secondary coil 11 having terminals 12, 13, and 14; the terminal 13 being a center tap. A pair of substantially identical inductance coils 15 and 16 are connected respectively to the terminals 12 and 14 of the secondary of the transformer.

The other terminals, 17 and 18, are connected to the center tap 13 in series with an electromagnet 19. Terminals 21 and 22 of coils 15 and 16, respectively are connected to the terminals 12 and 14 of the secondary 11 in series with diodes or rectifiers 23 and 24.

The inductance coils 15 and 16 are provided with magnetically permeable cores 25 and 26. It will be understood that the cores 25 and 26 are independent insofar as the magnetic flux contained therein is concerned.

The load circuit comprizes any convenient source of power such as P connected in series with a load L through the switch terminals 27 and 28.

It will be readily understood that energization of the electromagnet 19 by means of the relay circuit causes a closing of the contacts 27 and 28 and therefore energization of the load L.

The control circuit comprizes a biasing coil 30, a control coil 31, and a convenient source of electrical power such as the battery 32. The biasing coil 30 is connected to one side of the battery 32 by means of conductor 33 and returns to the other side of battery 32 through a variable resistor 34 and a conductor 35.

It should be pointed out at this time that the presence of the variable resistor 34 is not essential, but is inserted for the sake of convenience in

order to balance the biasing coil 30 against the residual magnetic flux in the coils 15 and 16 as will later become apparent and the sole function of the resistor 34 is to balance such bias.

The control winding 31 is connected to the battery 32 by means of a switch 36, voltage dividing resistor 37, sliding contact points 38 and 39 and resistor 40. The other end of the coil 31 returns to the battery through conductors 41 and 35.

The voltage dividing resistor 37 is also connected to the other side of the battery 32 by means of conductors 42 and 35.

It should be understood that the contact arms 38 and 39 are electrically connected and mechanically associated in such a manner that they move simultaneously across the resistance elements 37 and 40 respectively. It should be also understood that coils 30 and 31 are wound around both the cores 25 and 26 and are associated by a flux linkage.

The purpose of providing separate cores, such as 25 and 26, is to isolate the D. C. components from the A. C. source. Any configuration which results in an equivalent isolation should be considered within the scope of my invention.

The schematic diagram illustrated in Figure 2 comprises essentially the same circuit and parts bearing similar numerals indicate similar parts. The principal difference being that the circuit is adapted for use in connection with a single source of A. C. current.

The relay circuit is identical with Figure 1 since it was also designed to operate on A. C. current.

The load circuit differs only in the respect that the source of power P comprises a coil 50 forming a part or secondary of the transformer T2.

In the diagram of Figure 2, the battery 32 has been eliminated and a rectifier bridge 51 has been substituted therefor. A coil 52 which forms a secondary coil of the transformer T2 furnishes any desired A. C. voltage to the rectifier bridge 51 by means of conductors 53 and 54. The conductors 33 and 35 are connected to opposite corners of the rectifier bridge 51 in order to obtain a D. C. control and biasing current.

In order to follow the operation of my circuit, it must first be assumed that the switch 36 is open and that no current is flowing through the biasing coil 30.

When A. C. current is supplied to the primary 10 of the transformer T1 an average value D. C. component will flow through each of the coils 15 and 16 because of the rectifier units 23 and 24. This average D. C. component will saturate the cores 25 and 26 so that the impedance of the coils of 15 and 16 will be at a minimum. The magnet 19 would therefore be energized and the points 27 and 28 would be closed to thereby energize the load L.

If we next assume that current is supplied through the coil 30 in such amplitude and direction that the magnetic flux in the cores 25 and 26 will be neutralized there will be sufficient impedance in the coils 15 and 16 which would limit current flowing therethrough to a value less than sufficient to energize the magnet 19. Since the effect of the bias in the coil 30 is the product of the amper turns such product can be readily adjusted by changing the variable resistance 34.

After the bias in the coil 30 has been properly set the switch 36 may be closed thereby energizing the coil 31 which upsets the bias balance and saturates the cores 25 and 26 to permit sufficient

current to flow through the magnet 19 to cause closing of the contact points 27 and 28.

It should be understood that the inclusion of the relay 19 and the load circuit are for illustrative purposes only and not a limitation. It is readily apparent that any electrical device which is responsive above a threshold value may be connected between the terminals 13 and 17-18 and will be actuated after a predetermined period of time in the same manner as the relay 19.

The above described action does not take place instantaneously. In other words, there is a definite and substantial time lag between energizing the control circuit and the build up of current in the relay circuit sufficient to actuate the load circuit which time lag is dependent upon the E. M. F. applied to the coil 31.

For a given or constant impressed voltage in the control circuit, the current flowing there-through can be determined by the following equation:

$$E = N \frac{d\phi}{dt} + i_r R \quad (1)$$

Formula 1 may be rearranged as follows:

$$\left(\frac{E}{R} - i_r \right) = \frac{N}{R} \frac{d\phi}{dt} \quad (2)$$

If at $t=0$, i is zero, this equation may be solved for t in the form of the following definite integral:

$$t = \frac{N}{R} \int_{\phi=a}^{\phi=b} \frac{d\phi}{\left(\frac{E}{R} - i_r \right)} \quad (3)$$

It is therefore readily apparent that by decreasing E , or the impressed voltage across the terminals of coil 31 by moving the contact joints 38 and 39 to the right t in Equation 3 becomes larger. I have found that by properly adjusting the impressed voltage in the control coil that a time delay as long as one minute can be obtained in the response of the relay circuit.

What I consider the essence of my invention is an electrical control circuit for controlling the actuation of an electrical device which is responsive to electrical currents above a threshold value comprising a saturable reactor in series between said device and a source of current whereby the impedance of said reactor, in its unsaturated state, is sufficient to hold said current below said threshold value and a control winding magnetically coupled to said saturable reactor, said control coil being adapted to saturate said reactor to permit current therethrough to exceed said threshold value, said control coil having in series therewith a current divider mechanically linked to a variable resistor whereby the applied voltage to the control coil may be varied at will.

Whereas, I have explained my invention in connection with a specific physical embodiment, it is apparent that a great many modifications may be substituted therefore, and that the scope of my invention should not be confined thereto. The above specification is illustrative only and not a limitation to the specific form disclosed.

What I claim as my invention is set forth in the following claims and all reasonable equivalents thereof.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. An electrical control device comprising a saturable reactor core, an output winding on said core adapted to be connected in series with a

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load actuably responsive to electrical currents above a threshold value and a source of electrical current, and means for causing saturation of said reactor core during a discrete period of time to permit current in said output winding to exceed said threshold value after the lapse of said discrete period of time, said last means comprizing a control winding magnetically coupled to said reactor core, a source of electrical energy, a means for varying said discrete period of time, said last named means comprizing a current divider in parallel with said saturating means and a variable resistor in series with said saturating means.

2. An electrical control device comprizing a pair of saturable reactor cores, an output winding on each of said cores each of which is adapted to be connected in series with a load actuably responsive to electrical currents above a threshold value and a source of electrical current, and means for causing saturation of said reactor cores during a discrete period of time to permit current in said output windings to exceed said threshold value after the lapse of said discrete period of time, said last means comprizing a control winding magnetically coupled to both of said reactor cores, a source of electrical energy, a means for varying said discrete period of time, said last named means comprizing a current divider in parallel with said saturating means and a variable resistor in series with said saturating means.

3. An electrical control device comprizing a saturable reactor core, an output winding on said core adapted to be connected in series with a load actuably responsive to electrical currents above a threshold value and a source of electrical energy, and means for causing saturation of said reactor core during a discrete period of time to permit current in said output

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winding to exceed said threshold value after the lapse of said discrete period of time, said last means comprizing a source of unidirectional electrical energy, a control winding magnetically linked to said reactor core for causing saturation of said core, a current dividing resistor in shunt relation with said source of unidirectional electrical energy, and a variable resistor connected to said current divider, adapted to vary said discrete period of time in said control winding.

4. An electrical control device comprizing a pair of saturable reactor cores, an output winding on each of said cores, means for supplying half wave rectified current to one leg of each of said windings, the other leg of each winding being connected in common to a load containing an electrically responsive device, responsive to a current over a predetermined threshold value, a biasing winding to prevent saturation of said cores by the D. C. component in each of said output windings, a control coil common to both cores adapted upon energization to saturate each of said cores, and means in series with said control coil to vary the time response of saturation, said last means comprizing a first and second resistor, said first resistor being connected in parallel with said control coil to a source of electrical energy and having a moveable contact, said second resistor being connected to said control coil and having a variable contact, each of said contacts being electrically and mechanically connected to thereby vary their respective contact positions simultaneously.

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