June 25, 1940. C. STANSBURY ET AL 2,205,676

CIRCUIT CONTROLLER

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Fig. 1

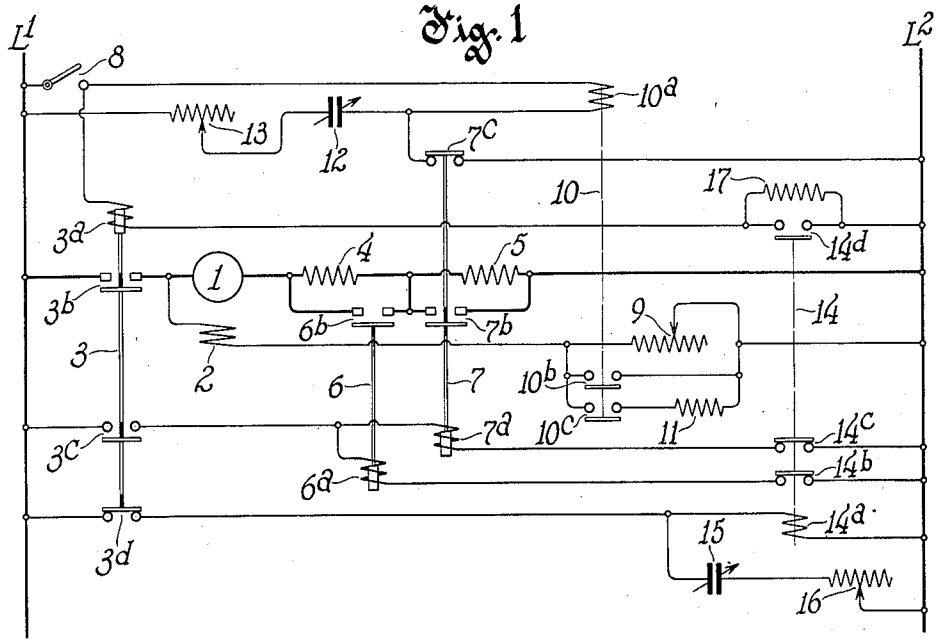


Fig. 2

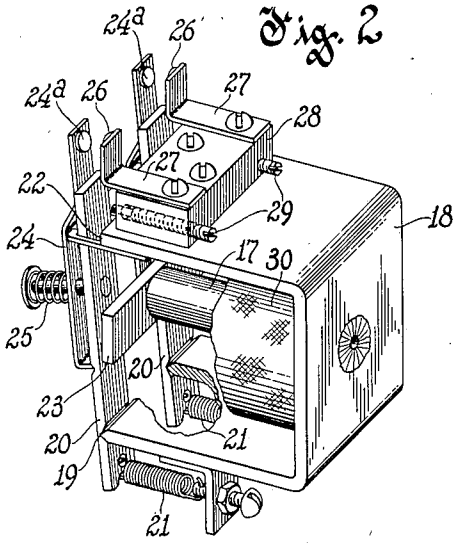
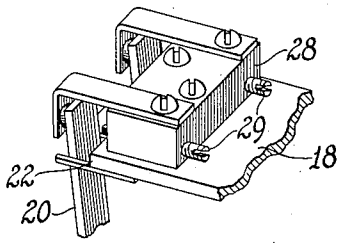


Fig. 3



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CIRCUIT CONTROLLER

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21 Claims. (Cl. 172—288)

This invention relates to circuit controllers and while not limited thereto is especially adapted to the control of electric motors which are started by varying the voltage impressed upon their windings in steps which succeed one another at given time intervals.

An object of the invention is to provide an improved circuit controller of the aforementioned type in which the time intervals are individually adjustable.

Another object is to provide an improved timer for the aforementioned purpose which involves use of electrically stored energy.

Another object is to provide a unitary timer actuated by electrically stored energy which is adapted to control a plurality of circuits in a manner whereby the time interval of response for each circuit is independently adjustable.

Another object is to provide a timing relay comprising a single electromagnetic winding interlinked with a multiple magnetic circuit, each magnetic circuit including an armature the response of which is individually adjustable.

Other objects and advantages will hereinafter appear.

The appended drawing is illustrative of an embodiment of the invention.

In the drawing,

Figure 1 is a circuit diagram embodying the invention, while

Figs. 2 and 3 illustrate certain details of electromagnetic relays employed in the system.

Referring to Fig. 1 of the drawing, the system shown therein comprises a direct current source of energy connected to the lines L^1 and L^2 and supplying energy to a direct current shunt motor provided with an armature 1 and a shunt field winding 2. The armature current is controlled by an electromagnetic main switch 3 having an energizing winding 3^a, normally open main contacts 3^b, connected between the armature 1 and line L^1, normally open auxiliary contacts 3^c and normally closed auxiliary contacts 3^d. Connected between the armature 1 and line L^2 are two starting resistors 4 and 5, respectively. Electromagnetic accelerating switches 6 and 7, having energizing windings 6^a and 7^a respectively, are equipped with normally open contacts 6^b and 7^b respectively, which are adapted to short circuit the resistors 4 and 5, respectively, while switch 7 is also equipped with normally closed contacts 7^c. A control switch 8 is provided for controlling the auxiliary control circuits of the system. It is connected between the line L^1 and one terminal of the energizing winding 3^a. Connected in series with the shunt field winding 2 is an adjustable field regulating resistance 9, which may be short circuited by the normally open contacts 10^b of an electromagnetic relay 10 or shunted by a resistor 11 controlled by normally open contacts 10^c of relay 10, as will be explained hereinafter. The relay 10 also has an energizing winding 10^a which is connected between the lines L^1 and L^2 in series with the control switch 8 and the normally closed contacts 7^c of switch 7. Connected in shunt with the coil 10^a is an adjustable condenser 12 in series with an adjustable resistor 13. A further electromagnetic relay 14 is provided with an energizing winding 14^a, normally closed contacts 14^b and 14^c and normally open contacts 14^d. The coil 14^a is connected in series with contact 3^d across the lines L^1 and L^2 and is shunted by an adjustable condenser 15 in series with an adjustable resistor 16.

A preferred form for relays 10 and 14 neglecting contact details is more fully illustrated in Fig. 2. It comprises a magnetic core 17 to be surrounded by the coil 10^a or the coil 14^a as the case may be, the coil shown being designated as 30. The return magnetic circuit is a U-shaped frame 18 which encloses the coil 30 and which at its lower limb is provided with a knife edge bearing 19 for the support of armatures 20. Each armature extends across the gap between the limbs of the frame 18 and is extended below the lower limb for connection to one end of a helical spring 21, the other end of which is suitably attached to the frame 18 to bias the armature away from the upper limb 22 of the frame 18. The spring 21 may be made adjustable as, for instance by a nut and screw as shown in the drawing. A horizontal rectangular pole shoe 23 extending substantially the full width of the frame 18 is fastened to the core 17 and is so located and arranged that the armatures 20 when attracted are arrested in a slightly spaced relation to said pole shoe 23. Each armature 20 carries a contact lever 24 which is pivoted on the armature and biased towards it by a spring 25. The contact lever carries a contact 24^a which is adapted to engage a stationary contact 26 attached to a bracket 27 which in turn is supported from the frame 18 by an insulating block 28. Non-magnetic adjusting screws 29 pass through the block and terminate opposite the armatures 20. By turning either screw 29 the air gap between its corresponding armature and the poles 22 and 23, in the attracted position of the armature may

be adjusted. In this manner the different armatures may be adjusted so that after having been attracted they will release at different current values flowing in the energizing coil. It is to be observed that when one armature releases, the percentage of flux flowing through the remaining armature or armatures increases which adds further to the time delay in their response when the coil current is interrupted as will be explained more fully hereinafter.

Fig. 3 shows a relay similar to that shown in Fig. 2, except that the armatures are provided with normally closed contacts. Obviously a relay of the type set forth might be provided with both normally open and normally closed contacts if desired.

The system operates as follows:

Whenever the lines L^1 and L^2 are energized, the switch 8 being open the relay 14 is energized through normally closed contacts 3^d of switch 3 and hence the resistor 17 is short circuited by the normally open contacts 14^d. Also normally closed contacts 14^b and 14^c are thus opened to hold open the circuits of windings 6^a and 7^a.

If it is desired to start the motor, the control switch 8 is closed. This energizes the coil 10^a and relay 10 responds to close its contacts 10^b and 10^c, thereby short circuiting the resistor 9 in the field winding circuit. A circuit is also completed through coil 3^a of main switch 3, and said switch closes the normally open contacts 3^b and 3^c and opens contacts 3^d. Closure of contacts 3^b completes the armature circuit and the field circuit of the motor, the former with the resistors 4 and 5 in series, while the field winding 2 is fully energized.

Opening of contacts 3^d interrupts current supply to the energizing coil of the relay 14, but due to the energy stored in its magnetic circuit, said relay does not release instantly. Moreover it will be observed that while the relay coil 14^a was energized, the condenser 15 was charged to the full voltage of the relay coil and the energy thus stored up in the condenser now tends to discharge through the coil, the discharge current having the same direction as the previously flowing energizing current, thereby maintaining a gradually decreasing current flow and a corresponding magnetic flux in the relay which is in the same direction as that produced by the previous energizing current of the relay. As a result, the contacts of the relay 14 which are attached to the armatures will stay in their respective initial positions until the flux has decreased to successive values at which the armatures are adjusted to release. These values and hence the time which must elapse between the closure of the main switch 3 and release of the armatures successively may be adjusted by adjustment of the condenser 15 or the resistor 16, or both, while the time of response of the individual armatures may be further adjusted by adjustment of the individual biasing springs 21 or of the air gap adjusting screws 29.

When the contacts 14^b close, they complete the circuit of the coil 6^a, causing closure of contacts 6^b and the short circuiting of the accelerating resistor 4. Likewise closure of contact 14^c causes energization of coil 7^a and short-circuiting of resistor 5, which action connects the armature 1 directly across the line.

The energization of coil 7^a also opens contacts 7^c, thereby deenergizing relay coil 10^a. Upon opening of contacts 7^c the condenser 12 which previously was charged to line potential is disconnected from the line and it discharges through the resistor 13 and coil 10^a, thereby maintaining the flux in the latter in the manner aforedescribed in connection with relay 14. The relay contacts 10^b and 10^c open sequentially after proper time intervals, thereby first removing the short circuit provided by contacts 10^b when closed and then removing the shunt through resistor 11 provided by contacts 10^c when closed, thus gradually inserting the resistor 9 into the field circuit of the motor to weaken the field excitation and to bring the motor to its maximum operating speed, which may be varied by adjustment of the resistor 9.

It is obvious that the relays 10 and 14 may be provided with a greater or smaller number of armatures and corresponding contacts so as to provide for a greater or smaller number of regulating points for the armature 1 or shunt field winding 2, or for both.

Furthermore, the invention is not limited to the control of direct current shunt motors, but may be applied with suitable modifications to other types of direct or alternating current motors and it may also be applied to other systems requiring the timing of response of electrical and electromagnetic devices.

If the current supply is alternating, the energy for the operation of the timing relay and the coordinated condenser may be supplied through a rectifier of any suitable type.

What we claim as new and desire to secure by Letters Patent is:

1. In a motor controller, in combination, separately operable switches to be operated successively, at least one of said switches having an electromagnetic control winding under the control of another of said switches to be deenergized to time operation of the former switch relative to the latter switch for certain circuit commutation, a condenser and a loop including said condenser in circuit with said winding to augment the time element of said former switch incident to effecting said circuit commutation.

2. In a motor controller, in combination, separately operable switches to be operated successively, at least one of said switches having an electromagnetic control winding under the control of another of said switches to be deenergized to time operation of the former switch relative to the latter switch for certain circuit commutation, a condenser and a loop including said condenser in circuit with said winding to augment the time element of said former switch incident to effecting said circuit commutation, said loop including also a substantial amount of resistance, and said condenser having charging connections including said resistance, to afford it a full charge prior to being required to function as aforestated.

3. In a motor controller, in combination, separately operable switches to be operated successively, at least one of said switches having an electromagnetic controlling winding under the control of another of said switches to be deenergized to time operation of the former switch relative to the latter switch for certain circuit commutation, a condenser having a charging circuit also controlled by said latter switch normally to be completed subject to interruption upon response of said latter switch to deenergize said winding, and connections between said condenser and said winding to delay the decay of magnetic flux of said winding by the discharge of said condenser to augment the time element of said

former switch incident to effecting said circuit commutation.

4. In a motor controller, in combination, a plurality of electromagnetic switches each having an operating winding, control means for said switches to effect by their deenergization operations thereof successively for certain circuit commutations, said control means including means giving one of said switches control of the operating winding of another of the same, condensers individually associated with the windings of said switches respectively and having charging connections controlled by said control means, said condensers coacting with their respective windings upon deenergization of the latter to augment the time elements of their respective switches in effecting said circuit commutations.

5. In a motor controller, in combination, a plurality of electromagnetic switches each having an operating winding, control means for said switches to effect by their deenergization operations thereof successively for certain circuit commutations thereby, said control means including means giving one of said switches control of the operating winding of another of the same, condensers individually associated with the windings of said switches respectively, each of said condensers having charging connections controlled by said control means and connections whereby it discharges to its respective switch winding upon deenergization of the latter to retard operation of its respective switch for the aforementioned circuit commutation thereby.

6. In a circuit controller, in combination, a plurality of separately commutatable circuits, and a relay adapted to commutate said circuits, said relay comprising a magnetic circuit including a core and a plurality of movable armatures, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, individual means for biasing said armatures to a given position in opposition to the magnetic pull thereon and to permit movement of said armatures to another position when the current in said winding exceeds a given value, and energy storage means adapted to store up energy while said winding is energized and to discharge said energy through said winding upon deenergization thereof to retard the decay of the magnetic flux and the return of the respective armatures to said given position, and commutating means operated by said armatures and adapted to control said commutatable circuits.

7. Circuit controlling means comprising a plurality of magnetizable armatures, a magnetizable frame forming with each of said armatures a magnetic circuit having a variable air gap between said armature and said frame to permit relative movement therebetween, circuit commutating means operable by said armatures, magnetizing means for inducing a magnetic flux in said magnetic circuits, individual adjusting means for biasing said armatures to a given position in opposition to the magnetic pull thereon and for permitting movement thereof to another position when said flux exceeds a given value, and energy storage means for storing energy while said magnetizing means is connected to a source of current and for discharging said energy through said magnetizing means upon its disconnection from said source to thereby retard the decay of said flux and the return of the armatures to said given position selectively.

8. In a controller for a motor, a plurality of commutatable starting connections and a relay adapted to control the commutation of said connections, said relay comprising a magnetic circuit including a core and a plurality of movable armatures, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, individual means for biasing said armatures to a given position in opposition to the magnetic pull thereon and to permit movement of said armatures to another position when the current in said winding exceeds a given value, and energy storage means adapted to store up energy while said winding is energized and to discharge said energy through said winding upon deenergization thereof to retard the decay of the magnetic flux and the return of the respective armatures to said given position and commutating means operated by said armatures and adapted to control said commutation of said connections.

9. In a controller for a motor having an armature circuit, a plurality of starting connections for said motor armature circuit and a relay adapted to control the commutation of said connections, said relay comprising a magnetic circuit including a core and a plurality of movable armatures, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, individual means for biasing said relay armatures to a given position in opposition to the magnetic pull thereon and to permit movement of said relay armatures to another position when the current in said winding exceeds a given value, and energy storage means adapted to store up energy while said winding is energized and to discharge said energy through said winding upon deenergization thereof to retard the decay of the magnetic flux and the return of the respective relay armatures to said given position and commutating means operated by said relay armatures and adapted to control said commutation of said connections.

10. Circuit controlling means comprising, a magnetic circuit including a core and a plurality of movable armatures, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, individual adjustable means for biasing said armatures to a given position in opposition to the magnetic pull thereon and to permit movement of said armatures to another position when the current in said winding exceeds a given value, and energy storage means adapted to store up energy while said winding is energized and to discharge said energy through said winding upon deenergization thereof to retard the decay of the magnetic flux and the return of the respective armatures to said given position.

11. Circuit controlling means comprising, a magnetic circuit including a core and a plurality of movable armatures, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, individual adjustable means for biasing said armatures to a given position in opposition to the magnetic pull thereon and to permit movement of said armatures to another position when the current in said winding exceeds a given value, and a condenser connected in circuit with said winding to afford it a time element.

12. Circuit controlling means comprising, a magnetic circuit including a core and a plurality of movable armatures, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, individual adjustable means for biasing said armatures to a given position in opposition to the magnetic pull thereon and to

permit movement of said armatures to another position when the current in said winding exceeds a given value, and a condenser connected across the terminals of said winding to afford it a time element.

13. Circuit controlling means comprising, a magnetic circuit including a core and a plurality of cooperating movable armatures, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, individual adjustable means for biasing said armatures to a given position when said winding is deenergized and to release said armatures for return thereto after they have been moved to another position upon decay of the current in said winding to a given value after its disconnection from a source of supply, and a condenser connected in circuit with said winding and adapted to control the decay of the current in said winding.

14. Circuit controlling means comprising, a magnetic circuit including a core and a plurality of cooperating movable armatures, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, individual adjustable means for biasing said armatures to a given position when said winding is deenergized and to release said armatures for return thereto after they have been moved to another position upon decay of the current in said winding to a given value after its disconnection from a source of supply, and a condenser connected across the terminals of said winding.

15. Circuit controlling means comprising, in combination, a magnetic circuit including a core and a plurality of armatures movably associated therewith, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, adjustable means individual to each of said armatures for affording different values of bias thereon toward given extreme positions thereof in opposition to the magnetic pull thereon from said core, whereby said armatures when in the magnetically attracted positions thereof are released to return to the respective biased positions thereof under conditions of different values of current in said winding, and a condenser connected across the terminals of said winding to afford a time element in the decay of the current in the latter upon disconnection thereof from a source of supply, for the purpose set forth.

16. Circuit controlling means comprising, in combination, a magnetic circuit including a core and a plurality of armatures movably associated therewith, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, adjustable means individual to each of said armatures for affording different values of bias thereon toward given extreme positions thereof in opposition to the magnetic pull thereon from said core, whereby said armatures when in the magnetically attracted positions thereof are released to return to the respective biased positions thereof under conditions of different values of current in said winding, a condenser connected across the terminals of said winding to afford a time element in the decay of the current in the latter upon disconnection thereof from a source of supply, for the purpose set forth, and an adjustable resistance included in circuit in series with said condenser to control the rate of discharge of current from the latter to said winding under the conditions last mentioned.

17. Circuit controlling means comprising, in combination, a magnetic circuit including a core and a plurality of armatures movably associated therewith, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, adjustable means individual to each of said armatures for affording different values of bias thereon toward given extreme positions thereof in opposition to the magnetic pull thereon from said core, additional adjustable means individual to each of said armatures to provide for preselection of the relative values of the minimum air gaps between said core and said armatures in the respective magnetically attracted positions of the latter whereby said armatures when in the magnetically attracted positions thereof are released to return to the respective biased positions thereof under conditons of different values of current in said winding, and a condenser connected across the terminals of said winding to afford a time element in the decay of the current of the latter upon disconnection thereof from a source of supply, for the purpose set forth.

18. Circuit controlling means comprising, in combination, a magnetic circuit including a core and a plurality of armatures movably associated therewith, a magnetizing winding adapted to induce a magnetic flux in said magnetic circuit, adjustable means individual to each of said armatures for affording different values of bias thereon toward given extreme positions thereof in opposition to the magnetic pull thereon from said core, additional adjustable means individual to each of said armatures to provide for preselection of the relative values of the minimum air gaps between said core and said armatures in the respective magnetically attracted positions of the latter whereby said armatures when in the magnetically attracted positions thereof are released to return to the respective biased positions thereof under conditions of different values of current in said winding, a condenser connected across the terminals of said winding to afford a time element in the decay of the current in the latter upon disconnection thereof from a source of supply, for the purpose set forth, and an adjustable resistance included in circuit in series with said condenser to control the rate of discharge of current from the latter to said winding under the conditions last mentioned.

19. In a controller for a motor having an armature circuit and a shunt field circuit, commutatable starting connections for said motor armature circuit and for said shunt field circuit respectively, a plurality of relays each comprising a magnetic circuit including a core and at least one movable armature, each of said relays having a magnetizing winding adapted to induce a magnetic flux in its respective magnetic circuit, means individual to the respective armatures of said relays to bias said armatures to given positions in opposition to the magnetic pulls thereon respectively and to permit movement of each of said armatures to another position thereof when the current in its associated winding exceeds a given value, electrical energy storage means individual to each of said windings and respectively adapted to store up energy while said windings are energized and to discharge said energy through the respective windings upon deenergization thereof to retard the decay of the magnetic flux in its respective magnetic circuit with a corresponding delay in the return of the respective armatures to said given positions thereof, and commutating means operated by the armatures of said relays and adapted to control said commutation of said starting connections, for the purpose set forth.

20. In a controller for a motor having an armature circuit and a shunt field circuit, commutatable starting connections for said motor armature circuit and for said shunt field circuit respectively, a plurality of relays each comprising a magnetic circuit including a core and at least one movable armature, each of said relays having a magnetizing winding adapted to induce a magnetic flux in its respective magnetic circuit, means individual to the respective armatures of said relays to bias said armatures to given positions in opposition to the magnetic pulls thereon respectively and to permit movement of each of said armatures to another position thereof when the current in its associated winding exceeds a given value, electrical energy storage means individual to each of said windings and respectively adapted to store up energy while said windings are energized and to discharge said energy through the respective windings upon deenergization thereof to retard the decay of the magnetic flux in its respective magnetic circuit with a corresponding delay in the return of the respective armatures to said given positions thereof, commutating means operated by the armatures of said relays and adapted to control said commutation of said starting connections, for the purpose set forth, and means associated with an armature of one of said relays to effect deenergization of the magnetizing winding of another of the same, whereby operation of said relays in a predetermined sequence is insured.

21. In a controller for a motor having an armature circuit and a shunt field circuit, commutatable starting connections for said motor armature circuit and for said shunt field circuit respectively, a plurality of relays each comprising a magnetic circuit including a core and at least one movable armature, each of said relays having a magnetizing winding adapted to induce a magnetic flux in its respective magnetic circuit, means individual to the respective armatures of said relays to bias said armatures to given positions in opposition to the magnetic pulls thereon respectively and to permit movement of each of said armatures to another position thereof when the current in its associated winding exceeds a given value, electrical energy storage means individual to each of said windings and respectively adapted to store up energy while said windings are energized and to discharge said energy through the respective windings upon deenergization thereof to retard the decay of the magnetic flux in its respective magnetic circuit with a corresponding delay in the return of the respective armatures to said given positions thereof, commutating means operated by the armatures of said relays and adapted to control said commutation of said starting connections, for the purpose set forth, means associated with an armature of one of said relays to effect deenergization of the magnetizing winding of another of the same, whereby operation of said relays in a predetermined sequence is insured, and means including an electromagnetically operable main switch adapted when energized to effect deenergization of the magnetizing winding of said one of said relays aforementioned.

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