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RELAY CIRCUIT

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Fig. 1.

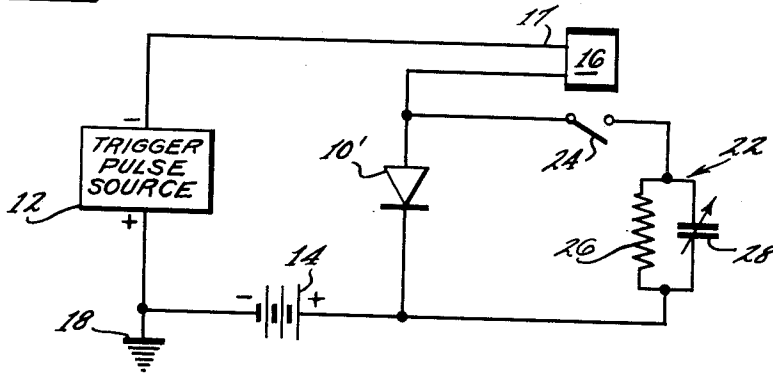


Fig. 2.

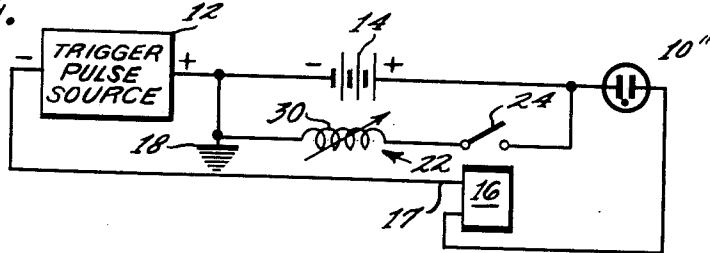
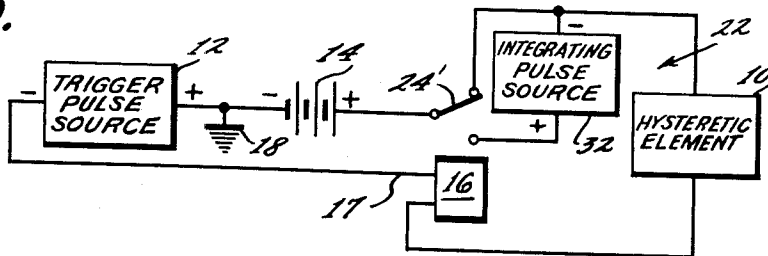


Fig. 3.



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RELAY CIRCUIT

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The present invention relates to trigger circuits, and more particularly to monostable relay circuits which may be triggered from their stable state.

Timing circuits of the prior art have utilized monostable multivibrator circuits which, after a working or timing interval, return to a stable condition. These circuits usually require a plurality of amplifying elements and auxiliary circuitry.

Certain conductive elements, such as diodes, semiconductors and cold cathode gas tubes have a so-called "hysteresis" characteristic. "Hysteresis" has been defined as the phenomenon exhibited by a system whose present state depends upon its previous history. This hysteresis characteristic may be compared with that of a magnetic element. A complete magnetization cycle, represented by a graph on a B-H scale, exhibits more than one value for B corresponding to any given value of H over an appreciable range of values.

In the case of cold cathode tubes, a voltage vs. current curve exhibits a similar property in providing more than one current value for a given voltage, depending on whether the tube is "ionized" or not. A glow lamp, if subjected to an increasing voltage "breaks down" and goes into conduction. The voltage may then be decreased gradually until a cutoff voltage is reached at which time the glow lamp is quenched.

It cannot be ascertained from a specification of the applied voltage alone whether or not such a glow lamp is conducting. Additional information, such as whether the voltage is increasing from the cutoff voltage or decreasing from the breakdown voltage, must be provided.

A similar "hysteresis" effect may be displayed by a semiconductor diode of the Zener type. Such diodes have a high impedance to current flow in the so called "reverse" direction so long as the voltage is below the Zener point value. When the voltage exceeds the Zener point, the impedance decreases sharply to a negative value and the diode conducts heavily. In the region of Zener breakdown, a given voltage corresponds to more than one value of current. Reduction of the current permits the diode to "recover" and again exhibit a high impedance to current in the "reverse" direction.

It is an object of the present invention to provide a simple trigger circuit utilizing electronic elements having "hysteresis" characteristics.

It is a further object of invention to provide a timing circuit of adjustable time interval.

It is a still further object of invention to provide a triggerable relay circuit that is simpler than those in the prior art.

It is a still further object of invention to provide an adjustable relay timing circuit simpler than those of the prior art.

In one embodiment of the present invention, a conductive element exhibiting hysteresis properties is connected into a relay circuit. A voltage bias is applied to the hysteretic element which is insufficient to cause conduction. A trigger pulse, added to the bias voltage, provides a net voltage which exceeds the "breakdown" or conductive potential for the hysteretic element. In conduction, the element draws sufficient current to energize the relay. The energized relay closes a relay controlled switch which connects a capacitive reactor in parallel with the hysteretic element. Initially, the reactor conducts heavily, drawing virtually all of the available current. The hys-

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teretic element then draws little or no current and recovers its high impedance. The impedance of the capacitor increases with time, decreasing the current through the relay winding until the current flow is insufficient to maintain energization. The reactive elements may be adjusted to vary the time constant of the circuit and, consequently, the period of time during which relay operates.

In an alternative embodiment of the invention, the relay controlled switch, when closed, connects an inductive reactor in parallel with the relay circuit, which functions as a timing circuit. The impedance of the reactor is initially high, decreasing with time. The current through the hysteretic element decreases as more current is shunted through the reactor. After an interval, determined by the time constant of the reactive elements, the current through the hysteretic element and relay winding becomes insufficient to maintain energization and the relay winding de-energizes, opening the relay switch. Before the switch opens, the current through the hysteretic element decreases sufficiently for conduction to cease, and control is restored.

In a third alternative form of the invention, the relay controlled switch is connected to the pulse output of a square wave integrating circuit which "bucks out" the bias source. When the relay is energized, the pulse output current, increasing with time, opposes the current across the hysteretic element. The net current in the circuit decreases until conduction ceases and the relay is de-energized.

The foregoing and other objects, the advantages and novel features of this invention, as well as the invention itself both as to its organization and mode of operation, may be best understood from the following description when read in connection with the accompanying drawing, in which like reference numerals refer to like parts, and in which:

FIGURE 1 is a block diagram of one embodiment of the present invention;

FIGURE 2 is a block diagram of a second embodiment of the invention, similar to that of FIGURE 1, but utilizing inductive rather than capacitive reactance to shunt the hysteresis element;

FIGURE 3 is a block diagram of alternative embodiment of the present invention in which a second pulse source in the control circuit opposes the bias of the hysteretic element.

In the circuit of FIGURE 1, a conductive element having a "hysteresis" characteristic, such as a semi-conducting diode 10', is connected to a source of triggering pulses 12. The pulse source 12 has a low internal impedance and applies a sharp, spike-like pulse to the diode 10'. The negative terminal of the pulse source 12 is connected with the anode of the diode 10' so that a trigger pulse is applied in the high impedance or "back" direction of the diode 10'.

The positive terminal of a bias voltage source 14 is connected to the cathode of diode 10' so that the bias is also applied in the high impedance or "back" direction of the diode 10'.

A relay 16 having a relay winding 17, is connected in series with the diode 10'. The winding 17 is interposed between the negative terminal of the pulse source 12 and the anode of the diode 10'. The negative terminal of the bias source 14 is connected to a common reference potential indicated by the conventional ground symbol 18.

A control circuit 22 is connected in parallel with the diode 10'. The control circuit 22 includes a relay controlled switch 24 in series with a reactive network including a resistor 26 in parallel with a capacitor 28.

With the relay 16 de-energized, the relay switch 24 is normally open. The capacitor 28 may be variable to permit variation of the time constant of the control circuit and, therefore, to control the time during which the relay operates.

In the quiescent state, the bias source 14 applies a potential to the diode 10' in the high impedance direction. The voltage of the bias is less than the Zener voltage of the diode 10'. The pulse source 12 has a low internal impedance, even when not emitting a pulse and, therefore, does not interrupt the circuit between the voltage source 14, the diode 10' and the relay winding 17.

The circuit is operated by applying a trigger pulse from a pulse source 12. The polarity of the trigger pulse is such that the voltage of the pulse is added to the voltage of the bias source 14. The resultant voltage exceeds the Zener voltage of the diode 10'. When the Zener voltage is exceeded, the diode 10' exhibits negative impedance characteristics and the diode 10' conducts heavily. During conduction, sufficient current flows through the relay winding 17 for energization of the relay 16 causing the relay switch 24 to close.

Closure of the relay switch 24 connects the reactive circuit 22 in parallel with the diode 10'. The initial impedance of the reactive circuit 22 is low enough to shunt substantially all of the current from the diode 10'. The diode 10' regains control and again presents a high impedance to the source 14. As the charge on the capacitor 28 increases, the impedance of the control circuit 22 increases until there is insufficient current flow to maintain the relay 16 in the energized state. The relay switch 24 opens, disconnecting the reactive circuit 22. The time constant of the control circuit 22 may be altered by adjustment of the capacitor 28 which varies the time interval during which the relay 16 is energized.

FIGURE 2 is a diagram of an alternative form of the embodiment of FIGURE 1. In the arrangement of FIGURE 2, an inductive reactor or inductor 30 is used in the control circuit 22 rather than the capacitor 28 of FIGURE 1. In this embodiment, the hysteretic element may be, for example, a neon glow lamp 10''.

The glow lamp 10'', the relay winding 16, the trigger pulse source 12 and the bias source 14 are connected together in a closed series configuration. A control circuit 22, including the normally open relay switch 24, is connected across the bias source 14. The reactive element of the control circuit 22 is an adjustable inductor 30 which may even be wound on the relay winding 17 for more compact packaging.

In operation, the positive voltage pulse added to the voltage of the bias source 14 ionizes the glow lamp 10''. Conduction starts, energizing the relay winding 17. The relay switch 24 closes, connecting the control circuit 22 across the bias source 14. The inductor 30 has an initial high impedance which, with time, decreases. The time constant of this circuit may be altered by adjustment of the inductor 30, thus varying the time during which the relay is energized. As the impedance of the inductor 30 becomes sufficiently small, the current flow through the neon glow lamp 10'' and relay winding 17 is reduced, finally extinguishing the glow lamp 10'' and de-energizing the relay 16. The relay switch 24 then opens, disconnecting the control circuit 22.

In the alternative embodiment of FIGURE 3, the control circuit 22 includes a second pulse source 32. The second pulse source 32 is connected to provide a pulse of increasing amplitude with time. The pulse is poled to oppose the output of the bias source 14 and, with time, effectively bucks out the bias source 14. A relay controlled switch 24' has a movable blade and two fixed contacts. In the normal configuration, with the relay 16 de-energized, the switch 24' connects the bias source 14 with the hysteretic element 10. With the relay 16 energized, the switch 24' assumes the alternate position and the pulse source 32 is connected in series with the hysteretic element 10 and the bias source 14.

In operation, as above, the steady state quiescent condition of the circuit is such that the voltage of the bias source 14 is, for example, less than the Zener voltage

of a diode 10'. A triggering pulse from the pulse source 12 adds to the bias, exceeding the breakdown voltage of the hysteretic element 10 causing conduction.

The relay 16 is energized and the switch 24' changes position. The second pulse source 32 of the control circuit 22 is interposed between the hysteretic element 10 and the bias source 14. The output of the pulse source 32 is in the nature of an integrated square wave, whose current amplitude increases with time. The current of the pulse 32 opposes the current flow from the bias source 14. The net current through the hysteretic element 10 and the relay 16 decreases with the increase of current from the source 32. When the net current of the circuit falls below the recovery level of the hysteretic element 10, conduction ceases and control is regained. The relay 16 de-energize when the current flow is less than necessary to maintain energization.

A circuit constructed in accordance with the diagram of FIGURE 1 was successfully operated with the following component values:

Diode 10' -----	1N34—germanium.
Relay 16—internal resistance -----	10 kilohms.
Relay de-energization time -----	10 milliseconds.
Pulse source 12 -----	15 volts.
Bias source 14 -----	75 volts.
Capacitor 28 -----	1 microfarad.

With the above values, the operating time of the relay 16 was approximately 20 milliseconds. The capacitor 28, when varied, changed the operating interval accordingly.

It may be seen that a suitable selection of circuit components may provide various operating periods for delaying purposes or interval timing. The only limitation on the time interval is that the interval be sufficiently long to permit recovery of the diode or glow lamp or other hysteretic element.

Thus, there has been provided a novel relay circuit which may be used for interval timing or as a time delay.

What is claimed is:

1. The combination comprising: the series combination of a relay winding and a semiconductor diode having a threshold in the reverse direction; first and second energizing means serially connected with said series combination for reverse biasing said diode and for triggering said diode into conduction in the reverse direction, respectively; an impedance element; and a switch actuated in response to current flow through said winding when said threshold is exceeded for connecting said impedance element in parallel with said diode.

2. The series combination of a relay winding, a semiconductor diode having a threshold voltage in the reverse-biased direction, and first and second energizing means operative together to exceed selectively said threshold voltage; a capacitor; and a switch actuated by said relay for connecting said capacitor in parallel with said diode.

3. The series combination of a relay winding, a unilateral conducting device having a threshold voltage in the reverse-biased direction, and first and second energizing means together operative to exceed said threshold voltage; a chargeable energy storage device; and a switch actuated in response to current flow through said winding when said threshold is exceeded for connecting said storage device in series with said relay winding and one of said energizing means.

4. An inductor and a semiconductor diode connected in series combination, said diode having a threshold voltage in the reverse direction and being characterized by heavy conduction in the reverse direction when said threshold voltage is exceeded; first energizing means connected in series with said combination for applying to said diode a reverse bias less than said threshold; second energizing means connected in series with said series com-

ination and said first energizing means and selectively operable to increase said reverse bias to a value exceeding said threshold; a chargeable energy storage device; and a switch magnetically closed in response to current flow through said inductor for connecting said storage device in series with said inductor and at least one of said first and second energizing means.

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