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ELECTRONIC CONTROLLED RELAY

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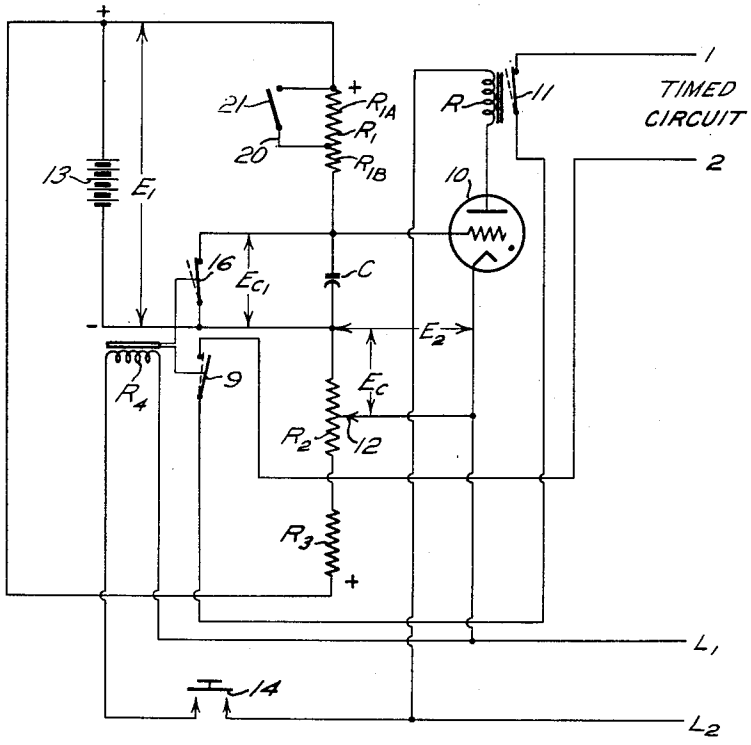


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## ELECTRONIC CONTROLLED RELAY

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3 Claims. (Cl. 175—320)

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This invention relates to electronic controlled relays.

Electronic timers of various sorts have been constructed in the past, but so far as known all have been subject to certain irregularities and inaccuracies because of variations in the timed interval arising from the fact that they have been responsive to fluctuations in the line voltage supplying the timer. It is well known that the commercial power transmissions supplying conventional 110 A.-C. are subject to more or less slight deviations in voltage, and when this is used as the actuating and charging source of an electronic timing system, as is more or less conventional, it introduces fluctuations in the timed interval, preventing such timers from functioning as truly precision instruments.

It is among the objects of this invention; to provide an electronic timer of exactness and never-failing precision capable of controlling electrical circuits in accurate increments down to 0.01 second or smaller; to provide an electronic timer which is independent in its determination of the timed interval of any fluctuations that may occur in the A.-C. line voltage supplying the circuit; to provide an electronic timer utilizing a variable bias on a tube derived from a common D.-C. source which also charges the timing condenser of the system to actuate the grid of such tube to overcome the bias and fire the tube; to provide a D.-C. source of the order of approximately 250 v. or higher, as both the charging source for the condenser of a timing circuit as well as for providing predeterminedly variable negative grid bias to the tube so that the same common source of voltage is used to control the firing of the tube to mark the termination of a timed interval, and which because of the relatively high voltage of the common D.-C. source charges in the relatively linear portion of the charging curve so that the values of each increment of charging for each increment of time is substantially the same throughout the charging range; to provide an electronic timer circuit in which both the grid bias and the voltage charging the condenser are from a common source of D.-C. derived from rectified A.-C. voltage so that fluctuations in the A.-C. voltage and thus in the rectified D.-C. voltage make no difference in the timing derived from the circuit; and to provide other objects and advantages as will become more apparent as the description proceeds.

The drawing illustrates a diagram of the preferred embodiment of the timer system of the invention.

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In constructing the circuit of the timer system, it is preferred but of course not essential to use a gas filled tube 10, such, illustratively, as the "Thyratron" tube 2050, 2D21, or GL502A, the plate voltage of which passes through a relay R to control the load or the timed event by a switch 11 in the load circuit, and to one side, $L_2$ of the supply line. The other side of the supply line $L_1$ passes to the cathode of the tube and to the wiping arm 12 of the voltage divider potentiometer $R_2$. As the potentiometer is, so to speak, the heart of the timer system, it should be of good quality within one-half of one percent of linearity, with good temperature stability, in order to make a printed dial calibration possible for the instrument. The line voltage of $L_1$—$L_2$ is nominally 110 A.-C. and may fluctuate as a maxium as much as from 105 v. to 125 v. As will appear, this has nothing to do with the timing functions, and therefore is substantially immaterial.

A D.-C. source, such as the battery 13, but which is preferably supplied by a rectifier fed by the A.-C. line, supplying a voltage $E_1$ preferably of the order of 250 v.–300 v., is connected from the positive side through a resistance $R_1$ to the grid of the tube 10 and also to the positive charging side of the capacitor C. The negative of the D.-C. source leads directly to the negative side of the charging condenser C. A shunt circuit across the capacitor is provided, running from the negative side of the common D.-C. source 13, controlled by the normally closed switch 16 to the plus side of the D.-C. source below the resistor R1. Switch 16 is effective when opened to start or initiate the beginning of the timed interval. The positive side of the D.-C. source is also led through a resistor $R_3$ and through the potentiometer 12, to the negative side of the charging condenser C. To facilitate easy switching from a time range of $x$ seconds to a feasible subdivision thereof, say $x/10$ seconds, to a far greater accuracy of a timer range, it is preferred to provide resistance $R_1$, having a total value of say, 2.2 megohms, as two resistors in series, of which one, $R_{1A}$, illustratively, is of 2 megohms and the other, $R_{1B}$, is of 0.2 megohm, with means 20 for shunting out the 2 megohm resistor. Thus, with both resistors in series in the circuit, while with the 2 megohm resistor shunted out by any suitable switch 21 in shunt 20, the timing range available from the full range of the potentiometer is reduced from $x$ seconds to $x/10$ seconds, with the same range on the dial of the potentiometer for the positions of the potentiometer control

arm. This simplifies the construction and enables the two ranges to be placed in proper calibrated relation on a single dial coordinated with the potentiometer range.

A load circuit is established by lines 1 and 2, of which line 1 leads to the normally closed or open switch 11, moved to the open or closed position respectively by the relay R when the latter is energized upon the firing of the tube 10, and beyond switch 11 to a normally open switch 9, the other side of which leads to the return load line 2. As the actuation of switch 11 marks the end of the timed interval, this is utilized either to open or close the load circuit, depending upon the nature of the control action desired.

The line $L_1$, in addition to supplying the cathode of the tube, runs to a relay $R_4$ and the return line to $L_2$ is interrupted by the push button or other switch switch 14. Relay $R_4$, upon actuation by closing of the switch 14, simultaneously moves switch 16 from its normally closed position to open the shunt about the condenser C, to start the charging of the condenser as the start of the timed interval, and also preferably moves switch 9 from its normally open position to a closed position and closes the work or load circuit 2, at least as far as switch 11. It will be understood that switch 9 can be normally closed, and moved to open when the relay $R_4$ is energized, so as to interrupt an established load circuit for the timed interval. In this case switches 9 and 11 will be in parallel in the work circuit in place of the series arrangement shown. The only question is as to whether it is desired to establish and maintain a work circuit for the desired timed interval only or to interrupt an established work circuit for the timed interval only. In the first case switch 11 will be normally closed and will be pulled open at the end of the timed interval, after the work circuit has been established and at the beginning of the timed interval by the additional closing of the switch 9. In the second case switches 11 and 9 will be in parallel and switch 9 will be normally closed and switch 11 normally open.

In operation the D.-C. source 13 places a negative grid bias on the tube 10 variable according to the setting of the potentiometer $R_2$. The opening of switch 16 can be made independent of any synchronous actuation of the load circuit, if this is desired, and can be secured in any desired manner, as by the push button 14 in the line $L_1$—$L_2$, without any collateral action of any other switch. It is preferred, of course, to control the load circuit simultaneously. Opening of the switch 16 removes the shunt and the condenser starts to charge as the inception of the time interval. This charging is from the same common D.-C. source 13 that establishes the negative grid bias on the tube. The charging of the condenser C is continued at a fairly even and constant rate, due to the relatively high voltage of the charging source, until the positive voltage $EC_1$ reaches a value nearly equal to the negative grid bias $E_2$, when the tube "fires" and pulls in the relay R, moving switch 11 to the desired position to control the load circuit. In the diagram shown it moves the switch to the open position, terminating the load circuit at the end of the timed interval.

The condenser C charges at a rate in accordance with the formula:

$$q=Q\left(1-\frac{t}{\epsilon R_1 C_1}\right)$$

where

$q$ is the instantaneous charge on condenser $C_1$ in coulombs

Q is the final, or maximum, charge on $C_1$ in coulombs

$\epsilon$ is 2.718

$t$ is the time C has been charging in seconds

$C_1$ is the capacity of the timing condenser in farads

$R_1$ is the resistance of the timing resistor in ohms

When the switch 14 is released, the relay $R_4$ is deenergized the switch 16 returns to its normally closed position, in the diagram shown, shunting out the condenser circuit, re-establishing the tube bias and simultaneously opening switch 9, and opening the load circuit. Tube 10 is cut off and the relay R will be deenergized dropping out switch 11, which returns to its normally closed position.

It is an important feature of the invention that while the circuit is timing, the tube is dormant and there is no flow of current to timing condenser C, except through its companion resistor $R_1$. This insures that the timing rate of C cannot be affected by variations in tube emission. As the firing of the tube is dependent upon $E_2$ substantially equalling $EC_1$, which is unaffected by any fluctuations or variations of $E_1$, the timing circuit is independent of the supply voltage. While the firing point of the tube 10 is, of course, dependent upon the A.-C. line voltage, but within the limits previously mentioned, i. e. 105 v. to 125 v., the grid potential required to fire tube 10 will only vary approximately 0.25 volt (determined from typical characteristic curves for the tube 10), and since sufficient provision has been made for circuit sensitivity to cover a one volt fluctuation in grid voltage requirements, this effect is negligible. It is recognized that lowering the supply voltage lowers the sensitivity, and, conversely, raising it increases sensitivity, but this factor is not too critical, since a sensitivity variation of as much as 17.4% would not be undesirable.

It will be seen that by having the biasing voltage on the tube from the same D.-C. source as the charging voltage on the condenser effective to fire the tube, that a common source establishes the balance and unbalance of the tube, in which the tube voltage has no part. Therefore, any fluctuation in voltage from the power line in the case where $E_1$ is rectified voltage, is equal on both the condenser and the grid bias and therefore has no effect on the timing of the instrument. Moreover, by having an appreciable voltage on the D.-C. source 13, of the order of approximately 250 v. as stated, the charging is on the linear portion of the curve so as to make the charging rate of the condenser at a substantially uniform rate, independent of the actuating A.-C. source voltage.

The accuracy and dependability of the system will be evident.

The details of construction and the mode of applying the instruments to dial control are explained in detail in a paper written by applicant, printed in "The Instrument Maker" for May–June 1946, to which reference can be made for details not fully developed herein.

Having thus described my invention I claim:

1. An electronic timer system comprising a load circuit, a plurality of switches in the load circuit, a multi-element tube, an A.-C. source connected to the cathode and anode of the tube

as the tube output when the latter is fired, a relay in the tube output operatively associated with one of said switches to control the load circuit, a common source of D.-C. voltage, a D.-C. circuit including a chargeable condenser, a potentiometer, a resistor, a resistance and the cathode and grid of the tube, said resistance in the line from the positive side of the common source to the positive side of the condenser, said condenser being connected on the negative side to the negative pole of said common source and to the positive pole of said common source through said resistor and potentiometer in series, a shunt line containing a shunt switch and connecting the negative pole of said D.-C. source and the positive side of the condenser for shorting out the condenser, a second relay, switch means for energizing said second relay from the A. C. source, said second relay controlling one of said load switches and said shunt switch, said D.-C. circuit applying a negative bias to the grid of the tube from the common D.-C. source variable as a function of potentiometer setting, operation of said switch means energizing the said second relay to synchronously operate both switches controlled thereby to open the shunt circuit and start charging the condenser from the common D.-C. source, and to establish a predetermined condition in the load circuit, and connections from the A.-C. source through the potentiometer arm, the potentiometer, and the condenser to the grid of the tube, whereby the firing of the tube is a function of time after the starting of charging of the condenser by the common D.-C. source after actuation of the second relay has opened the shunt line and actuated the switch it controls in the load circuit until the condenser charge substantially equals the negative bias imposed by the same common D.-C. source, which time function continues until the tube fires and actuates the first mentioned relay to operate the switch associated thereby to modify the load circuit to mark a termination of the timed interval.

2. A timing system comprising a tube including an anode, cathode and grid, leads for an A.-C. source to the cathode and anode of the tube to



provide the tube output, a network comprising a first resistance, a condenser, a potentiometer and a second resistance in a series, leads for a D.-C. source, connections from the positive side of said D.-C. leads respectively to the series spaced ends of the respective first and second resistances, a connection from the negative side of said D.-C. source to said series between an end of the potentiometer, and the negative side of the condenser, a connection from said series between the other end of the first resistance and the positive side of said condenser to said grid, a connection from one of the A.-C. leads to the movable arm of the potentiometer, a shunt circuit from the negative lead of the D.-C. source to said series between the said other end of the first resistance and the positive side of said condenser, and circuit controller means in the shunt line which when open starts the D. C. timing charging of the condenser terminated by its attainment of a charge substantially equaling the negative grid bias imposed on the tube from the D.-C. leads by the setting of the potentiometer arm manifested by conductivity of the tube.

3. A timing system as recited in claim 2, further characterized by a shunt in said first resistance and a circuit controller in said shunt for selectively changing the effective range of timing from said system by a predetermined ratio.

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