

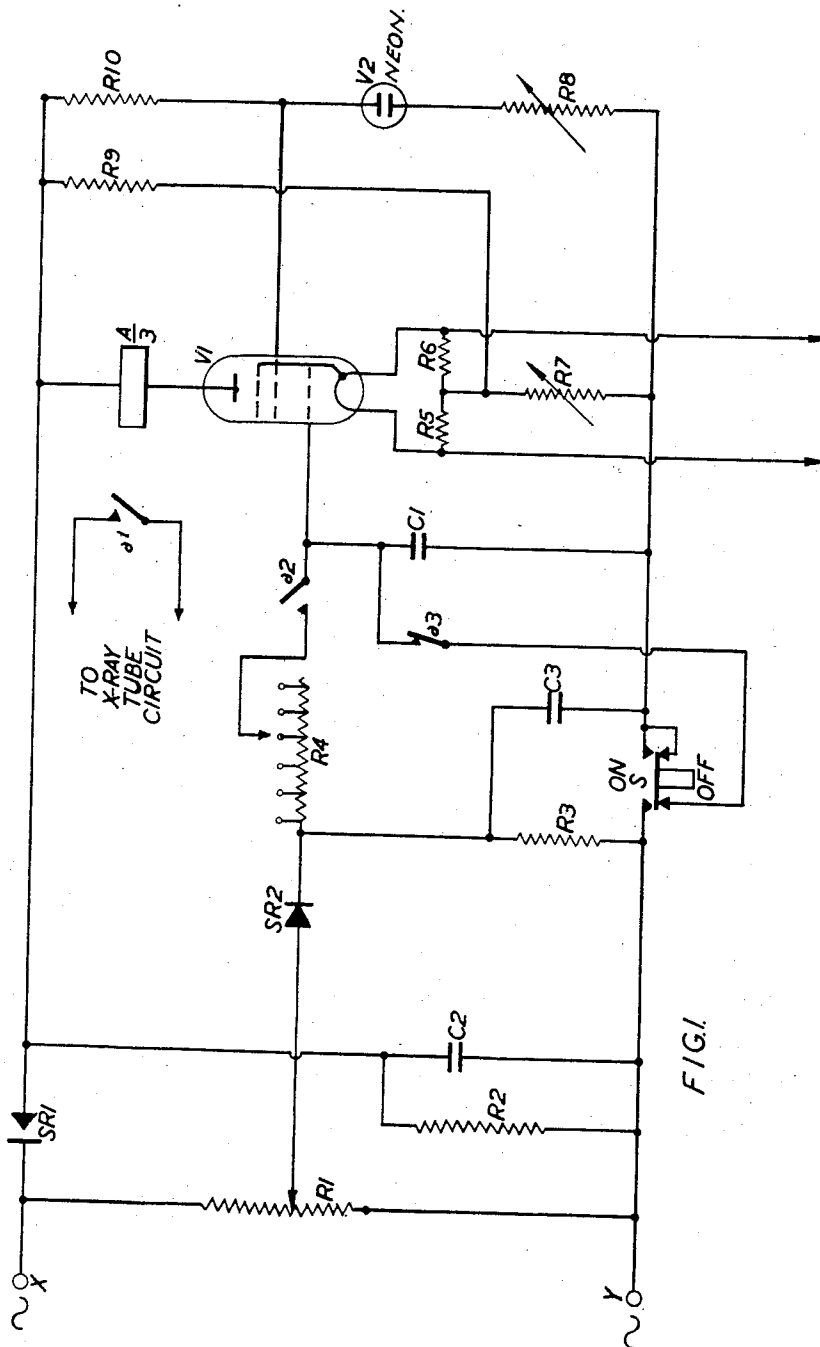
June 9, 1953

T. MOORE
TIMING DEVICE

2,641,701

Filed Aug. 30, 1947

3 Sheets-Sheet 1



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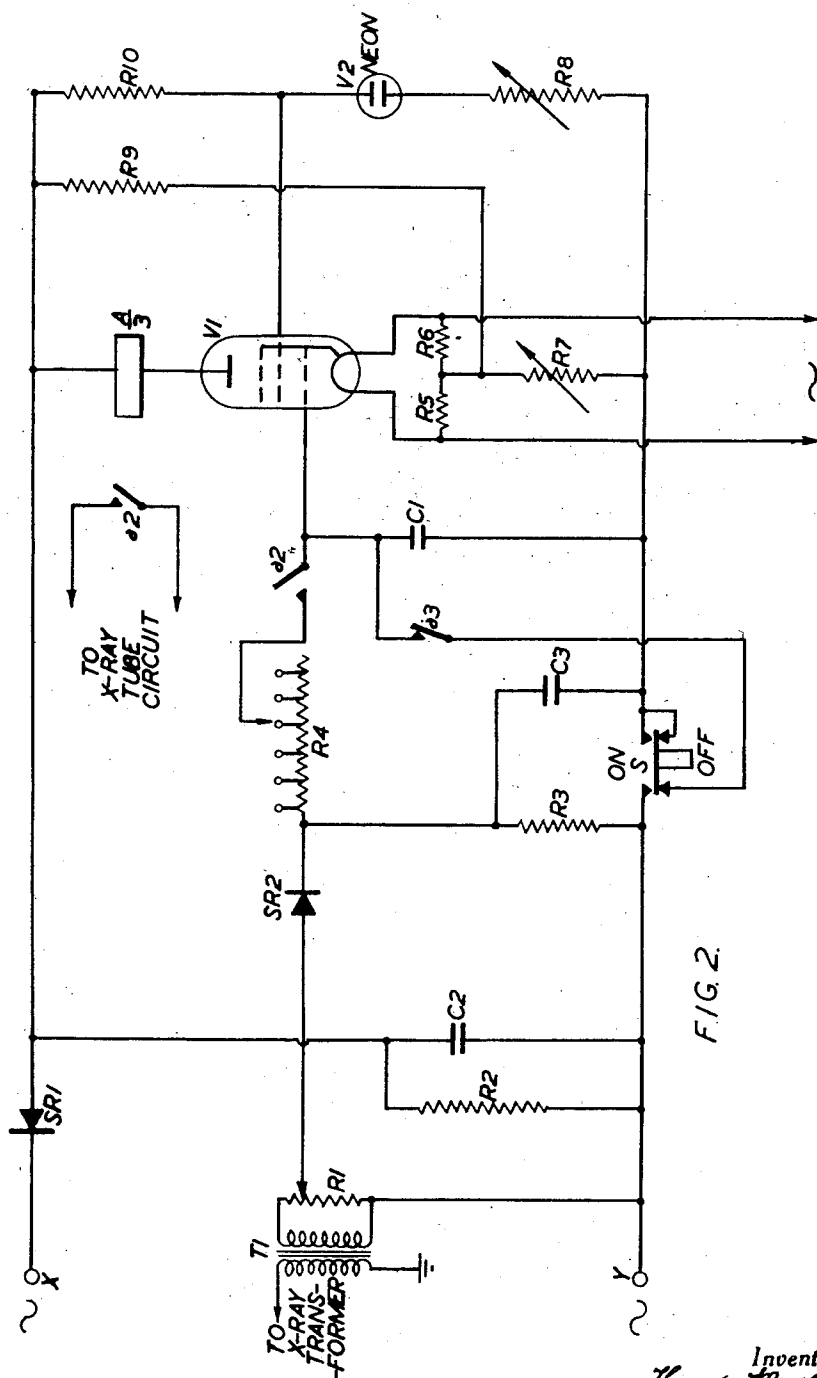
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3 Sheets-Sheet 2



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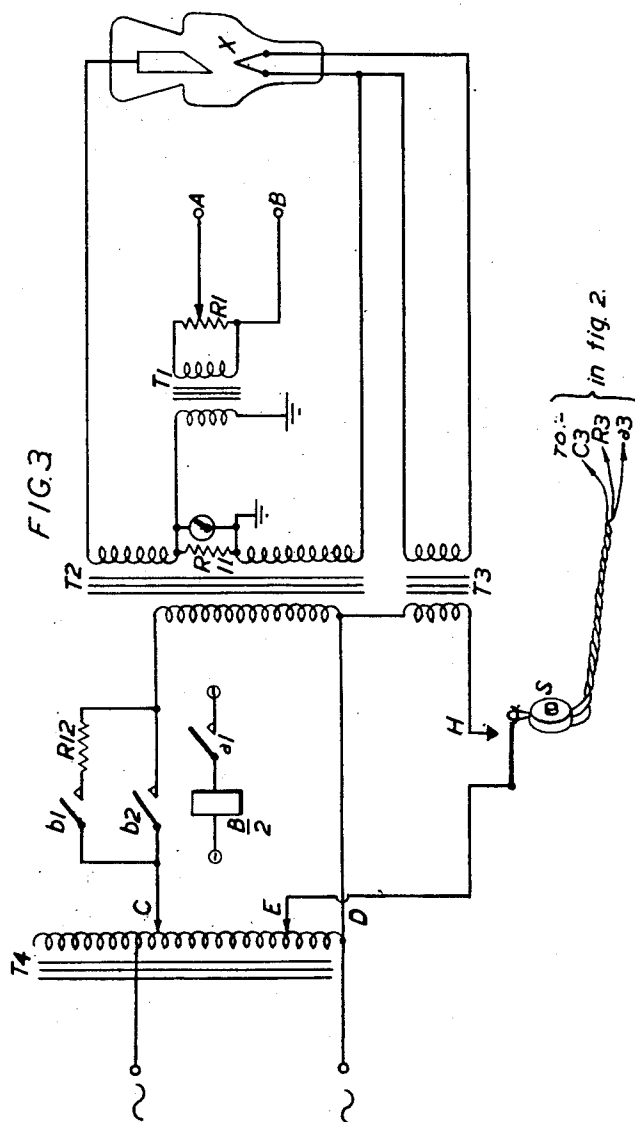
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,641,701

TIMING DEVICE

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Application August 30, 1947, Serial No. 771,457
In Great Britain November 29, 1946

2 Claims. (Cl. 250—27)

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This invention relates to electronic timing devices. In such devices it is known to use a valve normally conducting and to initiate the timing by the operation switch which applies a potential through a resistance across a condenser connection between grid and cathode of the valve so that, the condenser charges up to a potential which eventually raises the grid to a negative potential of a value sufficient to render the valve nonconducting and to regulate the time taken to "cut off" the valve by adjustment of the said resistance or condenser or both of them.

It is a disadvantage of such devices as heretofore designed that the time interval between switching on and the cut off of the valve is varied by fluctuations in the potential of the source providing the anode supply potential to the valve and the potential applied via the resistance condenser combination to the grid of the valve.

This invention consists of a device of the type above described in which fluctuation in the supply potential are compensated in a novel manner. It is furthermore sometimes required that such device shall be capable of automatically compensating for irregularities in the functioning of the apparatus controlled. An alternative form of the invention is described in which this object is attained in a novel manner.

The two embodiments to be described have been developed for controlling the exposure time of X-ray apparatus but the invention is capable of measuring time intervals which vary within wide limits and of controlling a variety of different things.

These embodiments will now be described in relation to the accompanying drawings in which Fig. 1 is a circuit diagram of an embodiment which compensates for fluctuation in supply potential;

Fig. 2 is a circuit diagram of an embodiment similar to that illustrated in Fig. 1 but including in addition a means of automatically compensating for irregularities in the operation of the X-ray generator;

Fig. 3 is a diagram of a typical X-ray generator circuit showing the manner in which the circuit of Fig. 2 is connected thereto so as to compensate for irregularities in the operation of the X-ray generator.

In the drawings, the relays and their contacts are shown in accordance with the detached contact method, the contacts being shown where they are used in the circuit and not necessarily next to the corresponding relays. The relays are marked with capital letters and the corresponding

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contacts with the same small letters and in addition, a numeral distinguishing the various contacts of the same relay. The numeral appearing under a capital letter associated with a relay indicates the number of contacts controlled by the relay.

In Fig. 1 a valve V1 has a relay A connected in series in its anode circuit and is supplied with anode current from an alternating current supply source, which may be the electric supply mains, at X and Y. This alternating current is rectified by rectifier SR1 and smoothed by resistance R2 and condenser C2. V1 is shown in the figure as a directly heated cathode pentode though any type of valve may be used having a second grid the potential of which affects the control grid potential necessary to cut off the anode current of the valve. A directly heated cathode has the advantages that it heats up quickly so that the device can be used immediately it is required but in some applications of the invention this is not important. Resistances R5 and R6 are inserted to provide an electrical mid point of the cathode for connection of the negative high tension supply and the cathode is returned to a point on the potentiometer constituted by the resistances R6, R7, so that the grid of the valve is negative in respect of the cathode but not to a degree sufficient to render the valve nonconducting, when the press button S is first operated into the "on" position. This standing grid bias may be varied by adjusting R7.

The screen of the valve is connected to the junction of resistance R10 and a neon tube V2, the combination R10 V2 and potentiometer R8 constituting a potential divider in which V2 operates to hold the screen-to-cathode potential of the valve constant under differing conditions of supply voltage potential to a degree depending on the adjustment of R8. Large values of R8 increase the permissible fluctuation of the screen potential of V1, when the supply potential varies.

Other voltage stabilising devices could be substituted for V2.

When the press button S is operated, the supply source is connected to the valve which conducts and relay A operates by virtue of the valve anode current flowing in its windings.

The X-ray generator is switched on directly by a1 or indirectly via another relay operated by the closing of a1 and the time period commences.

Contacts a2 connect the grid of V1 to a source of negative potential provided by the potentiometer R1 bridged across the alternating current supply source, via the rectifier SR2, connected so

as to conduct the negative half cycles of the alternating current supply, smoothed by resistance R3 and condenser C2 and via the tapped resistance R4.

At the same time a3 contacts open and remove the short circuit across condenser C1.

The negative potential across grid and cathode is the same as that across condenser C1 which commences to charge at a rate depending upon the potential supplied from SR2, the value of resistance R4 and the capacity of condenser C1.

When the potential across C1 reaches the point at which the valve becomes nonconducting, the anode current ceases, A releases, a1 switches off the X-ray generator, a2 disconnects the grid of V1 from the source of negative potential at SR2, and when the press button S is released a3 short circuits the condenser C1, the circuit being thus restored to normal.

The potentiometer R1 is adjusted in the initial setting up of the equipment and is capable of varying the timing range of the device.

Resistance R7 is an adjustment primarily intended to recalibrate the device when a valve is changed, though it, again may be used to vary the timing range of the device.

The time setting control, accessible to the operator, is the resistance R4, alterations of which affect the time taken for C1 to charge up to the critical value.

The manner in which fluctuations in the supply potential are compensated will now be described.

Suppose that the supply potential rises. The following factors tend to lengthen the time measured by the device:

- (a) The filament current rises tending to increase the valve emission and raise the grid cut-off voltage of V1.
- (b) The anode voltage rises tending to raise the grid cut-off voltage of V1.
- (c) Screen voltage rises to a greater or less degree depending on the setting of R8, a large value of R8 causing a larger rise and a zero setting of R8 causing practically no variation of screen voltage due to the voltage regulation action of V2. A rising screen voltage raises the grid cut off voltage of V1.

The following factors tend to reduce the time measured by the device:

- (d) The standing grid bias, due to the potentiometer R6, R7 rises, accelerating the rise of negative grid potential to the cut-off value.
- (e) The charging voltage applied to C1 rises owing to the increased potential across R1.

When the supply voltage falls all these factors operate in the reverse direction.

The values of the components are chosen so that these conflicting factors balance one another and three adjustments are provided to adjust the device so that accurate balance is obtained. These are R1, R7, and R8. The first two are primarily intended as calibratory adjustments for the initial setting up of the equipment to compensate for tolerances in components and variations in supply potential. The resistance R8 however can be used to adjust the degree of compensation for supply potential fluctuations and it can be set to give any desired characteristic to the device, varying from completely stable operation, to a decreasing time measurement for a rising supply voltage, on the one hand, or the converse, on the other hand. This can be understood when it is seen that variation of R8 varies the effect of factor (c) above described. This may be a useful adjustment where the appa-

ratus controlled has an effectiveness not directly proportional to the supply potential supplied to it and where the device and the controlled apparatus can be energised from the same supply source.

This is particularly applicable to X-ray equipment where the rise of X-ray emission is more than proportional to any rise in the supply potential.

In the second embodiment, illustrated in Fig. 2 the circuit is the same as that illustrated in Fig. 1 except that the source of charging potential applied to C1 is derived from a potentiometer bridge not across the power supply source but across the secondary windings of a transformer T1 the primary of which is connected in series with the current flowing in the apparatus controlled, in this case an X-ray tube.

Any apparatus in which an alternating current or pulsating direct current flows which is approximately proportional to the output of the apparatus, may be controlled in this manner.

The current passing between cathode and anode of an X-ray tube is an approximate index of the emission of X-rays by the tube and is a pulsating direct current. A part of this current is passed through T1 primary windings and thus the voltage across R1 is approximately proportional to the X-ray emission from the tube. As this rises, the charging potential applied across C1 rises also and the grid cut-off potential of V1 is more quickly reached, reducing the timing period for a given setting of R4. As the tube emission falls, the timing period is correspondingly increased.

Fig. 3 shows a typical X-ray circuit with the connections of transformer T1.

T4 is an auto transformer connected to an alternating current source.

Secondary tapplings at C and D are connected to an X-ray transformer T2, on one side through contacts b1 and b2 in parallel of relay B which is operated on closure of a1 contacts, b1 closing first and completing the circuit through a resistance R12 to be shortly afterwards short circuited by b2 contacts. The secondary of T2 is in two halves joined in the middle by a resistance R11 one end of which is earthed and the other connected to the primary windings of T1 being the same as T1 of Fig. 2. The other end of T- primary is earthed making this winding effectively in parallel with R11. A meter may also be connected across R11.

An X-ray tube X is connected across the outer ends of the secondary winding of T2 and when the tube is operating, a voltage is developed across R11 proportional to the current passed by the tube and a current passes through T1 primary winding also proportional to the tube current. The voltage appearing across A, B is therefore proportional to the tube current for any given setting of R1. A and B are connected to SR2 and the negative supply lead shown in Fig. 2.

Secondary tapplings E and D of T4 are connected to the primary winding of an X-ray filament transformer T3, the circuit being normally broken at switch hook H from which hangs press button S. Leads from S are connected to C3, R3 and a3 as shown in Fig. 2.

When it is desired to make an X-ray exposure the press button S is lifted from its hook and the filament of the X-ray tube is automatically switched on, R4 having been first set to the correct exposure time.

A brief wait ensues, to allow the X-ray fila-

ment and the cathode of valve V1 to heat up. The button is then pressed and the exposure is regulated by the device.

The button is released after a short pause or after the re-lighting of a lamp operated on release of relay A (a feature not shown in the figures), and the press button should then be promptly replaced on its hook to disconnect the X-ray tube filament as soon as possible.

The purpose of including contacts a2 in the circuit between R4 and the grid of V1 is to start the timing process in accurate synchronism with the switching of the controlled apparatus by a1 and to isolate C1 from any stray voltages which might partially charge it prior to the operation of A.

The purpose of including contacts a3 in the connection from the upper end of C1 and press button S, in Figs. 1 and 2, is to disconnect C1 from the leads to the press button S, which may be of some length, and thus to avoid interference with the timing by stray effects from such leads which would otherwise be effectively in parallel with C1.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. An electronic timing device comprising a current supply source, a source of biasing voltage, an electron valve having control grid, cathode and anode electrodes, a relay connected in series between said anode electrode and said current supply source, said relay operating responsive to flow of current in said valve, a charging circuit comprising a condenser and resistor in series, said condenser being connected between said control grid electrode and said cathode electrode, and means including said relay for connecting both said condenser and said control grid electrode to

said source of biasing potential upon operation of said relay.

2. An electronic timing device for controlling the operation of associated apparatus, said device comprising a current supply source, an electron valve having a control grid, a cathode, an anode and an auxiliary grid, a relay having a pair of contacts, said contacts being closed when said relay is energized, means connecting said relay in series between said anode and said source, means connecting said cathode to a positive voltage point in said source whose voltage varies with the voltage applied to said anode, means connecting said auxiliary grid to a positive voltage point in said source whose voltage varies with the voltage applied to said anode, a condenser connected between said control grid and said cathode, a resistor and means connecting said resistor, said condenser and said pair of contacts in series to a negative voltage point in said source whose voltage varies with the voltage applied to said anode.

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