

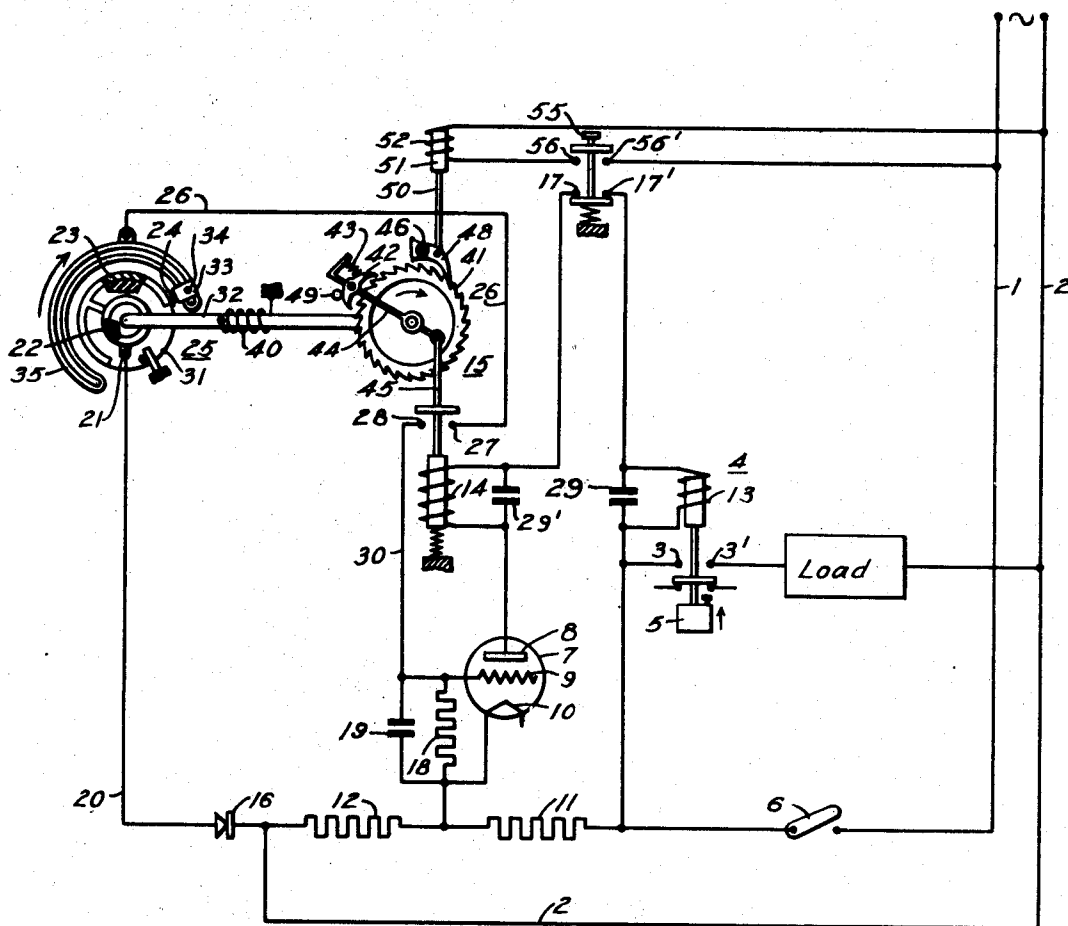
Aug. 21, 1945.

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2,383,328

TIME DELAY DEVICE

Filed June 27, 1941



WITNESSES:

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2,383,328

TIME DELAY DEVICE

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Application June 27, 1941, Serial No. 400,009

7 Claims. (Cl. 175—320)

This invention relates to control circuits and, more particularly, to a time-delay circuit for retarding the operation of electrical devices.

In control systems of the type to which this invention pertains, the discharge time of a capacitor through a resistance is utilized to effect a time-delay in the actuation of relays. The time-constant produced by resistance and capacity has been utilized in various control circuits for effecting a prolongation of time in the actuation of certain devices. When a considerable length of time is desired between certain operations, a resistance-capacity delay network in effecting this time-delay must necessarily be of large ohmic and capacitive values, respectively. In practice there are certain limitations imposed upon such combinations, and it is difficult and costly to construct large capacitors and large values of resistances.

The current of a discharging condenser which is shunted by a resistor is given by the equation

$$I = I_0 \frac{-t}{RC}$$

and theoretically the time required to discharge depends entirely upon the electrical constants represented by the product of RC. In every condenser a certain leakage is unavoidable which is also likely to vary from day to day. The shunting resistor used with the condenser must be small in comparison to this leakage resistance, otherwise, the time scale will become erratic and the time constant will not be uniform. Since the leakage resistance is substantially inversely proportional to the size of the capacitance, it is evident that the maximum shunting resistor which should be only a definite fraction of the leakage resistance is also inversely proportional to the capacitance. Consequently, there is a practical limit to the value of RC in any physical embodiment which fixes the maximum obtainable time constant.

It is often desirable to obtain a larger time-constant than the maximum which the physical sizes of the components permit. In such cases the practice heretofore was to employ several time-delay networks, each including resistance and capacity and connect these successively in the circuit when the discharge time of one was very nearly reached. Generally, the use of resistance-capacity combinations involves also the use of vacuum tubes. Consequently, a time-delay device operating beyond the discharge time of one resistance-capacity unit necessitated several tubes and component parts which adds to the

physical size as well as to the cost of the equipment.

The salient feature of this invention is that the time-constant of a resistance and capacity network may be extended in effect for any length of time and a control of the apparatus effected when the desired time has elapsed.

Another feature of this invention is that a single delay network of a definite time-constant within practical limits may be utilized and automatically applied at any desired number of times, whereby the effective delay time may be extended to a predetermined multiple of the time-constant value of the delay network.

A particular advantage of the delay apparatus in accordance with this invention is that the delay network components, such as the condenser and the discharge resistor, may be so chosen that the latter represents a very small fraction of the inherent leakage resistance of the condenser. In this manner a stable and uniform discharge cycle can be obtained which, although inherently of comparatively short duration, is cumulative in effect so that the ultimate result can be extended to any desired length of time.

Other features and advantages will be apparent from the following description of the invention, pointed out in particularity by the appended claims and taken in connection with the accompanying drawing, in which the single figure illustrates diagrammatically a circuit of the electronic time-delay device in accordance with this invention.

The invention herein described comprises a circuit arrangement which includes a vacuum tube for the actuation of a relay which controls the switching-off or the switching-on of a load supplied from a power line. The delay in the operation of the relay is effected by means of a resistance capacity network which when the condenser is charged, biases the grid of the vacuum tube to such anode current value which is insufficient for the operation of the relay. The effective time-delay of this circuit is extended by repeated successive charges of the capacity, the charging being controlled by the anode current following the discharge of the capacity, and the number of instantaneous rechargings being determined by the movement of a sliding contact switch mechanism.

Referring to the drawing, a power supply line indicated by the conductors 1 and 2 is intended to supply a load when contacts 3 and 3' of the relay 4 are closed. The relay 4 is of the slow acting type being equipped with a retarding de-

vice in the form of a dash-pot 5. The main switch 6 in series with the line 1 controls the supply of power to the load as well as to the time-delay device about to be described. The latter consists of a vacuum tube 7 having anode 8, control electrode 9 and cathode 10. A voltage dividing network comprising resistors 11 and 12 connected in series across the line 1 and 2 provides operating voltages for the vacuum tube 7, the cathode 10 of which is connected to the junction point of resistors 11 and 12. The anode circuit between anode 8 and cathode 10 includes the energizing winding 13 of the relay 4 and the energizing winding 14 of an electromagnetic device 15. When the power line is an alternating current supply, as indicated here, the winding 13 as well as the winding 14 is shunted by condensers 29 and 29', respectively. The windings 13 and 14 are connected in series by means of contacts 17 and 17' which may be opened when the reset switch 55, to be described later, is depressed. The control circuit of the tube 7 includes between the grid 9 and cathode 10 the parallel combination of resistor 18 and condenser 19. A charging circuit for the condenser from the voltage appearing across the resistor 12 includes a rectifier 16 in series with a current conductive path formed by conductor 20, brush 21, collector ring 22, contact segment 23, and sliding contact 24 of the switch 25 and a connection by means of conductor 26, contacts 27 and 28 operated by the electromagnetic device 15 and conductor 30 to the grid 9.

The switch 25 is so constructed that the segment 23 mounted on an insulating disk 31 is driven by a shaft 32. The sliding contact 24 is affixed to a holder 33 which may be moved in the frame 35 along the segment 23 from the starting position in which it is shown to any desired position and secured there by the locking screw 34. The shaft 32 is displaced by means of a ratchet and pawl arrangement against the biasing force of a spring 40. The ratchet and pawl assembly comprises the ratchet wheel 41 affixed to the shaft 32, the ratchet 42 depressed by the spring 43 and carried by the lever 44, the latter being connected to the arm 45 of the electromagnetic device 15. A pawl 48 pivoted around the pin 46 engages the ratchet wheel 41. It may be lifted by means of the rod 50 connected to the plunger 51. The latter is actuated by means of the winding 52 energized from the supply line when the switch 55 is closed. The lifting of the pawl 48 permits the reverse rotation of the ratchet wheel 41 provided the lever 44 is in the position shown. The ratchet 42 is then out of engagement being lifted by the pin 45.

The circuit above described illustrates the example of an operative arrangement for an alternating current power line supply. When a direct current line feeds the load, the rectifier 16 may be omitted. It is understood, of course, that the polarity of the line must be taken into consideration and the positive side connected to the anode circuit. The heater for the cathode 10 is not shown inasmuch as the heater connection depends largely on the type of tube used. In certain tubes such as the RCA Type 117N6GT the heater may be connected directly across the 110-volt alternating current supply.

Considering the operation of the circuit, it is assumed that the system is at rest, as shown in the drawing, and a maximum time delay is desired. Consequently the sliding contact 24 is placed near the end of the holder 33 making

contact with the starting end of the segment 23. Conductors 20 and 26 are in this manner interconnected completing the current path from the source, that is, the resistor 12, to the grid 9 provided that the contacts 27 and 28 are also closed. The current flow in the charging circuit just mentioned is always in one direction because of the rectifier 16. The latter is so polarized that only the negative half cycles of the alternating current voltage will be impressed on the condenser 19.

In closing the main switch 6 the vacuum tube becomes energized, and since the condenser 19 is not charged, the grid 9 is effectively at cathode potential. This permits anode current to flow which will energize the windings 13 and 14. The energization of the winding 14 will cause actuation of the arm 45 prior to the actuation of the relay 4. The reason for this is that the relay 4 is of the slow acting type and must overcome the retardation of the dashpot 5. When the arm 45 is pulled down, the segment 23 is moved in the direction of the arrow one fraction of its length which is equivalent to the movement effected by one step of the ratchet wheel 41. At the same time the contacts 28 and 27 are closed, and the circuit is completed for the charging of the condenser 19 which is now effectively connected across the resistor 12. The condenser will charge practically instantaneously to the peak voltage of the negative half cycles of the alternating current flowing in the resistor 12. The latter is so proportioned that the voltage drop thereacross is of such magnitude as to effect anode current cutoff of the tube 7. At the instant of anode current cutoff, the arm 45 will be released, which, in turn, disconnects the condenser 19 from the charging circuit, so that it may discharge through the resistor 18. The aforesaid operation takes place in less time than required for the relay 4 to overcome entirely the retarding force of the dashpot 5 so that the circuit of the load is not completed as yet. The anode current again is of such low value that the force acting on the relay 4 is released so that it returns to its original starting position.

As stated before, the condenser 19 is free to discharge. The time of discharge will take place in accordance with the time-constant produced by the parallel combination of the condenser 19 and the resistor 18, represented by the product RC. When this time elapses the slowly rising plate current again reaches a value which actuates the arm 45. The segment is moved another step in the direction of the arrow, effecting again a recharge of the condenser 19, which, in turn, because of the bias on the grid 9, will release the arm 45. This operation will be repeated at intervals determined by the time-constant of the time delay network as many times as it is necessary for the ratchet wheel 41 to move the segment 23 past the sliding contact 24. When the position is reached that the sliding contact 24 is in contact with the insulating support 31, the circuit between conductors 20 and 26 is broken. The next discharge of the condenser 19 results again in the operation of the arm 45, closing the contacts 28 and 27. However, no recharge of the condenser 19 will be effected due to the open circuit position of the switch 25. The sustained plate current ultimately operates the relay 4 closing the contacts 3 and 3' and thereby completing the circuit to the load from the supply lines 1 and 2. The load will remain energized until the mechanism is reset. This is effected by

the closure of the switch 55, which, in closing the contacts 56 and 56' will energize the winding 52, lifting the pawl 48. At the same time the contacts 17 and 17' are opened, disrupting anode current flow in the windings 13 and 14. Since the winding 14 is deenergized, the arm 45 returns to the position which lifts the ratchet 42. The ratchet wheel 41 is now free to return propelled by the force exerted by the spring 40 to the starting position determined by the stop pin 31'. The switch 25 will now complete the contact between conductors 20 and 26 so that when the switch 55 is released, the movement of the arm 45, in closing contacts 27 and 28, will again recharge the condenser 19. The entire operating cycle will then be repeated. The delay-time may be adjusted at will by the replacement of the sliding contact 24 to the desired number of movements of the ratchet wheel 41 for the opening of the contact between conductors 20 and 26.

It is apparent that the effective time delay, will be a certain multiple of the time-constant of the network comprising resistor 18 and condenser 19, and may be expressed by the formula $nRC + RC$ in which n is the number of rechargings of the condenser 19 and RC the product of the capacitance value of the condenser and the ohmic value of the resistance.

What is claimed is:

1. In a time delay circuit for retarding the actuation of a relay, a vacuum tube having anode, cathode and control electrodes, a circuit between said anode and cathode including in series a source of anode potential, the energizing winding of said relay and the energizing winding of an electromagnetic device; said device comprising an actuating arm, a pair of contacts and a lever operable by said arm, a second pair of contacts in series with said first pair comprising a conductive segment and a slidable member adapted to be positioned at various distances over said segment, means for moving said segment from a certain starting position upon each actuation of said lever for a fractional portion of its peripheral length whereby said last-mentioned contacts may be held in physical engagement for repeated actuation of said lever depending upon the displacement of said sliding contact with respect to the length of said segment and said starting position, a resistance and a capacity connected in parallel between control electrode and cathode of said tube, a voltage source for applying a potential to said control electrode which is negative with respect to said cathode, thereby charging said condenser, a charging circuit including said two pairs of contacts in series whereby, upon actuation of said electromagnetic device due to anode current, said first pair of contacts complete said charging circuit to said condenser, said tube being so biased thereby as to release said device until repeated actuation thereof following each discharge-time of said condenser displaces said second pair of contacts to an open position, said relay being operatively energized upon anode current flow maintained in said tube when said sliding contacts are disengaged.

2. A time delay circuit in accordance with claim 1 characterized in that means are provided for retarding the acting time of said relay in comparison with the acting time of said electromagnetic device.

3. A time delay circuit in accordance with claim 1, wherein said means for moving said segment comprises a ratchet affixed to said lever, a shaft carried at one end, said segment mounted on an insulating support, and at the other end a ratchet wheel cooperating with said ratchet, a stop mechanism therefor comprising a pawl, spring means biasing said shaft upon rotation by said lever for resetting said shaft when said pawl is disengaged, means for disengaging said pawl, and stop means engaging said support upon resetting to said starting position.

4. A time delay circuit in accordance with claim 1 wherein said source of anode potential is derived from a portion of a voltage dividing resistor connected across an alternating current supply line, and said charging potential source includes another portion of said resistor and a rectifier, said cathode being connected to an intermediate point of said voltage divider and the energizing winding of said relay and the winding of said electromagnetic device being each shunted by a capacity.

5. In an electrical time delay circuit, a current source, a load device energized therefrom, switching means for controlling the energization of said device from said source, means for actuating said switching means comprising a capacitor, a first and a second circuit-interrupter, a source of voltage connected to charge said capacitor only when said circuit interrupters are closed, means for discharging said capacitor at a predetermined rate, means maintaining said first circuit interrupter normally open but actuating it to closed position when the charge on said capacitor falls below a predetermined value, means for maintaining said second circuit interrupter normally closed but for moving it to open position after a predetermined number of actuations of said first circuit interrupter to open position, and means for actuating said switching means only after the opening of said second circuit interrupter.

6. In an electrical circuit, a capacitor, a first and a second circuit interrupter, a source of voltage connected to charge said capacitor only when said circuit interrupters are closed, means for discharging said capacitor at a predetermined rate, means maintaining said first circuit interrupter normally open but actuating it to closed position when the charge on said capacitor falls below a predetermined value, and means for maintaining said second circuit interrupter normally closed but for moving it to open position after a predetermined number of actuations of said first circuit interrupter to open position.

7. In an electrical circuit, a capacitor, a first and a second circuit interrupter, a source of voltage connected to charge said capacitor only when said circuit interrupters are closed, means for discharging said capacitor at a predetermined rate, an electrical discharge device having a pair of principal electrodes and a control electrode, means for maintaining said first circuit interrupter closed when current flows between said principal electrodes and open at other times, means for impressing the voltage of said capacitor on said control electrode, and means for maintaining said second circuit interrupter normally closed, but for moving it to open position after a predetermined number of actuations of said first circuit breaker to open position.

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