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T. L. DIMOND

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CONTROL CIRCUIT FOR SLOW-RELEASING RELAYS

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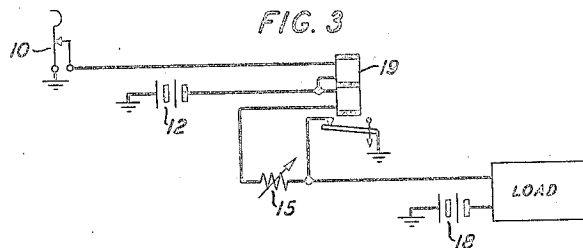
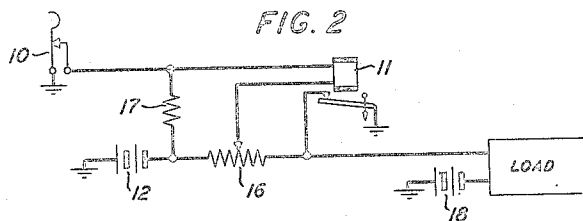
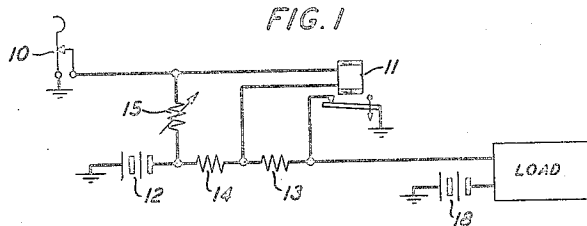
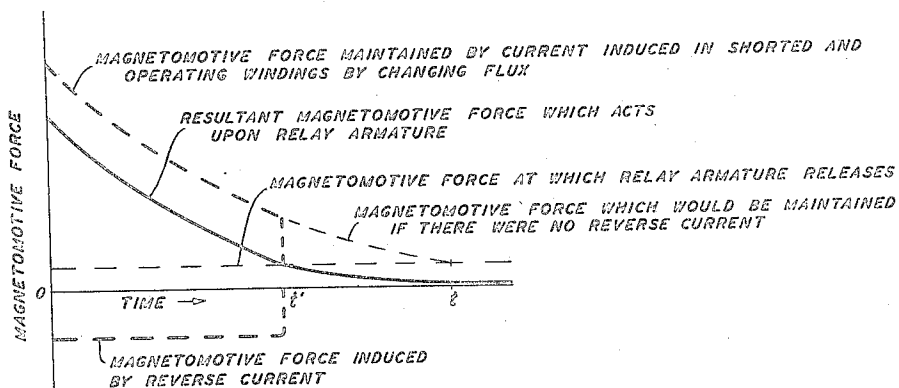


FIG. 4
MAGNETOMOTIVE FORCE - TIME CURVES
FOR RELAY INDICATED IN FIG. 1, 2, OR 3



INVENTOR
T. L. DIMOND
BY *J. W. Schmitt*
ATTORNEY

UNITED STATES PATENT OFFICE

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CONTROL CIRCUIT FOR SLOW-RELEASING RELAYS

Thomas L. Dimond, Rutherford, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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6 Claims. (Cl. 175-320)

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This invention pertains to timing apparatus, and more particularly to circuits for controlling the release time of a slow-releasing relay.

The usual means for delaying the release of a relay armature involves the use of a short-circuited winding or copper slug on the relay core or the use of a specially constructed relay. The latter is expensive, and the former is difficult to adjust. An object of this invention is to provide a simplified and inexpensive means for adjusting and controlling the release time of a relay which employs an operating winding and a copper slug or shorted winding circumscribing the relay core. This and other objects of the invention will be apparent from the following description, the appended claims, and the drawings, in which:

Fig. 1 is the basic circuit diagram of the invention;

Fig. 2 is a modification of the basic circuit diagram;

Fig. 3 is an alternative form of the invention; and

Fig. 4 is a graph showing in qualitative manner a typical magnetomotive force time curve for the relay indicated in Fig. 1, 2, or 3.

Relay 11 used in this invention is a conventional slow-releasing type which employs an operating winding and either a shorted winding or a copper slug to obtain the slow-releasing effect. When the flow of current through the operating winding of a relay of this type is interrupted, the magnetic flux in the relay core does not immediately drop to zero since any change in magnetic flux causes a current to flow in the shorted winding or copper slug. This current maintains a magnetic flux in the relay core, and, as a result, the magnetomotive force which is applied to the relay armature temporarily maintains the armature operated. This magnetomotive force decays exponentially, and when it is reduced to a certain predetermined value, the magnetic attraction which the relay core exerts upon the armature is insufficient to hold the armature operated and it is released. For the purpose of this disclosure the operation of a slow-releasing relay which employs a shorted winding will be discussed. However, it will be understood that the invention is equally applicable to a relay which employs a copper slug or similar means to attain a slow-releasing effect.

In this invention the magnetic attraction which the relay core exerts upon the armature after the operating current is disconnected is governed by the magnetic flux maintained in the

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relay core by the current flowing in the shorted winding and by the magnetomotive force generated by the application of a reverse current to the operating winding so as to partially counteract the effect of the magnetomotive force maintained by the shorted winding. The reverse current is obtained in the basic circuit by the use of a divider network arranged so that when a control circuit is closed, a current flows through the operating winding in one direction and the relay armature is operated, and so that a smaller current is allowed to flow through the operating winding in the opposite direction when the control circuit is open but before the armature has released.

Referring to Fig. 1, while switch 10 is closed, the armature of relay 11 is operated and the circuit across battery 13 and the load is shorted. Current flows from battery 12 through resistor 15 and switch 10 to ground; from battery 12 through resistor 14, the winding of relay 11, and switch 10 to ground; and from battery 12 through resistor 14, resistor 13, and the operated armature of relay 11 to ground. Under ordinary conditions the resistance of resistors 13 and 15 is high compared with the resistance of resistor 14 and the winding of relay 11; therefore most of the current supplied by battery 12 flows through resistor 14, the winding of relay 11, and switch 10 to ground. This current serves to hold the armature of relay 11 operated. When switch 10 is opened, the magnetic flux maintained by current flowing in the shorted winding is sufficient to hold the armature operated until the magnetic flux decays to a certain predetermined value. During the interval of time while switch 10 is open and the armature of relay 11 is operated, current supplied by battery 12 flows through resistors 14 and 13 and the armature of relay 11 to ground, and through resistor 15, the winding of relay 11, resistor 13, and the armature of relay 11 to ground. Since serially connected resistor 15 and the winding of relay 11 are in shunt with resistor 14, the ratio of the current flowing through the relay winding to the total current is governed by the ratio of the combined resistance of resistor 15 and the operating winding of relay 11 to the resistance of resistor 14. It will be observed that the current now flowing through the operating winding of relay 11 flows in a reverse direction to the current which served to operate the relay armature. This reverse current sets up a magnetomotive force acting on the relay core which is of an opposite polarity to the magnetomotive force induced in the two windings by

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the decaying magnetic flux; therefore, the total magnetomotive force acting upon the relay armature is reduced by an amount which is proportional to the magnitude of the reverse current. Since resistor 15 is adjustable, the magnitude of this reverse current may be controlled, thereby controlling the resultant magnetomotive force which acts upon the relay armature.

Fig. 4 indicates this resultant magnetomotive force as a solid line curve. The decaying magnetomotive force maintained by the changing flux acting on the shorted winding is indicated by a dashed line curve and is considered as being of positive polarity for the purpose of this illustration. The constant magnetomotive force induced by the reverse current is indicated by a dashed line and is considered as being of negative polarity for the purpose of this illustration. If the total magnetic attraction applied to the relay armature resulted from the magnetomotive force maintained by the shorted winding, the armature would release at time t ; however the effect of the reverse current is to reduce the total magnetomotive force so that less magnetic attraction is applied to the armature and so that the armature releases at time t' .

The instant switch 10 opens, the magnetomotive force induced in the shorted and operating windings is a maximum, and the resultant magnetomotive force is this maximum magnetomotive force less the magnetomotive force induced by the reverse current. The resultant magnetomotive force continues to be less than the magnetomotive force maintained by the shorted winding by an amount equal to the magnetomotive force induced by the reverse current until time t' when the resultant magnetomotive force becomes less than the magnetomotive force required to hold the relay armature operated. At this time, t' , the armature releases, the reverse current is interrupted, and the circuit across the load is opened. Since no reverse current flows after time t' , the resultant magnetomotive force is equal to the magnetomotive force maintained thereafter by current flowing in the shorted and operating windings, and its magnitude decays in an exponential manner.

Since the magnitude of the reverse current may be controlled by the adjustment of resistor 15, the time at which the armature releases may be adjusted to any desired time which is less than time t . If a precise adjustment of the release time is not required, adjustable resistor 15 may be replaced with a fixed resistance of suitable value.

The circuit is restored to normal by the closure of switch 10, and the timing action may be initiated again by the opening of the switch as described above.

Referring to Fig. 2, the circuit diagram is essentially the same as that disclosed in Fig. 1, and the apparatus functions in the same manner with the exception that the magnitude of the reverse current is governed by the adjustment of the tap on divider 16. As before, the resistance of resistor 17 and the right-hand portion of divider 16 is high compared with the resistance of the left-hand half of divider 16 and the winding of relay 11. If a precise adjustment of the release time is not required, divider 16 may be replaced with fixed resistors of suitable value.

The result achieved by the apparatus disclosed in Figs. 1 and 2 is also attained by the apparatus disclosed in Fig. 3. Relay 19 is a slow-releasing type but it differs from relay 11 as employed in

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Figs. 1 and 2 in that it has two windings in addition to the shorted winding. These two windings are connected to battery 12 in such manner that the magnetomotive force generated by current flowing in one winding is of opposite polarity to that generated by current flowing in the other. While switch 10 is closed, the armature of relay 19 is operated and the circuit across battery 18 and the load is shorted. Current flows through both windings, but the current flowing through the lower winding is adjusted by resistor 15 so that the magnetomotive force generated by this current is less than that generated by current flowing through the upper winding. When switch 10 is opened, current ceases to flow through the upper winding of relay 19 but continues to flow through the lower winding, resistor 15, and the operated armature of relay 19 to ground. When the flow of current through the upper winding is interrupted, a decaying magnetic flux is maintained in the relay core by current caused to flow in the shorted winding as a result of the changing magnetic flux. It will be observed that the current flowing through the lower relay winding generates a magnetomotive force which is of opposite polarity to the decaying magnetomotive force as maintained by current flowing in the shorted winding; therefore the total magnetomotive force acting upon the relay armature is reduced by an amount which is proportional to the magnitude of the current flowing through the lower winding. Since resistor 15 is adjustable, the magnitude of this current may be controlled, thereby controlling the resultant magnetomotive force as before.

The circuit element designated as Load in Figs. 1, 2, and 3 may be any electrical circuit which is used in conjunction with a slow-releasing relay. Battery 18 should be of approximately the same potential as battery 12 so as to prevent the flow of current from battery 12 through the Load. If it is desired to isolate the electrical circuit of the Load from the energizing circuit of the slow-releasing relay, an additional armature and contact may be added to the relay structure, and battery 18 is not required in this case. It is apparent that additional armatures and contacts may be added to the relay structure without departing from the scope of the invention.

Although specific embodiments of this invention have been shown and described, it will be understood that modifications may be made therein without departing from the scope and spirit thereof as defined by the appended claims.

What is claimed is:

1. A timing circuit comprising a slow-releasing relay employing a shorted conductor circumscribing the core of said relay, said slow-releasing relay comprising a winding, potential means applied across said relay winding adapted to generate a first magnetic flux in the core of said relay of sufficient magnitude to cause the armature of said relay to operate, and controlling means comprising a switch adapted to initiate the timing operation by interrupting the generation of said first magnetic flux and other means comprising a resistance network and said potential means to generate a second magnetic flux of opposite polarity to said first magnetic flux, thereby causing said second magnetic flux to partially counteract the effect of the magnetic flux generated by current flowing in said shorted conductor and thereby control the time interval between the operation of said controlling means and the release of the armature of said relay.

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2. A timing circuit comprising a relay employing an operating winding and a shorted conductor circumscribing the core of said relay, potential means adapted to energize said operating winding with a current flowing in a first direction, and controlling means comprising a switch and a network of resistances adapted to initiate the timing action by interrupting the flow of current in said first direction and causing a smaller current to flow in the reverse direction through said operating winding, thereby causing said current flowing in the reverse direction to partially counteract the effect of the current flowing in said shorted conductor and thereby control the time interval between the operation of said controlling means and the release of the armature of said relay.

3. A timing circuit comprising a slow-releasing relay employing an operating winding and a shorted winding wound upon a common core, a source of potential means adapted to energize said operating winding with a current flowing in a first direction, and controlling means comprising a switch and a network of resistances adapted to initiate the timing action by interrupting the flow of current in said first direction and causing a smaller current to flow in the reverse direction through said operating winding, thereby causing said current flowing in the reverse direction to partially counteract the effect of the current flowing in said shorted winding and thereby control the time interval between the operation of said controlling means and the release of the armature of said relay.

4. A timing circuit comprising a slow-releasing relay employing an operating winding and a shorted winding, a source of potential, the first terminal of said source of potential being connected to an armature of said relay, a voltage divider interconnecting the second terminal of said source of potential and a front contact associated with said armature, a controlling resistance interconnecting the second terminal of said source of potential and one terminal of said operating winding, the other terminal of said operating winding being connected to the tap on said voltage divider, and a switch interconnecting the first terminal of said source of potential and the junction between said controlling resistor and said operating winding, thereby causing the time at which said armature releases after said switch is opened to be proportional to the resistance of said controlling resistance.

5. A timing circuit comprising a slow-releasing relay employing an operating winding and a shorted conductor circumscribing the core of said relay, a source of potential, the first terminal of

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said source of potential being connected to an armature of said relay, a voltage divider interconnecting the second terminal of said source of potential and an inner contact associated with said armature, a resistance interconnecting the second terminal of said source of potential and one terminal of said operating winding, the other terminal of said operating winding being connected to the tap on said voltage divider, and a switch interconnecting the first terminal of said source of potential and the junction between said resistor and the operating winding, thereby causing the time at which said armature releases after said switch is opened to be governed by the position of the tap on said voltage divider.

6. A timing circuit comprising a source of potential, a relay employing an operating winding, an auxiliary winding, an impedance in the circuit of said auxiliary winding, and a shorted conductor circumscribing the core of said relay, said operating and auxiliary windings being connected to said source of potential in such manner that magnetic flux generated by the auxiliary winding is of opposite polarity than that generated by said operating winding and smaller than that generated by said operating winding due to the said impedance in the auxiliary winding circuit, means adapted to generate a first magnetic flux by causing current to flow through said operating and auxiliary windings, said first magnetic flux serving to cause the armature of said relay to operate, and controlling means adapted to initiate the timing action by interrupting the flow of current in said operating winding, thereby causing the current flowing in said auxiliary winding to generate a second magnetic flux which partially counteracts the effect of the magnetic flux caused by current flowing in said shorted conductor and thereby control the time interval between the operation of said controlling means and the release of the armature of said relay.

THOMAS L. DIMOND.

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