

April 17, 1951

P. G. WHITE
TIME DELAY CONTROL

2,549,149

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2 Sheets-Sheet 1

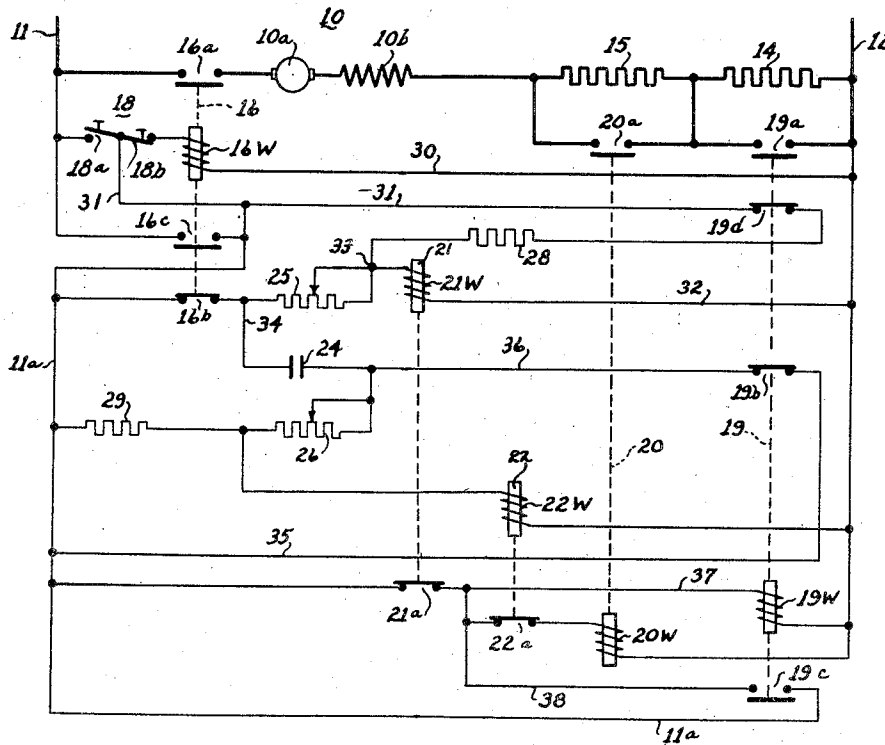


FIG. 1

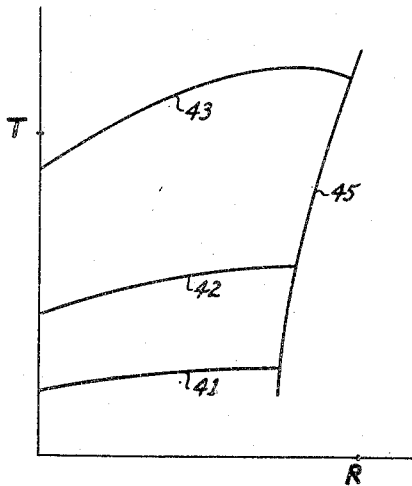


FIG. 3
(PRIOR ART)

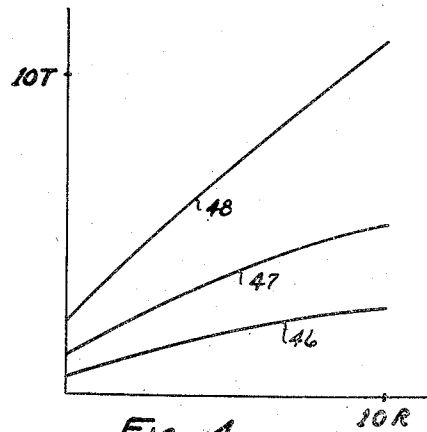


FIG. 4

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2 Sheets-Sheet 2

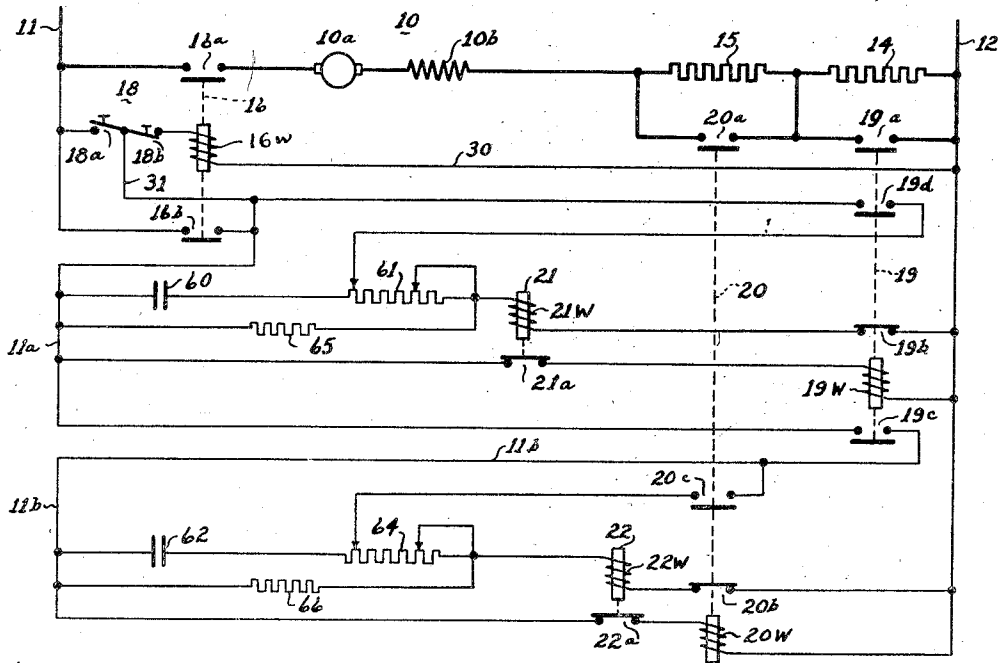


FIG. 2

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UNITED STATES PATENT OFFICE

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TIME DELAY CONTROL

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14 Claims. (Cl. 175-320)

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This invention relates to a control system for an electric translating device, the illustrative examples hereinafter disclosed being improved control systems for automatically short circuiting the resistance in a circuit of an electric motor during acceleration of the motor and for introducing a time delay between the closing of successive starting switches, the extent of the time delay intervals being dependent upon the rate of change of the energy in an electrical energy accumulation device such as a condenser.

Heretofore, in the control of translating devices other than motors by timing circuits, it has been proposed to connect a condenser, an adjustable resistor, and the operating winding of an electromagnetic relay in series with each other across a source of substantially constant unidirectional voltage, the electrical constants of the circuit being so proportioned that, upon initial application of voltage to the circuit terminals, the initial impulse of condenser charging current is sufficient to cause pick-up or actuation of the relay which temporarily remains in its actuated or closed magnetic circuit position until the condenser charging current decreases to the drop-out current value of the relay. A series connected condenser, resistor and relay winding circuit such as just described and in which all of the relay current passes through the timing condenser is not suitable for determining the time delay intervals between the closing of successive motor acceleration switches because, when the resistance of the circuit is made low enough to permit the initial flow of charging current to be large enough to pick up the relay, the resistance is too low to delay adequately the charging time of the condenser, and consequently the timing period is too short for many purposes including that of motor starting control. This disadvantage is aggravated by low voltage conditions that often occur on industrial power supply systems. The time delay period can obviously be increased by using a condenser of larger capacity, but this expedient is generally not justified both because of the increased cost and because of the larger space required. Another disadvantage of the simple series connected timing circuit such as above described is that relatively large variations in the resistance of the resistor have but little effect on the time interval during which the relay is in its actuated position so that other means must be resorted to in order to obtain the usual required adjustment of the duration of the timing period.

By taking advantage of the phenomenon that substantially less current is required to hold a

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relay in its actuated position than is required to actuate it, various modifications of the simple series connected timing circuit have heretofore been proposed for increasing the timing interval for unit of capacity. However, the switching sequences required in the prior modified series connected timing circuits are such that the circuits are not adaptable for use in motor starter circuits and in some instances also require the use of a relay having a tapped or two separate operating windings.

The present invention involves timing circuits of the above indicated character and takes advantage of the fact that the drop-out current of a relay is less than the relay pick-up current, but the timing circuits are so arranged as to be eminently suitable for use in controlling motor acceleration, each of the timing relays requires but a single operating winding, and connections are provided which conduct additional current for effecting pick-up of the relays and which also function to prolong the timing interval. More specifically in accordance with this invention, means such as a resistor is connected in parallel with the condenser and resistor portion of a series connected condenser, resistor, and relay winding timing circuit thereby providing an additional path for current flowing to the relay winding so that part of the current required for picking up and holding in the relay flows through the shunting resistor and the remainder is supplied through the series connected condenser and resistor. The amount of current flowing through the shunting resistor when the condenser approaches its charged condition is less than the drop-out current value of the relay so that the relay temporarily remains in its actuated position for a time interval or until the sum of the condenser charging current and the current flowing through the shunting resistor becomes less than the drop-out current value of the relay. The combination of such a by-pass or shunting means with a series connected condenser, resistor, and relay winding timing circuit not only increases the maximum duration of the timing interval obtainable with a given size of condenser, but also greatly increases the range of adjustment of the timing interval and provides a circuit useable for controlling motor acceleration. By proper selection of resistance values in the circuit of the present invention, it is possible to obtain sufficient time delay to control properly the acceleration of a motor driving a load of high inertia even though a condenser of relatively low capacity is used.

In one embodiment of the invention herein

disclosed one of the improved series connected condenser and relay winding timing circuits is provided for each motor starting switch which is to be operated at the expiration of a predetermined time interval. In another embodiment operation of a first motor starting switch which is time-controlled by one of the improved series connected condenser and relay winding timing circuits sets up circuits whereby the condenser used for timing the operation of the first switch also times the operation of a succeeding switch. During the second timing period of the condenser, the condenser discharges through a loop circuit including the operating winding of a second relay, and connections including a resistor are provided to permit additional current to flow to the winding of a second relay directly from the source of supply during the timing period thereby causing the relay to be held in its actuated position for a longer period of time than if the condenser discharge current alone were used to hold the relay in its picked-up position.

An object of this invention is to provide an improved time delay control system.

Another object is to provide a time delay control system which does not have the disadvantages and which has the advantages above set forth.

Another object is to provide an improved time delay control system in which an electromagnetic relay is temporarily held in its actuated or energized position by the charging current of a condenser connected in series with the operating winding of the relay.

A further object is to provide a time delay control system in which a relay is temporarily held in its actuated position by the charging current of a condenser connected in series with a resistor and the relay winding and in which a circuit bypassing the condenser and resistor supplies part of the current for picking up and holding in the relay.

Another object is to provide an improved time delay control system in which the operating winding of an electromagnetic relay is initially supplied with current through a circuit bypassing a substantially discharged condenser connected in series with the winding.

Still another object is to provide a time delay control system in which an electromagnetic relay is temporarily held in its picked-up position by current flowing to its operating winding through a parallel circuit having a resistor in one branch and a condenser and a resistor connected in series with each other in another branch.

A further object is to provide a time delay control system in which the operating winding of an electromagnetic switch is supplied through a parallel circuit having a gradually increasing current in one branch and a gradually decreasing current in another branch.

A still further object is to provide an improved timing circuit for a plurality of electromagnetic devices in which both the charging current and the discharging current of a condenser are used for controlling the devices.

An additional object is to provide an improved control system for an electric motor which includes means responsive to the charging current of a condenser for controlling the operation of electromagnetic switches.

Other objects include the provision of a plurality of cooperating time delay circuits each utilizing the charging time of a condenser, the provision of a plurality of series connected con-

denser and relay winding timing circuits for controlling the acceleration of an electric motor, and the provision of an improved time delay control system in which both the charging and discharging intervals of a condenser are utilized.

A still further object is to provide a motor control system in which a relay, having normally-closed contacts in series with the operating winding of a switch to be operated after a time delay, is operated to the open position of its contacts before a circuit to the switch can be completed and then is held in its operated position for a time interval measured by the charging time of a condenser.

Other objects and advantages will become apparent from the following description wherein reference is made to the drawings, in which:

Fig. 1 is a circuit diagram illustrating the invention;

Fig. 2 is a circuit diagram of a modification;

Fig. 3 is a graph illustrating time-resistance characteristics of a prior art time delay circuit, and

Fig. 4 is a graph illustrating time-resistance characteristics obtainable with the time delay control circuit of Figs. 1 and 2.

Referring to Fig. 1, a direct current motor 10 having an armature winding 10a and a series field winding 10b is arranged to be connected between a pair of supply conductors 11 and 12 through series connected accelerating resistors 14 and 15 when normally open main circuit contacts 16a of an electromagnetic switch or contactor 16 are in their closed position. The switch 16 additionally has normally closed auxiliary contacts 16b, normally open auxiliary contacts 16c, and an operating winding 16w the energization of which is controlled by a pilot device or master switch shown as a push button 18 having normally open contacts 18a and normally closed contacts 18b. The accelerating resistors 14 and 15 are arranged to be short circuited by normally open main circuit contacts 19a and 20a, respectively, or electromagnetic switches or contactors 19 and 20, respectively. The switch 19 is additionally provided with normally closed auxiliary contacts 19b and 19d, normally open auxiliary contacts 19c, and an operating winding 19w. The switch 20 has an operating winding 20w. The energization of the windings 19w and 20w is controlled by normally closed contacts 21a and 22a, respectively, of electromagnetic relays 21 and 22, respectively. The relays 21 and 22 have operating windings 21w and 22w, respectively, and are designed, preferably by having moving parts which are relatively much smaller than the moving parts of the switches 16, 19 and 20, so that they move to their operated position more quickly upon energization of their respective windings than do the switches. That is, when the winding of a switch and the winding of a relay are energized concurrently, the relay moves to its operated position before the switch. Any suitable type of relay may be used for the relays 21 and 22 so long as it has a drop-out current value which is less than its pick-up current value, but preferably the relays 21 and 22 are of the clapper type having either a fixed drop-out current value or having means for adjusting the drop-out current value, it being understood that the representation of the switches and relays in the drawings is merely schematic.

For controlling time delayed drop-out of the relay 21, a condenser 24 and an adjustable re-

sistor 25 are connected in series with each other and with the winding 21w between the conductor 12 and a conductor 11a which is electrically connected to the conductor 11 when the contacts 16c and/or 18a are closed. The time delayed operation of the relay 22 is controlled by connecting the condenser 24, the adjustable resistor 25, an adjustable resistor 26, and the windings 21w and 22w in a closed loop circuit. In accordance with this invention, resistors 28 and 29 of relatively high ohmic value are provided in the energizing circuits of the relays 21 and 22, respectively, for facilitating the adjustability and increasing the duration of the timing intervals in a manner to be described in the following description of operation.

With the conductors 11 and 12 connected to a suitable source of direct current, closure of the contacts 18a of the push button 18 concurrently completes respective energizing circuits for the windings 16w and 21w. The energizing circuit for the winding 16w extends through the contacts 18b, the winding 16w, and a conductor 38 to the conductor 12. The energizing circuit for the winding 21w has a plurality of parallel branches one of which extends from the contacts 18a through a conductor 31, the contacts 19d, the resistor 28, a junction point 33, the winding 21w, and a conductor 32 to the conductor 12. Another of the parallel branches extends from the now energized conductor 31 through the conductor 11a, the contacts 16b, a branch point 34, and the adjustable resistor 25 to the junction point 33. A third parallel branch of the energizing circuit for the winding 21w is from the conductor 11a through a conductor 35, the contacts 19b, a conductor 36, and the condenser 24 to the branch point 34. The ohmic resistance of the resistor 28 and the maximum possible resistance of the resistor 25 together with the resistance of the winding 21w are so selected relative to the minimum expected voltage of the source that sufficient current for operating the relay 21 flows through the branch point 33 to the winding 21w while the contacts 16b remain closed or while the condenser 24 is substantially discharged.

Opening of the contacts 21a upon operation of the relay 21 prevents immediate operation of the switch 19, the coil 19w of which is connected between the conductors 11a and 12 through the contacts 21a and a conductor 37. An energizing circuit for the winding 22w which is also completed upon closure of the contacts 18a extends from the conductor 11a through the conductor 35, the contacts 19b, the conductor 36, the resistor 26, and the winding 22w to the conductor 12. The resistor 29 is permanently connected between the conductor 11a and the common terminal of the resistor 26 and the winding 22w and supplies part of the energizing current for the winding 22w. Opening of the contacts 22a upon energization of the winding 22w prevents premature operation of the switch 20 which otherwise would occur upon reclosure of the contacts 21a.

In response to the energization of its winding 16w, but after the faster operating relay 21 has moved to its picked-up position, the switch 16 operates to close its contacts 16a and 16c and to open its contacts 16b. Closure of the contacts 16a connects the motor 19 to the source of power in series with the resistors 14 and 15, and closure of the contacts 16c completes a circuit around the contact 18a between the conductors 11 and 11a thus permitting the contacts 18a to be opened. Opening of the contacts 16b permits a charging

current to flow through the condenser 24 and the relay 21 is thereafter held in its picked-up position by the sum of the currents which flow through the branch circuit including the condenser 24 and the resistor 25 and through the branch circuit including the resistor 28. The current flowing through the condenser 24 gradually decreases as the condenser accumulates a charge, and the current flowing through the resistor 28 gradually increases. The resistor 28, however, has an ohmic value so related to the voltage between the conductors 11 and 12 and to the resistance of the winding 21w that insufficient current can flow therethrough to hold the relay 21 in its actuated position. Consequently, when the condenser 24 becomes charged to a predetermined degree after a lapse of time determined by its capacity, the resistance of its charging circuit, and the applied voltage, the current flowing through the winding 21w becomes less than the drop-out current value of the relay 21 which thereupon drops out to close its contacts 21a.

Closure of the contacts 21a completes the energizing circuit previously traced for the winding 19w causing operation of the switch 19. Movement of the switch 19 to its operated position causes closure of the contacts 19a which short circuit the resistor 14 thereby increasing the voltage applied to the motor 19, and causes closure of the contacts 19c which complete a holding circuit for the winding 19w from the conductor 11a through the contacts 19c and a conductor 38 to the conductor 37. The contacts 19b open consequent upon operation of the switch 19 and interrupt the charging circuit for the condenser 24, and the contacts 19d also open to interrupt the last remaining circuit between the left-hand terminal of the condenser 24 and the conductor 11.

A closed loop circuit for the discharge of the condenser 24 becomes effective upon operation of the switch 19 and extends from the right-hand terminal of the condenser 24 through the resistor 26, the winding 22w, the conductors 12 and 32, the winding 21w, and the resistor 25 to the left hand terminal of the condenser. The discharge current of the condenser 24 together with the current flowing through the resistor 29 holds the relay 22 in its picked-up position for a period of time dependent upon the amount of charge on the condenser 24 and the resistance of the discharge loop. The ohmic value of the resistor 29 is so chosen that during the discharge period of the condenser 24 a current slightly less than the drop-out current value of the relay 22 flows through the resistor 29 to the winding 22w. When the condenser 24 has discharged to a predetermined low value, the sum of the currents flowing through the condenser 24 and the resistor 29 becomes less than the drop-out current value of the relay 22 and the contacts 22a reclose completing a circuit from the conductor 38 through the winding 20w to the conductor 12. The switch 20 in response to the energization of its winding 20w closes the contacts 20a which short circuit the resistor 15 to connect the motor 19 directly across the source of power.

The resistor 26 may be omitted, if desired, provided the winding 22w has sufficient resistance to limit the current flowing to the winding through the contacts 19b in which case the resistor 25 only is available to control the time delay periods of both relays 21 and 22.

Using a condenser having a capacity of 40

microfarads, a total time delay period of fourteen seconds was obtained between the instant of pick-up of the relay 21 and the instant of drop-out of the relay 22 when the supply potential was 230 volts, the resistors 28 and 29 each had a resistance of 100,000 ohms, the windings 21w and 22w each had a resistance of 8400 ohms, the resistor 25 was adjusted to have a resistance of 25,000 ohms, and the resistor 26 was not used. The foregoing values are given by way of additional explanation only and are not to be considered as limiting values in any sense.

In Fig. 3 which illustrates the operation of a prior art timing circuit comprising a condenser, a resistor, and a relay winding connected in series and in which all of the relay current flows through the condenser, the time during which the relay is held in its operated position by the charging current of the condenser is plotted against adjusted values of the series resistor. A curve 41 is the time-resistance characteristic of such a circuit in which the condenser has a given capacity C, and curves 42 and 43 are time-resistance characteristics of similar circuits having a condenser with a capacity of twice C and four times C, respectively. It is to be noted that as the capacity of the condenser is increased, time delay periods of increased duration result, and that by increasing the ohmic value R of the resistor, relatively small increases in the time delay period are obtained. In order to prolong the flow of condenser charging current, it is necessary to increase as much as possible the ohmic value of the series resistor, but if, as in the prior art circuit being considered, the initial impulse of condenser charging current alone is used to pick up the relay, there is a limit beyond which it is impossible to increase the resistance of the circuit. This limiting value of the resistor for a particular value of supply voltage and for a particular relay is represented by a curve 45 in Fig. 3, it being obvious that if the supply voltage has any lesser value, the limiting resistance curve 45 moves to the left.

Referring now to Fig. 4, which shows time-resistance characteristics of the timing circuit including the relay 21 as connected in Fig. 1, the units of both the time scale and the resistance scale are ten times as large as the corresponding scales of Fig. 3, hence the indication of the ordinate point 10T and the abscissa point 10R. A similar relay was used to obtain the data for Figs. 3 and 4, and in Fig. 4 curves 46, 47 and 48 are plotted for the same values of capacity as the curves 41, 42, and 43, respectively, of Fig. 3. Since in the circuit of Fig. 1 all of the current necessary for picking up the relay 21 does not flow through the resistor 25, the resistor 25 may have a larger value than otherwise would be possible.

In the embodiment of Fig. 2, a timing condenser is provided for each resistance shunting acceleration switch and the charging time only of the condensers is utilized. The relays 21 and 22 of Fig. 2 may be the same as the relays 21 and 22 of Fig. 1. As distinguished from Fig. 1, in Fig. 2 the switch 16 has normally open contacts 16a and 16b only, the contact 19d of the switch 19 is normally open instead of normally closed, and the switch 20 is provided with a normally closed auxiliary contact 20b and a normally open auxiliary contact 20c. A condenser 60 and an adjustable resistor 61 of relatively low ohmic value are connected in series with the winding 21w, and a condenser 62 and an adjustable re-

sistor 64 of relatively low ohmic value are connected in series with the winding 22w. For supplying part of the current for picking-up and holding-in the relay 21, a resistor 65 of relatively high ohmic value is connected in parallel with the condenser 60 and the resistor 61, and similarly, for supplying part of the current for picking-up and holding-in the relay 22, a resistor 66 of relatively high ohmic value is connected in parallel with the condenser 62 and the resistor 64. Other details of the motor starter of Fig. 2 will become apparent from the following description of operation:

With unidirectional voltage available at the supply conductors 11 and 12, closure of the contacts 18a concurrently completes energizing circuits for the windings 16w and 21w. The energizing circuit for the winding 16w includes the stop contacts 18b and the conductor 30. The energizing circuit for the winding 21w includes the normally closed contacts 19b and the parallel circuit having the resistor 65 in one branch and the series connected condenser 60 and resistor 61 in the other branch. The resistances of the resistors 61 and 65 and of the winding 21w are so related to each other and to the voltage across the conductors 11 and 12 that, if the condenser 60 is substantially discharged, the combined current flowing through the parallel connected resistors 61 and 65 is sufficient to actuate the relay 21 thereby causing opening of the contacts 21a. As explained in connection with Fig. 1, the contacts 21a open before current flowing through the winding 19w can cause operation of the switch 19. Operation of the switch 16 in response to the energization of its winding 16w results in closure of the contacts 16a connecting the motor 10 across the conductors 11 and 12 in series with the resistors 14 and 15.

Charging current flowing through the condenser 60 and the resistor 61 combined with that flowing through the resistor 65 holds the relay 21 in its actuated position until the condenser 60 is substantially charged. When the condenser 60 reaches a predetermined charged condition, the relay 21 drops out and closes its contacts 21a completing the energizing circuit for the winding 19w of the switch 19. Operation of the switch 19 causes closure of the contacts 19a thereby increasing the voltage applied to the motor 10, causes closure of the contacts 19d to complete a low resistance discharge circuit for the condenser 60 through a small portion of the resistor 61, and causes opening of the contacts 19b to prevent re-actuation of the relay 21.

Operation of the switch 19 also causes closure of the contacts 19c to connect the conductor 11a to a conductor 11b and thus completes an energizing circuit for the winding 22w which circuit includes the contacts 20b and a parallel circuit having a branch including the series connected condenser 62 and the resistor 64 and a branch including the resistor 66. If the condenser 62 is substantially discharged, the combined current i which flows initially through the branch circuits is sufficient to cause actuation of the relay 22 thereby opening the contacts 22a to prevent operative energization of the winding 20w which is connected across the conductors 11b and 12 in series with the contacts 22a. During the accumulation of a charge on the condenser 62, the current flowing through the condenser 62 and the resistor 64 decreases to a value less than the drop-out current value of the relay 22, but the relay 22 remains in its actuated position for a

further time interval due to the additional current flowing through the resistor 66. Eventually the condenser 62 becomes charged to such a value that the sum of the currents flowing in the two parallel branch circuits is less than the drop-out current value of the relay 22 which thereupon returns to its normal position in which the contacts 22a are closed.

Reclosure of the contacts 22a causes energization of the winding 20w of the switch 20 which responds to close the contacts 20a and 20c and to open the contacts 20b. Closure of the contacts 20a short circuits the remaining resistor 15 so as to connect the motor 10 directly across the conductors 11 and 12, and closure of the contacts 20c completes an obvious discharge circuit of low resistance for the condenser 62 through a portion of the resistor 66. Opening of the contacts 20b prevents reactivation of the relay 22.

The motor 10 is thus gradually accelerated as a consequence of the time delay intervals provided by the charging time of the condensers 60 and 62. Opening of the contacts 18b at any time causes disconnection of the motor 10 from the source of supply and drop-out of the switches 16, 19 and 20 as well as the relays 21 and 22. The low resistance condenser discharge circuits that are completed upon drop-out of the switches 19 and 20, respectively, permit proper time-delayed re-acceleration of the motor 10 should the contacts 18a be closed immediately after the contacts 18b have been operated.

I claim:

1. In a time delay control the combination with a condenser, an electromagnetic relay having an operating winding and operative to pick up and to drop out at predetermined current values respectively in said winding, and connections for connecting said condenser and said winding in series with each other across a source of unidirectional voltage, of a by-pass circuit connected in parallel with said condenser and operative during the charging period of said condenser to provide an additional path for current flowing to said winding, a resistor in said by-pass circuit, and the resistance of said resistor and said relay winding being so related to the voltage of said source that a combined current greater than the drop-out current value of the relay flows through said resistor and said condenser to said winding after the charging current of said condenser has decreased below said drop-out current value and being further so related to the voltage of the source that a current having a value slightly less than the drop-out current value of said relay flows through said by-pass circuit to said winding when said condenser approaches a charged condition.

2. A time delay control comprising a condenser, a first resistor, an electromagnetic relay having an operating winding, connections for connecting said condenser, said first resistor, and said winding in series across a source of unidirectional voltage, said first resistor and said winding having a combined ohmic resistance so related to the voltage of said source that insufficient current flows through said first resistor and said condenser to actuate said relay, a by-pass circuit connected in series with said winding and in parallel with said condenser and said first resistor and a second resistor in said by-pass circuit, the ohmic resistance of said by-pass circuit being so related to the voltage of said source that the sum of the current flowing through said by-pass circuit and through said condenser and said first

resistor when said condenser is substantially discharged is sufficient to actuate said relay.

3. A time delay control comprising a condenser, a resistor, an electromagnetic relay having an operating winding, connections for connecting said condenser, said resistor, and said winding in series across a source of unidirectional voltage, said resistor and said winding having a combined ohmic resistance so related to the voltage of said source that insufficient current flows through said resistor and said condenser to actuate said relay when said condenser is uncharged, and means completing a circuit in parallel with said condenser and said resistor and in series with said winding, the combined resistance of said parallel circuit and said winding being so related to the voltage of said source that the sum of the current flowing through said parallel circuit and the current flowing through said condenser and resistor when said condenser is substantially discharged is sufficient to actuate said relay, and the resistance of said parallel circuit and said winding being further so related to the voltage of said source that the current flowing through said parallel circuit and through said condenser and resistor when said condenser is substantially charged is insufficient to hold said relay in its actuated position.

4. A timing control system, comprising an electromagnetic device which has an operating winding and which becomes operatively deenergized upon decrease of current in said winding below a predetermined value, a supply circuit for said winding including a first resistor and a condenser connected in series with each other and with said winding and a second resistor connected in parallel with said first resistor and said condenser and in series with said winding, means operable to connect said circuit for energization from a source of unidirectional voltage, energization of said circuit causing a charging current to flow through said condenser and a current to flow through said second resistor, the sum of said currents being sufficient to cause operative energization of said electromagnetic device, and said second resistor and said electromagnetic device having constants so related to the voltage of said source that said electromagnetic device remains operatively energized for an appreciable time interval after the current flowing through said condenser during the charging period of said condenser decreases below said predetermined value and then becomes operatively deenergized.

5. A timing control system comprising an electromagnetic device which has an operating winding, a supply circuit for said winding including a first resistor and a condenser connected in series with each other and with said winding and a second resistor connected in series with said winding and in parallel with said first resistor and said condenser, means operable to connect said circuit for energization from a source of unidirectional voltage, energization of said circuit causing a charging current to flow through said condenser which is insufficient to cause actuation of said electromagnetic device and also causing a current to flow through said second resistor, the sum of said currents being sufficient to cause actuation of said electromagnetic device, and said second resistor and said electromagnetic device having constants so related to the voltage of said source that said electromagnetic device becomes operatively deenergized during the charging period of said condenser.

6. A timing control system comprising an electromagnetic device having a winding, a supply circuit for said winding including a first resistor and a condenser connected in series with each other and with said winding, a second resistor connected in series with said winding and in parallel with said first resistor and said condenser, means operable to energize said circuit by connecting said circuit across a source of unidirectional voltage, the electrical constants of said circuit and of said electromagnetic device being so related to the voltage of said source that upon operation of said means with said condenser substantially discharged neither said first resistor and said condenser nor said second resistor conducts sufficient current to operatively energize said electromagnetic device but said electrical constants being so related to the voltage of said source that the sum of said currents is sufficient to operatively energize said electromagnetic device, and said second resistor and said electromagnetic device having constants so related to the voltage of said source that said electromagnetic device becomes operatively deenergized during the charging period of said condenser.

7. In a time delay control the combination with a condenser, a timing resistor, an electromagnetic relay having an operating winding, said resistor, and said winding in series with each other across a source of unidirectional voltage, of a resistive by-pass circuit permanently connected in parallel with said condenser to provide an additional path for current flowing to said winding and having a resistance such that the current in said additional path is less than the drop-out current value of said relay and operatively increases the flux produced by the winding.

8. In a time delay control the combination with a condenser, an electromagnetic relay having an operating winding, and connections for connecting said condenser and said winding in series with each other across a source of unidirectional voltage, of a by-pass circuit connected in parallel with said condenser and operative during the charging period of said condenser to provide an additional path for current flowing to said winding, the sum of the currents flowing to said winding through said condenser and said by-pass circuit being greater than the pick-up current value of said relay, and a resistor in said by-pass circuit, the resistance of said resistor and of said relay winding being so related to the voltage of said source that the current flowing through said by-pass circuit operatively increases the flux produced by said winding while remaining below the drop-out current value of said relay.

9. A timing control system comprising a condenser, a resistor, an electromagnetic relay having an operating winding, connections for completing a charging circuit for said condenser through said resistor and said winding in series from a source of unidirectional voltage, a by-pass circuit including a resistance means and connected in parallel with said condenser and resistor and in series with said winding and operative to supply to said winding a current sufficient, when combined with current flowing in said charging circuit, to cause pick up of said relay by the combined current and operative, when said condenser approaches a charged condition, to limit the current supplied to said winding sufficiently to cause drop out of said relay, and means connected in said by-pass circuit and

operative in response to drop-out of said relay for interrupting said by-pass circuit.

10. A timing control system in accordance with claim 4 characterized in that a second electroresponsive means has an operating winding connected in parallel with said condenser and which becomes operatively energized upon connection of said supply circuit for energization, switch means are connected in said supply circuit and are operable upon said operative deenergization of said first electromagnetic device to disconnect said supply circuit from said source while maintaining said operating winding of said second device connected in parallel with said capacitor, whereby operation of said switch means permits said condenser to discharge through said parallel connected winding, there are a third resistor and a holding circuit connecting said third resistor and said second winding across said source, the electrical constants of said condenser, said second device, and said third resistor are so related to the voltage of said source that the winding of said second device remains operatively energized after said supply circuit is disconnected and for a predetermined time after the discharge current of said condenser decreases below the drop-out current value of said second device.

11. A timing control system comprising an electromagnetic device having a winding and operative to move to a picked-up position when the current in said winding is above a predetermined pick-up value and to move to a dropped-out position when the current in said winding becomes less than a predetermined drop-out value less than said pick-up value, a supply circuit for said winding including a charging resistor and a condenser connected in series with each other and with said winding and a by-pass resistor connected in series with said winding and in parallel with said charging resistor and said condenser, means operable to energize said circuit by connecting said circuit across a source of unidirectional voltage, the electrical constants of said circuit and of said electromagnetic device being so related to the voltage of the source that upon operation of said means with said condenser substantially discharged neither the charging current which flows through said charging resistor and said condenser nor the by-pass current which flows through said by-pass resistor is above said pick-up value but said electrical constants being so related to the voltage of the source that the sum of said charging and by-pass currents is above said pick-up value, and said electrical constants being further related to the voltage of the source that the charging current is above said drop-out value when said condenser is uncharged, said by-pass current is at all times less than said drop-out value, and said charging current decreases below said drop-out value during the charging period of said condenser while the sum of said charging and said by-pass currents remains above said drop-out value.

12. A time delay control comprising a condenser, connections for connecting said condenser across a source of unidirectional voltage, a switch in said connections closeable to permit charging of said condenser from said source, an electromagnetic device having an operating winding and capable of becoming operatively deenergized upon decrease of current in said winding below a predetermined drop-out value, said winding being connected in parallel with said condenser and

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in series with said switch, a resistor connected in series with said winding and in parallel with said switch, the electrical constants of said device being so related to the voltage of said source that said device remains in operative position so long as said switch is closed and said condenser is charged, the electrical constants of said condenser, said resistor, and said device being so related to each other that upon opening of said switch the current flowing to said winding through said resistor is and remains less than the drop out current value of said device whereas the sum of the current flowing to said winding from said condenser and the current flowing to said winding through said resistor remains above the drop out current value of said device for a time interval.

13. A time delay control comprising a resistance means, a switch operable when closed to connect one end of said resistance means to one side of a source of direct current, a condenser, means connecting said condenser between said one end of said resistance means and the other side of said source of current, a resistor connected between said one side of said source and the other end of said resistance means, an electromagnetic device having an operating winding connected between said other side of said source and said other end of said resistance means, and the electrical constants of said resistance means, said condenser, said resistor, and said device being so related to each other and to the voltage of said source that upon closure of said switch said device moves to an operated position and said condenser becomes charged and that upon opening of said switch the sum of the current flowing to said winding from said condenser and the current flowing to the winding through said resistor is sufficient to hold said device in operated position whereas the current flowing to said winding through said resistor is insufficient of itself to hold said device in operated position.

14. A timing control system comprising an electromagnetic relay having a winding, a supply circuit for said winding including a first resistor and a condenser connected in series with each other and with said winding and a second resistor connected in series with said winding and in parallel with said first resistor and said condenser, a

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pair of electroresponsive devices having respective energizing circuits, means operable to connect concurrently said supply circuit and said energizing circuits in parallel with each other across a source of unidirectional voltage, the electrical constants of said supply circuit and of said relay being so related to the voltage of said source that upon operation of said means when said condenser is substantially discharged neither said first resistor and said condenser nor said second resistor conducts sufficient current to operatively energize said relay but said electrical constants being so related to the voltage of said source that the sum of said currents is sufficient to operatively energize said relay, said relay having normally closed contacts in one of said energizing circuits operative to open, upon said concurrent connection of said circuits across the source, and thereby interrupt said one energizing circuit while said other energizing circuit is maintained, and said second resistor and said electromagnetic device having constants so related to the voltage of said source that said relay becomes operatively de-energized during the charging period of said condenser and thereby recloses said contacts, completing said one energizing circuit.

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