

July 18, 1950

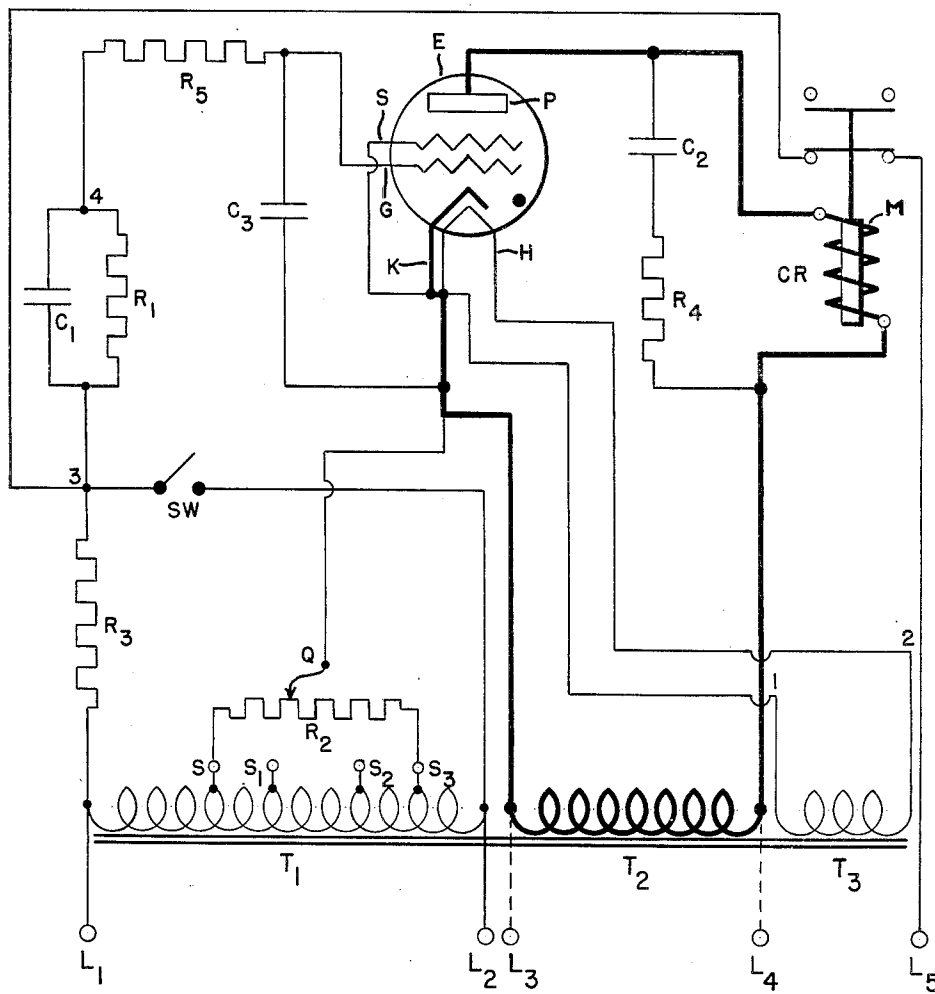
B. F. TELLKAMP
ELECTRONIC TIMER

2,515,477

Filed Nov. 9, 1946

2 Sheets-Sheet 1

FIG. 1.



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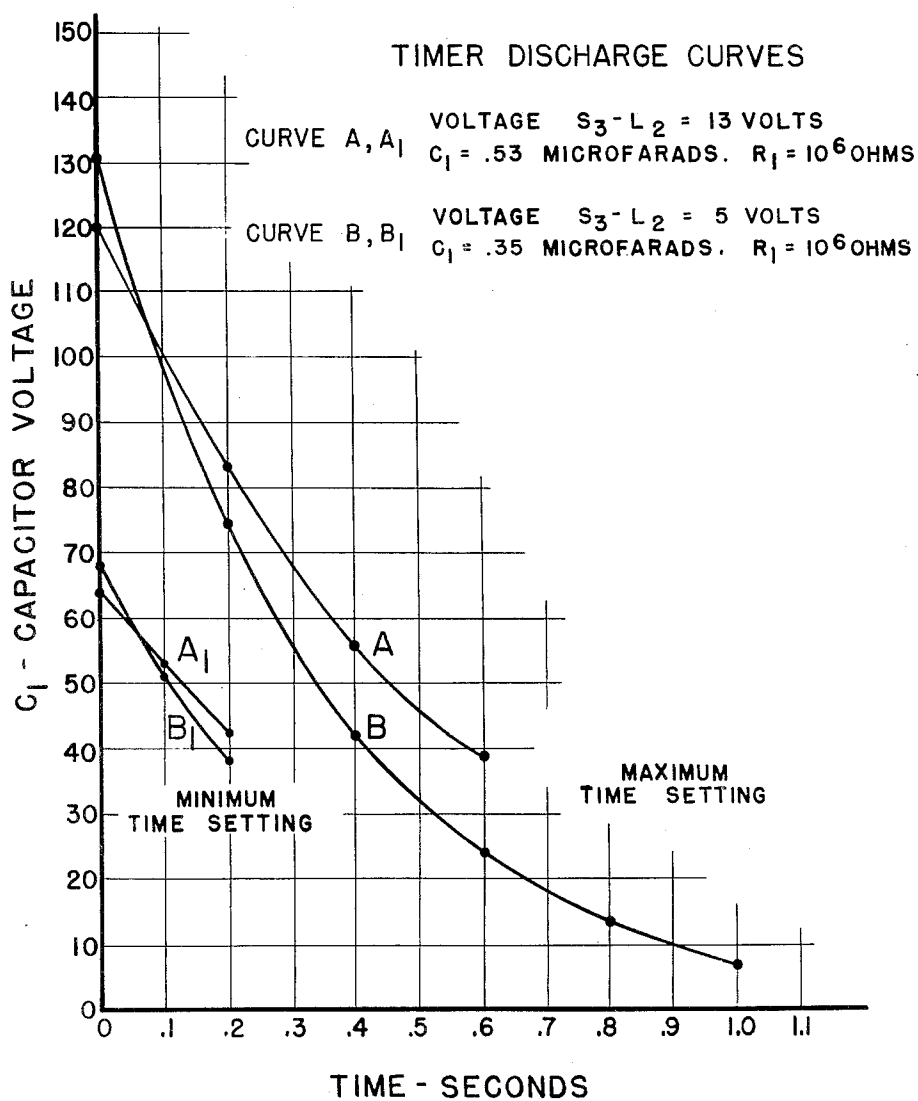
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FIG. 2.



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ELECTRONIC TIMER

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Application November 9, 1946, Serial No. 709,016

7 Claims. (Cl. 250—27)

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This invention relates to improvements in electronic timing devices, and in particular to electronic timing devices in which the time setting is adjustable over a range of values, or in which predetermined time intervals are obtained without the necessity of accurately matched resistance values. It is in the field of the developments contained in the pending application, Serial No. 567,721 of Lynn H. Matthias filed December 11, 1944. Both applications are assigned to the Allen-Bradley Company.

One object of my invention is an electrical timing circuit which as made in commercial production will be uniform in performance.

Another object of my invention is an electrical timing circuit that will maintain its timing range regardless of normal changes in electron tubes; variations in one tube to another; or of changes in values of adjusting resistors.

A further object of my invention is the provision of a circuit employing a variable charging voltage for the timing capacitor, and also a variable bucking voltage to which it is discharged. This feature, when used in conjunction with various appropriate values of the timing capacitor and its associated discharge resistor, allows the use of various shapes of discharge curve for the same time range, and consequently the selection of the optimum shape of discharge curve to minimize the effect of line voltage changes, and changes in the characteristic curves of the electron tubes used in the circuit.

A further object of my invention is the use of the maximum voltage capabilities of the grid circuit of the electron tube employed and at the same time providing the maximum timing range.

Timing circuits utilizing the discharge time of a capacitor shunted by a resistor are well known in the art, however, these devices as presently made require the accurate matching of resistance values of a number of resistors to maintain their calibration and small changes in these resistance values or of the tube characteristics make large changes in the timing.

The negative grid voltages developed in present timing circuits are so high as to limit the timing capacitor voltage to a low value requiring large timing capacitors, particularly when used with gas filled Thyatron tubes.

It is desirable that an electronic timing circuit be simple and inexpensive to manufacture and that the resulting devices be uniform and permanent in their operating characteristics.

My invention fulfills these requirements and the accompanying diagrams and description illus-

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trate the manner of obtaining the above desirable characteristics, in which Fig. 1 is a circuit diagram of my invention in which Fig. 2 are time curves showing results obtainable in my invention.

In the circuit arrangement in Fig. 1 the electronic tube is represented by E, its anode by P, its control grid by G, and its cathode by K. The cathode is heated by heater H, and an auxiliary grid S is connected to the cathode in this instance. This tube may be of the type commonly known as a Thyatron tube, particularly the gas filled type.

The work circuit illustrated in heavy lines consists of the cathode K, transformer winding T₂, the magnet coil M of relay CR and the anode P.

Variation in the control potential on the grid G prevents or allows completion of the work circuit thus operating the relay CR. Condenser C₂ and resistor R₄ which are connected in shunt with magnet coil M stabilize the operation of relay CR on the rectified half wave current.

The control and timing portion of this circuit consists of grid G, resistor R₅, the timing network C₁R₁, transfer resistor R₃, transformer winding T₁, the voltage dividing potentiometer R₂ and cathode K. The purpose of transfer resistor R₃ is to change the connection of point 3 from L₁ to L₂ by the closing of the single pole single throw switch SW. The switch SW changes from the reset or charging condition when open to the timing condition when closed. Potentiometer R₂ adjusts the length of the timing interval. The cathode heater H is connected to transformer winding T₃ as shown. Transformer windings T₁, T₂ and T₃ are on the same core and arranged to make the grid negative when the anode is positive. Terminals L₁ and L₂ are used to connect the timing relay to a power supply source such as 115 volts, 60 cycle alternating current. Capacitor C₃ connected as shown bypasses high frequency surges and resistor R₅ limits the grid current when capacitor C₁ is being charged.

Alternatively the transformer winding T₂ may be used as the primary and connected by leads L₃ and L₄ to a different voltage power source as 230 volts, making the device useful on either of two voltages without added windings.

In one method of operation the transformer primary T₁ is connected to a source of power through connections L₁ and L₂ as shown. The heater H which is connected to transformer winding T₃ heats the cathode K to operating temperature. With the switch SW in the open position current flows from winding T₁ through re-

sistance R_3 when connection L_1 is positive, and continues by way of capacitor C_1 and resistance R_5 to grid G , cathode K and adjustable connection Q to a point effectively near the opposite end of winding T_1 . Electron flow is in the reverse direction around this circuit and the voltage is thereby built up across condenser C_1 making the grid more negative. During the grid-positive part of each succeeding cycle this voltage increases until the voltage across the capacitor C_1 is nearly equal to the crest of the positive half cycle. The resistor R_1 conducts a small amount of current from point 3 to point 4, namely, the connections at opposite sides of resistor R_1 , slightly lowering the capacitor voltage during the grid-negative half cycle. This loss is made up on each grid-positive half cycle, and the small voltage drop of the tube E and the circuit resistance while conducting the current discharged through resistor R_1 is the difference between the crest voltage and the voltage across capacitor C_1 . During this charging period the anode is negative when the grid is positive and no current flows through magnet coil M . When the anode is positive the grid is negative and blocks the flow of current through magnet coil M and relay CR remains in the non-operated position.

To start a timing interval the switch SW is closed connecting point 3 to terminal L_2 . The alternating voltage from connection Q to L_2 is thus placed in series with the direct voltage stored in the capacitor C_1 and when L_2 is negative with respect to Q , adds to the negative voltage on the number 4 terminal of the capacitor. At this time the anode is negative and no current flows through magnet coil M . When L_2 is positive with respect to Q the voltage from Q to L_2 opposes the voltage across capacitor C_1 and after the voltage across C_1 has been reduced by the continued discharge through resistance R_1 the net voltage on the grid is reduced to a value too low to block the flow of current in the anode circuit, the timed interval ends and the relay CR is operated by flow of current through magnet coil M . On succeeding cycles current flows in the anode circuit each time the anode is positive and the relay CR remains operated as long as the switch SW is closed. When it is desired to energize a load during the timing interval and disconnect it at the end of the timing interval the load is connected from L_1 across the contacts of the relay to terminal L_5 .

Thus the load is energized through a normally closed contact on CR and the switch SW during the time interval between the closing of SW and the operation of CR . This time interval is adjusted by changing the position of tap Q on resistor R_2 . Moving the tap Q toward S reduces the timing interval by lowering the voltage to which the capacitor C_1 is charged and simultaneously increasing the bucking voltage from Q to L_2 to which the capacitor C_1 discharges. When the bucking and charging voltages are made substantially equal the grid G is at the critical voltage immediately when SW is closed, anode current flows, and the time interval is only that required for the relay CR to close, on the order of a few one hundredths of a second.

At this minimum setting the bucking and charging voltage crests are each approximately equal to half the voltage crest from L_1 to L_2 and on the half cycle when L_2 is negative with respect to Q with SW closed at the start of the timing interval the maximum negative grid voltage is equal to the sum of these bucking and

charging voltage crests or on the order of $115 \times \sqrt{2} = 163$ volts for 115 volts from L_1 to L_2 .

In circuits where the charging voltage is not reduced for short time intervals the bucking voltage must be increased to equal the full charging voltage to obtain minimum timing and this results in the sum of the charging and bucking voltages being on the order of $2 \times 115 \times \sqrt{2} = 326$ volts negative on the grid of the tube E . This exceeds the allowable negative grid voltage on desirable types of gas filled Thyratrons, hence the charging voltage must be lowered and capacitor C_1 increased in capacity to maintain the same timing range with increased cost and bulk.

Moving the tap Q toward S_3 increases the timing interval by raising the voltage to which the capacitor C_1 is charged and simultaneously decreasing the bucking voltage from Q to L_2 to which it discharges. With Q set at S_3 the maximum time interval is obtained, and since the voltage of S_3 to L_2 is fixed by the transformer and does not depend upon possible changes in a resistor voltage divider it may be set at a value most desirable from the standpoint of accuracy under fluctuating line voltage conditions, and changes in tube critical grid voltage, and it will maintain this value. In Fig. 2 is shown the effect of two different values of voltage S_3 to L_2 on the shape of the discharge curve of timing capacitor C_1 .

Taps S , S_1 , S_2 and S_3 may be connected to Q by a multi-position switch thus eliminating the potentiometer.

In a particular assembly of parts the following values were used; and the timing range and typical voltages are listed.

$R_1 = 1,650,000$ ohms
 $C_1 = .25$ microfarad
 $R_5 = 2000$ ohms
 $R_3 = 5000$ ohms
 $R_4 = 200$ ohms
 $C_2 = 8$ microfarads
 $C_3 = .01$ microfarad
 $R_2 = 6850$ ohms

Electron tube type 502 Thyatron

Voltage of T_1 winding, SW closed, 115 volts
 R. M. S.

Voltage of T_2 winding, SW closed, 154 volts
 R. M. S.

Voltage of T_3 winding, SW closed, 6.1 volts
 R. M. S.

Voltage S_3 to L_2 winding, SW closed, 4.5 volts
 R. M. S.

Voltage across magnet winding M , SW closed, 111 volts avg.

Minimum time setting .035 second Q at S , C_1 charges to 69 volts, discharges to 61 volts

Maximum time setting 1.07 seconds Q at S_3 , C_1 charges to 132 volts, discharges to 6 volts

Supply voltage 115 volts, L_1 to L_2

The exact components described and the particular circuit shown are one embodiment of my invention and not to be considered as the only means of obtaining its advantages. With appropriate circuit constants vacuum type electronic tubes may be used as well as the Thyatron type used in the foregoing illustrative case.

What I claim as my invention is as follows:

1. In an apparatus for producing a time delay, having an electron tube with anode, cathode and grid; a current responsive device and a power source connected in series with said anode and cathode; a capacitor bridged by a resistor with

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one terminal of the capacitor connected to said grid; the other terminal of the capacitor connected through a resistance to a second power source phased to make the grid of said tube negative when its anode is positive; a switch arranged to connect said second terminal of the capacitor to the other terminal of said second power source when closed; in combination therewith a potential divider connected to said second source of power with its adjustable contact connected to said cathode.

2. In an apparatus for producing a time delay, having an electron tube with anode, cathode and grid; a current responsive device and a transformer winding connected in series with said anode and cathode; a capacitor bridged by a resistor with one terminal of the capacitor connected to said grid; a second transformer winding connected to the second terminal of said capacitor and phased to make the grid of said tube negative when its anode is positive; a switch arranged to connect a transfer resistor across said second transformer winding; in combination therewith a potential divider connected across said second transformer winding and having its adjustable contact connected to said cathode, and means including said switch to charge said capacitor to a predetermined voltage when said switch is open and discharge said capacitor to a second predetermined voltage when said switch is closed to effect operation of the current responsive device.

3. In an apparatus for producing a time delay, having an electron tube with anode, cathode and grid; a current responsive device and a transformer winding connected in series with said anode and cathode; a capacitor bridged by a resistor with one terminal of the capacitor connected to said grid; the second terminal of the capacitor connected through a resistance to a second transformer winding phased to make the grid of said tube negative when its anode is positive; a switch arranged to connect said second terminal of the capacitor to the other terminal of said second transformer winding when closed; in combination therewith a potential divider connected to said second transformer winding with its adjustable contact connected to said cathode.

4. In an apparatus for producing a time delay, having an electron tube with anode, cathode and grid; a current responsive device and a power source connected in series with said anode and cathode; a capacitor bridged by a resistor with one terminal of the capacitor connected to said grid; a second power source connected through a transfer resistor to the second terminal of said capacitor and phased to make the grid of said tube negative when its anode is positive; a switch arranged to connect said transfer resistor across said second power source; in combination therewith a potential divider with its ends connected to said second power source and its movable contact connected to said cathode, and means including said switch and transfer resistor for connecting the said second terminal of said capacitor to one end of said second power source when said switch is open and to the other end of said second power source when said switch is closed.

5. In an apparatus for producing a time delay, having an electron tube with anode, cathode and grid; a current responsive device and a power source connected in series with said anode and

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cathode; a capacitor bridged by a resistor with one terminal of the capacitor connected to said grid; a second power source connected through a transfer resistor to the second terminal of said capacitor and phased to make the grid of said tube negative when its anode is positive; a switch arranged to connect said transfer resistor across said second power source; in combination therewith a potential divider with its ends connected to said second power source and its movable contact connected to said cathode and means including said switch and transfer resistor for charging said capacitor to an adjustable fraction of the supply voltage crest when the switch is open and allowing the capacitor to discharge to the remaining fraction of the supply voltage crest when the switch is closed, to effect operation of the current responsive device.

6. In an apparatus for producing a time delay, having an electron tube with anode, cathode and grid; a current responsive device and a power source connected in series with said anode and cathode; a capacitor bridged by a resistor with one terminal of the capacitor connected to said grid; a second power source connected through a transfer resistor to the second terminal of said capacitor and phased to make the grid of said tube negative when its anode is positive; a switch arranged to connect said transfer resistor across said second power source; in combination therewith a potential divider having its ends connected to said second source of power and its movable contact connected to said cathode; and means including said switch and transfer resistor for connecting the second terminal of said capacitor to one end of said second power source to charge the capacitor when said switch is open and allow the capacitor to discharge when said switch is closed to effect operation of the current responsive device.

7. In an apparatus for producing a time delay, having an electron tube with anode, cathode and grid; a current responsive device and a power source connected in series with said anode and cathode; a capacitor bridged by a resistor with one terminal of the capacitor connected to said grid; a second power source connected through a transfer resistor to the second terminal of said capacitor and phased to make the grid of said tube negative when its anode is positive; a switch arranged to connect said transfer resistor across said second power source; in combination therewith a potential divider connected across said second source of power and having its adjustable contact connected to said cathode, and means including said switch to charge said capacitor to a predetermined voltage when said switch is open and discharge said capacitor to a second predetermined voltage when said switch is closed to effect operation of the current responsive device.

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