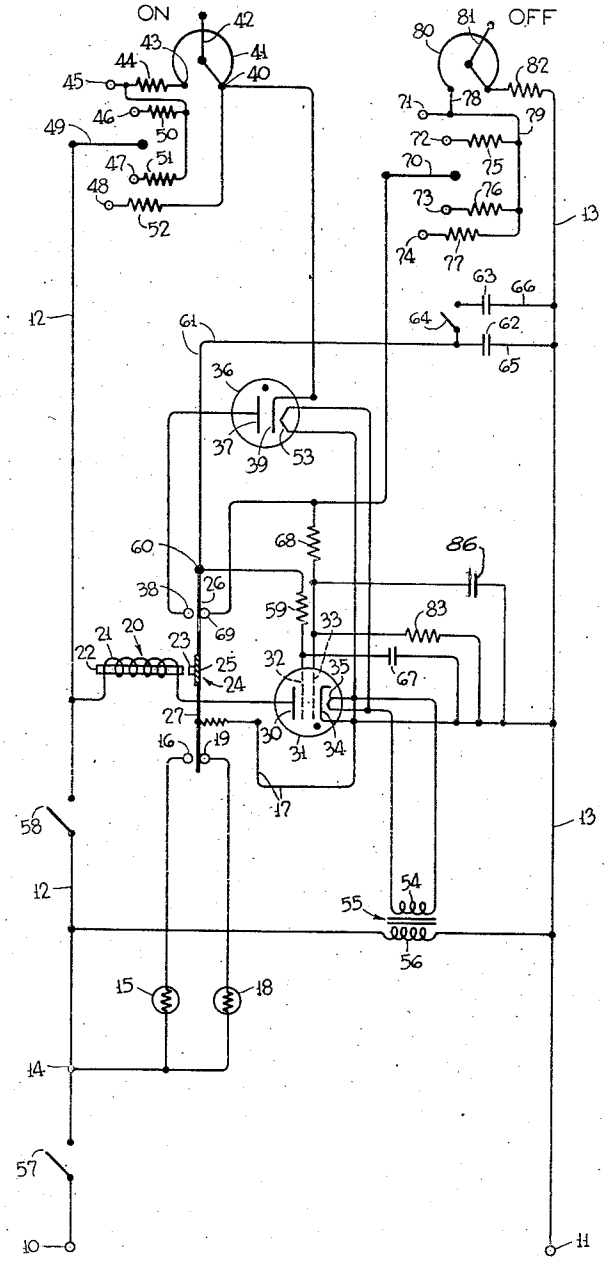
Oct. 15, 1946. E. M. CALLENDER 2,409,473

ELECTRONIC TIMING DEVICE

Filed Jan. 4, 1944



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Patented Oct. 15, 1946

2,409,473

UNITED STATES PATENT OFFICE

2,409,473

ELECTRONIC TIMING DEVICE

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Application January 4, 1944, Serial No. 516,928

11 Claims. (Cl. 171—97)

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This invention relates to an electronic timing device of the type having adaption for indicating a repeated cycle of operation.

In many industrial operations and in the utilization of various equipment in the arts, such as photographic apparatus, it is frequently desirable that the apparatus function intermittently at a uniform time interval with a uniform maintenance of effectiveness at each interval. For example, in aircraft photography where it is desirable to secure landscape photographs at definite time intervals there being a predetermined length of exposure at each interval, apparatus of the above-described type is essential.

It is one of the important objects of the invention to provide a timing device of the electronic type which functions with complete uniformity as to time for length of actual interval and for time period between intervals, provided a constant source of voltage is impressed on the unit. Another important object of the invention is to provide apparatus of the type mentioned in which adjustability to "on" or "off" position may separately be accomplished and with a close degree of gradation of time.

In the following specification there is described apparatus which may be preferred for accomplishing the objects hereinabove mentioned, the elements of the circuit being diagrammatically indicated in the accompanying drawing. With special reference to the drawing I have indicated terminals 10 and 11 which are adapted for connection to a source of alternating current. Connected to these terminals are the conductors 12 and 13 hereinafter referred to as "mains" or "lines" between which the timing apparatus is connected. Two load circuits, referred to in the claims as first and second loads, are indicated in the diagram, one from the point 14 through load 15, relay contact 16, relay arm 27 and conductor 17 to the opposite main 13, and the other circuit from point 14 to load 18 through relay contact 19, arm 27, to circuit 17 and power main 13. Each of these loads may consist of an indicating element such as a lamp which when the current flows therethrough is energized.

The relay 20 for making effective current flow through the contacts 16 and 19 of the load circuits comprises a coil 21 having a magnet core 22 and movable armature 23 fixed to a contact member 24 including a central insulation block 25 and spaced contact plates 26 and 27 extending on either side from the insulation block 25 and pivoted at point 60. The arm 27 is positioned between the contacts 16 and 19 of the load circuit,

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and, in the de-energized position of the relay, rests on the lower contact 19 by gravity, or equivalent means thus completing the circuit through the load 18. When, however, the relay is energized, the arm 27 moves upwardly and engages the upper contact 16 thereupon breaking the circuit through 18 and closing it through the load 16. In the description that follows, load 18 is referred to as an "off" load and load 15 as an "on" load, visualize a lamp as load 15 and a non-luminous resistor as load 18.

The lower end of the coil 20 is extended downwardly and connected with the anode 30 of a grid-controlled-gaseous-discharge tube, otherwise known as a thyratron. This tube encloses a shield grid 32 and control grid 33, an indirectly heated cathode 34 and a heater filament 35. The main 13 is directly connected to the cathode of this tube.

As is well known, a tube of the mentioned type passes current only in one direction, namely, from the anode to the cathode and the starting of this current flow when the appropriate voltage exists between the tube elements is controlled by the various grids of the tube, a negative potential on the control and shield grid of sufficient value preventing the flow of current between the anode and cathode and a decrease of this negative potential on the other hand to a point approaching zero permitting the current to again flow between the tube elements. In the operation of the circuit a zero or slightly negative potential on the grids 32 and 33 with a line potential of 110 or more volts on the mains permits current flow through the relay circuit and thyratron 31.

The gas filled diode tube 36 is associated with the thyratron 31 in perfecting the time control of the apparatus. The anode 37 of the diode is connected to the upper contact 38 associated with the armature plate 26 of the relay and is normally disconnected therefrom as shown. The cathode 39 of the diode is extended from the tube to one end 40 of the variable resistor 41 having a slidable contact 42 for obtaining a fine gradation of resistance and variation. Connected to the other terminal 43 of the variable resistor is a fixed resistor 44 having a resistor terminal 45, one of a bank of resistor terminals 45, 46, 47 and 48, each of which may be connected to the power main 12 by means of a movable contact arm 49. Terminal 46 is connected through fixed resistor 50 and terminal 47 through fixed resistor 51 in parallel to the terminal 45. The terminal 48 is connected through a fixed resistor 52 to one end 40 of the variable resistor 41. The values of these

resistors are adjusted so as to give a broad variation in total resistance between the diode cathode 39 and the power main 12. For example, in the specific circuit described, to give excellent results the values of the resistor 41 should be .5 megohm, resistor 44, 15 thousand ohms, resistor 50, $\frac{5}{10}$ megohm, resistor 51, 3 megohms and resistor 52, 10 megohms. All of these resistors, it is pointed out are included in the "on" load circuit and are effective in adjusting the time interval during which the relay is energized and load 15 is receiving current.

The diode 36 is provided with a heater 53 for the cathode 39, this heater having a series connection with the heater 35 of the thyratron 31, the current for these heater filaments being supplied from the secondary 54 of the transformer 55, the primary 56 of which is connected directly across the mains. To insure a proper functioning of the tubes 31 and 36, switches 57 and 58 are placed in the main 12 on either side of the point 14 to include the connection to the transformer 56 so that power may be applied to the transformer 55 with the switch 58 open to delay activation of the relay. Screen grid 32 of the thyratron 31 is connected through a leakage resistor 59 to the end 60 of the armature plate 26 and from this point a conductor 61 connects to a bank of capacitors 62 and 63, a switch 64 providing means for adjusting the capacitors of the capacitor bank. Conductors 65 and 66 connect the capacitors to the power main 13. The transient arresting capacitors 67 and 36 are connected between the cathode 34 of the thyratron and screen grid 32 and control grid 33, respectively.

Control grid 33 is connected through a resistor 68 to the lower contact 69 adjacent relay armature 26. This grid is also connected through the grid resistor 68 to a resistance arm 70 making positive contact with the resistor terminals 71, 72, 73 and 74. Terminals 72, 73 and 74 connect respectively with resistors 75, 76 and 77, the same forming a parallel circuit to a conductor 78 in conjunction with the conductor 79 from the terminal 71. The conductor 78 leads through the variable resistor 80 having a movable contact arm 81 and through the fixed resistor 82 to the main 13. For the specific arrangement hereinabove referred to, values for these resistors found satisfactory are resistor 75, 5 megohms, 76, 10 megohms, 77, 20 megohms, resistor 80, 400,000 ohms and resistor 82, 1½ megohms.

In addition to the resistor 68 connected directly to the control grid of the thyratron, use is made of a leakage resistor 83 which in the circuit as set up with the control resistor as indicated may have a value of 10 megohms. This value assisted with the value of 10 megohms for the resistor 68 affords a satisfactory leakage path for the capacitors as will now be explained.

In the operation of the apparatus, switch 57 is closed, thereby energizing the transformer 55 and causing filaments 35 and 53 of the tubes to become heated. With the proper load elements in the load circuits for the "on" and "off" positions, the switch 58 is closed thereby impressing on the anode of the thyratron 31 a potential of sufficient value, in view of the zero potential of the grids, to cause a flow of current through the tube during the positive alternation of the initial cycle of current alternation. This flow of current energizes the relay 20 which lifts armature 23, closing the "on" load circuits 15 and 16 and the circuit from the diode anode 37 to the screen grid 32 of the thyratron.

On the reversal of the line voltage the relay armature remains in the closed position. This is made possible through the use of a so-called telephone type relay which employs a shading ring on the movable armature end, the action of which is to make effective the pull of the armature through the negative half cycle. This arises from the fact that the current and flux values of the relay coil and the shaded ring are 90° out of phase with each other, the shaded ring voltage being 180° out of phase with the primary potential so that the simultaneous effect of coil and shading ring values is to extend a positive pull of flux over substantially all of the negative half cycle of the line voltage and this extension combines with the physical lag of the armature to maintain the armature of the relay in closed position throughout the period of alternation. (For definition of "shaded coil" see page 489, "Standard Handbook for Electrical Engineers," 7th edition, 1941.)

On the reversal of the voltage in the power mains, after the first positive half cycle, current is interrupted through the thyratron and is permitted to flow into and charge the condensers 62 and 63, the circuit being completed through the point 69 contact 38, diode anode 37 and cathode 39 and through the "on" resistor control to the main 12. The amount of current flow is, of course, controlled by the adjustment of the resistor arms 42 and 49 in the "on" unit, larger resistance decreasing the amount of current flow. In this negative half cycle of current flow a definite limited quantity of current is passed into the capacitors 62 and 63 which is at once effective as a negative potential on the screen grid 32 thus reducing the potential of the grid below zero. At the second positive half cycle current again passes through the thyratron 31 re-energizing the relay 20 and on the second negative half cycle a further increment of charge is effected in the capacitors thus reducing by a second definite amount the potential of the screen grid 32. Subsequent alternations of the cycle build up the negative charge on the screen grid 32 to the point where it falls below the striking potential of the tube, at which point current will fail to flow through the thyratron at the next positive half cycle and the "on" position of the circuit will thus be ended. At the moment of break of current through the thyratron due to the action of the shield grid 32, the relay 20 becomes de-energized and the armature falls thus breaking contact with the "on" load 15 and making contact with the "off" load 16 and simultaneously making contact between the capacitors and the "off" control resistor unit arm 70. It will be seen that placement of the resistor arm 70 at any given resistor terminal will result in a leakage flow of current from the capacitors 62 and 63 which, after a predetermined time interval as determined by the particular resistor to which the arm 70 is connected, reduces the negative potential of screen grid 32 to a point where it will exceed the striking potential of the tube whereupon current will once again flow through the thyratron in the positive half cycle of the line voltage and charging of the capacitor 62 will again be resumed.

It is pointed out in connection with the thyratron that as the load passes from "on" to "off" position and the relay 20 is de-energized a connection is made between capacitor 62 or 63 and the control grid 33 whereby the negative biasing of the shield grid is amplified. This is due to the

fact that the control grid is closer to the cathode than the screen grid and therefore a reversal of effect at the critical striking point is prevented through the joint action of both screen and control grids.

As described, the "off" position of the load circuit is confined to the time period in which the leakage current flows through the "off" control unit to the point of reversal. The leakage effect is supplemented also by the resistors **68** and **83** connected to the control grid to form a circuit to the power main **13**.

The circuit as described including the electronic elements and accessory relay and other apparatus has been found efficient and particularly applicable to the purpose and effective in accomplishing the objects of the invention. However, modifications of the circuit and elements may, of course, be made to accommodate the same to particular uses, and hence, no limitation is implied by the specification other than indicated by the claims as hereto appended.

What is claimed is:

1. An electric timing device comprising power mains, a normally closed first load circuit, a normally open second load circuit, relay means for connecting alternately said first and second load circuits to the power mains, and time change means for independently adjusting the timing of said alternate load circuit connection both as to off and on positions.

2. An electronic timing device comprising power mains, a normally closed first load circuit, a normally open second load circuit, relay means for connecting alternately said load circuits to the power mains, and time change means for adjusting the timing of said alternate load circuit connections, said relay means comprising a relay, load circuit switch contacts operable by said relay, an electronic device including a control grid, a branch circuit conductor connecting said relay and electronic device in series across said mains, and a capacitor connected to said control grid and to said mains adapted to impress at recurrent intervals a negative potential on said grid of sufficient value to disrupt the current flow in said electronic device and relay.

3. An electronic timing device comprising power mains, a normally closed first load circuit, a normally open second load circuit, relay means for connecting alternately said load circuits to the power mains, and time change means for adjusting the time of said alternate load circuit connections, said relay means comprising a relay, load circuit switch contacts operable by said relay, an electronic device including a control grid, a branch circuit conductor connecting said relay and electronic device in series across said means, a capacitor connected to said control grid and to said mains adapted to impress at recurrent intervals a negative potential on said grid of sufficient value to disrupt the current flow in said electronic device and relay, and means for varying the length of said intervals.

4. An electronic timing device comprising power mains, a normally closed first load circuit, a normally open second load circuit, relay means for connecting alternately said load circuits to the power mains, and time change means for adjusting the timing of said alternate load circuit connections, said relay means comprising a relay, load circuit switch contacts operable by said relay, an electronic device including a control grid, a branch circuit conductor connecting said relay and electronic device in series across said

mains, a capacitor connected to said control grid and to said mains adapted to impress at recurrent intervals a negative potential on said grid of sufficient value to disrupt the current flow in said electronic device and relay, and means to reduce said negative potential to a point where current flow is resumed through said electronic device.

5. An electronic timing device comprising power mains, a normally closed first load circuit, a normally open second load circuit, relay means for connecting alternately said load circuit to the power mains, and time change means for adjusting the timing of said alternate load circuit connections, said relay means comprising a relay, load circuit switch contacts operable by said relay, an electronic device including a control grid, a branch circuit conductor connecting said relay and electronic device in series across said mains, a capacitor connected to said control grid and to said means adapted to impress at recurrent intervals a negative potential on said grid of sufficient value to disrupt the current flow in said electronic device and relay, means to reduce said negative potential to a point where current flow is resumed through said electronic device, and said time change means including plural means for controlling the time intervals in which current does, and does not, flow.

6. An electric timing device comprising power mains, first and second load circuits connected to said mains, relay means including switch mechanism in said load circuits for transmitting power from said mains alternately through each of said load circuits through movement of said switch mechanism and timing means for fixing the time of alternation of said relay switch mechanism, said relay means including a coil magnet, an armature associated therewith and connected to said switch mechanism to bring about alternate load circuit contacts, and means connected to said magnet for permitting current flow therethrough in one direction only.

7. An electric timing device comprising power mains, load circuits connected thereto, switch mechanism operative to connect alternately each load circuit to said mains, a relay circuit including a relay operative to move said switch mechanism to secure alternate connection of said load circuits, means in said relay circuit for transmitting current therethrough in one direction only, and timing means for fixing the period of current flow and non-flow in said relay.

8. An electronic timing device comprising power mains, plural load circuits, switch mechanism for connecting each load circuit alternately to said mains, relay means connected to said mains for actuating said mechanism, an electronic device connected to said relay means for passing current through said relay means in one direction only, said electronic device including a control element, and means connected to said control element for interrupting periodically the flow of current through said relay means.

9. An electronic timing device comprising power mains, dual load circuits, and relay means for connecting said load circuits alternately across said mains, said relay means comprising a relay, load circuit switch contacts operable by said relay, an electronic device including a control grid, a branch circuit conductor connecting said relay and electronic device across said mains, and means connected to said electronic device for recurrently blocking current flow therethrough.

10. An electronic timing device comprising

power mains, dual load circuits, and relay means for connecting said load circuits alternately across said mains, said relay means comprising a relay, load circuit switch contacts operable by said relay, an electronic device including a control grid, a branch circuit conductor connecting said relay and electronic device across said mains, and a capacitor connected to said control grid adapted to impress at recurrent intervals a negative potential on said grid of sufficient value to disrupt current flow in said electronic device and relay.

11. An electronic timing device comprising

power mains, dual load circuits, relay means for connecting said load circuits alternately across said mains, and time change means for adjusting the timing of said alternate load circuit connections, said relay means comprising a relay, load circuit switch contacts operable by said relay, an electronic device including a control grid, a branch circuit conductor connecting said relay and electronic device across said mains, and means connected to said electronic device for recurrently blocking current flow therethrough.

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