Oct. 4, 1932. H. P. THOMAS 1,880,576

TIME DELAY APPARATUS

Filed Oct. 3, 1930

Fig. 1.

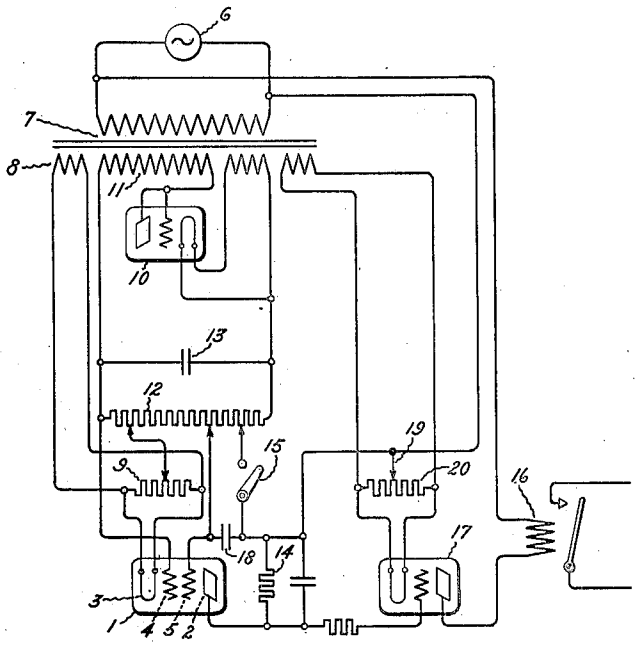
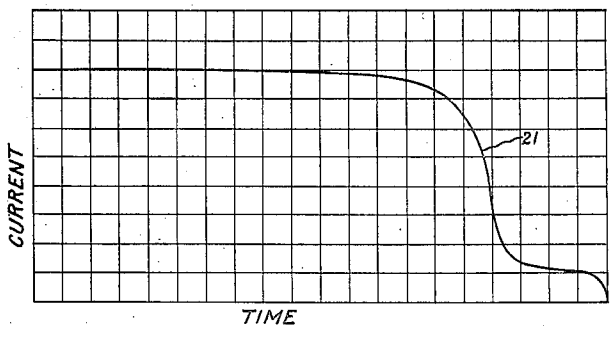


Fig. 2.



Inventor:
Henry P. Thomas,
by Charles E. Mullen
His Attorney.

Patented Oct. 4, 1932 1,880,576

UNITED STATES PATENT OFFICE

HENRY P. THOMAS, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

TIME DELAY APPARATUS

Application filed October 3, 1930. Serial No. 486,275.

My invention relates to time delay circuits and more particularly to time delay circuits of the electron discharge type.

One of the objects of my invention is to provide a time delay apparatus of the electron discharge type in which the time interval produced by operation of the apparatus may be accurately predetermined over a long range.

A further object of my invention is to provide time delay apparatus of the type indicated in which the time interval is substantially independent of variations of the potentials applied to the discharge device employed.

Still a further object of my invention is to utilize in a time delay apparatus the characteristic of an electron discharge device in that the anode current is practically independent of anode voltage when the grid is positive with respect to the cathode.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 represents an embodiment of my invention and Fig. 2 represents a characteristic thereof.

Referring to the drawing, I have shown at 1 an electron discharge device of the screen grid type, this device having an anode 2, a cathode 3, a control grid 4 and a screening grid 5 interposed between the anode and the control grid 4, these electrodes being enclosed in a vessel which is evacuated sufficiently to cause the device to operate substantially unaffected by gas ionization. This discharge device is energized from any suitable source of electromotive force 6 which may be connected to the primary winding of transformer 7 having a plurality of secondary windings. The cathode of the discharge device 1 is energized from secondary winding 8 and has a resistance 9 connected in parallel therewith. In order that the grid and anode of the discharge device may be energized with unidirectional electromotive force with respect to the cathode, a rectifier 10 is provided which is connected in circuit with secondary winding 11 of the transformer 7 and a potentiometer 12, a suitable smoothing condenser 13 being connected in shunt with the potentiometer 12.

The cathode of device 1 is connected to potentiometer 12 through a connection to the midpoint of resistance 9. The grid 5 of the discharge device 1 is connected to a point upon the resistance 12 such that it is maintained at a substantial positive potential with respect to the cathode, and the control grid 4 is connected to a point upon the resistance such that it is maintained at a negative potential with respect to the cathode. The anode 2 is likewise connected to the potentiometer 12 through a suitable resistance 14 and a switch 15, the point upon the resistance 12 at which the anode is connected being such that it is at positive potential with respect to the screen grid 5.

As thus described the current flowing in the anode circuit of the discharge device is substantially independent of variations in the anode voltage. In accordance with my invention I utilize this characteristic of the discharge device definitely to predetermine the time interval between the operation of a primary control device, such as the switch 15, and a secondary control device such for example as the relay 16.

In the drawing I have shown the relay 16 connected between the anode and cathode of a second electron discharge device 17, this anode being energized from the source of electromotive force 6. This discharge device preferably is one of the type in which the envelope is filled with a suitably attenuated gas such as mercury vapor. The resistance 14 is connected between the cathode and grid of the discharge device 17 whereby the operation of this discharge device is controlled in accordance with current in the anode circuit of the discharge device 1.

To control the time interval between the operation switch 15 and the relay 16 a suitable energy storage device 18 is connected between the screen grid 5 and the anode 2, of discharge device 1 whereby this condenser

is charged when the switch 15 is closed. The operation of the device thus is as follows:

Assuming that the switch 15 is in its closed position, a certain difference of potential will exist between the anode and the screen grid and the storage device 18 is charged substantially to this difference of potential, the right hand electrode of condenser 18 being positive with respect to the left hand electrode. Sufficient current then flows in the anode and through resistance 14 to maintain the grid of the discharge device 17 sufficiently negative to prevent the flow of current in the relay 16. Thus this relay is deenergized. When the switch 15 is opened, however, the potential on the anode is maintained by the condenser but any electrons which flow from the cathode to the anode 2 then store themselves into the positive electrode of the storage device 18 thereby causing this electrode to become gradually less positive until it reaches the potential of the opposite condenser electrode. In other words, the condenser 18 is gradually discharged through flow of negative electrons into its positive plate.

I have found that the anode current flowing in the resistance 14 during this discharging of the condenser 18 has the form shown by the curve of Fig. 2. It will be observed that this current is substantially constant until a point is reached at which the anode potential is substantially equal to the screen grid potential where it suddenly is reduced to a very small value, as shown by the right hand portion of the curve. A potential in accordance with this current is thus impressed upon the grid of the discharge device 17. When this potential is sufficiently reduced, as to a point indicated at 21 in Fig. 2, anode current is caused to flow in the discharge device 17 thereby to operate the relay 16.

I have found that with an arrangement of the type described a time interval of 30 minutes or more can readily be produced between the operation of the switch 15 and that of relay 16. During the principal portions of this time interval beginning with the opening of switch 15 the rate of discharge of the condenser 18 is practically constant as shown in Fig. 2 as distinct from known arrangements in which the rate of discharge varies during the time interval from a comparatively rapid rate at the beginning of the period to a comparatively slow rate during the latter portion of the time interval. This constant rate of discharge of the condenser lends itself well to accuracy in the predetermination of the time interval resulting from a particular adjustment of the device.

While in the drawing I have shown a discharge device 1 as one of the screen grid type, it will be understood that I do not wish to be limited thereto since discharge devices of other construction may also be used. The principal function of the control grid in the arrangement disclosed is that of limiting the amount of current flowing from the cathode to the anode and screening grid. This result may of course be accomplished by other expedients well known in the art, such for example as that of reducing the filament energization thereby to limit emission from the filament.

I have further stated that the discharge device 17 is preferably one of the vapor electric type; that is, the envelope is filled with an attenuated gas, such as mercury vapor. This type of discharge device used in the manner shown also lends itself to an accurate predetermination of the time interval since it is a characteristic of these devices that no anode current flows until the grid voltage reaches a definite value with respect to the cathode. The anode current then flows having a magnitude independent of the grid voltage. Thus for example, let us assume that the discharge device 17 is so adjusted, as by adjusting the tap 19 on resistance 20, that current starts to flow in the anode when a point is reached in the discharge characteristic of Fig. 2 which is indicated at 21. Thus no current flows in the anode circuit until this point on the characteristic is reached. Thereafter full anode current flows in the discharge device having magnitude dependent upon the anode voltage, and independent of the grid voltage, thereby causing very positive actuation of the relay 16. It will of course be understood, however, that other discharge devices may also be employed.

While I have shown a particular embodiment of my invention it will of course be understood that I do not wish to be limited thereto since many modifications may be made both in the circuit arrangement and in the instrumentalities employed and that I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, a primary control device, a secondary control device, and means for operating said secondary control device after a predetermined interval subsequent to operation of said primary control device, said means comprising an electron discharge device having a cathode and two additional electrodes enclosed in a vessel, said vessel being evacuated sufficiently to cause operation of said device substantially unaffected by ionization of gas within said vessel, an energy storage device, connected between said additional electrodes, and means for operating said secondary control device at a time subsequent to operation of said first device dependent upon the rate of discharge of said

energy storage device through action of said electrodes.

2. In combination, an electron discharge device, having an anode, a cathode, and an additional electrode, energy storage means connected between said additional electrode and anode, means for supplying electromotive forces of different values to said anode and additional electrode whereby said energy storage means is charged, means for interrupting the supply of electromotive force from said means to said anode whereby said storage means tends to discharge and means operable responsively to the discharge of said condenser.

3. In combination, an electron discharge device, having an anode, a cathode, a control electrode and a screening electrode interposed between the control electrode and anode, energy storage means connected between the screening electrode and anode, means for supplying negative electromotive force to said control electrode, means for supplying positive electromotive forces of unequal values to said screening electrode and anode whereby said energy storage means is charged, means for interrupting said supply of electromotive force to said anode whereby said energy storage means tends to discharge and means operable responsively to discharge of said energy storage means.

4. In combination, an electron discharge device, having a plurality of electrodes including an anode, a cathode and a grid electrode, a source of electromotive force, a connection between each of said electrodes and said source of electromotive force whereby unequal positive potentials with respect to said cathode are supplied to said anode and grid electrode, said anode being positive with respect to said grid electrode, an energy storage device connected between the anode and grid electrode, means for interrupting the connection between said anode and source of electromotive force whereby the anode potential is dependent upon the energy stored in said energy storage means, and means operable responsively to current to said anode whereby said means is operated after a time interval subsequent to interruption of said connection between said anode and source of electromotive force dependent upon the rate of discharge of said energy storage device.

5. In combination, an electron discharge device, having an anode, a cathode, and an additional electrode, energy storage means connected between said additional electrode and anode, means for supplying electromotive forces of different values to said anode and additional electrode, whereby said energy storage means is charged, means to interrupt the supply of electromotive force from said means to said anode whereby said storage means tends to discharge, a vapor electric device connected to operate responsively to current to said anode and a relay connected in the anode circuit of said vapor electric device, whereby said relay is operated after a definite time interval subsequent to said interruption of the supply of electromotive force from said means to said anode.

6. In combination, an electron discharge device, having an anode, a cathode, a control electrode and a screening electrode interposed between the control electrode and anode, energy storage means connected between the screening electrode and anode, means for supplying negative electromotive force to said control electrode, means for supplying positive electromotive forces of unequal values to said screening electrode and anode whereby said energy storage means is charged, means for interrupting said supply electromotive force to said anode whereby said energy storage means tends to discharge and a vapor electric device connected to respond to discharge of said energy storage means.

7. In combination, an electron discharge device having a cathode and two additional electrodes, an energy storage device connected between said additional electrodes, a source of electromotive force, connections from said cathode and electrodes to said source arranged to supply potential with respect to said cathode to said electrodes and to charge said energy storage device, means to interrupt the connection to one of said electrodes whereby said storage device is discharged at a substantially constant rate, and means responsive to the discharge of said storage device.

In witness whereof I have hereunto set my hand this 2nd day of October, 1930.

HENRY P. THOMAS.