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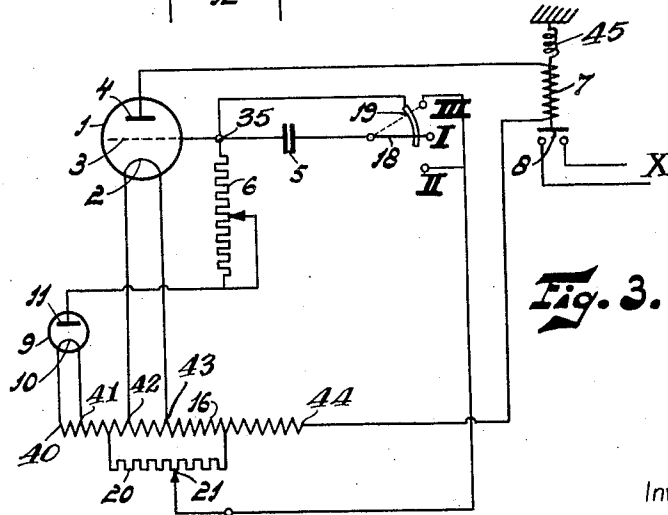
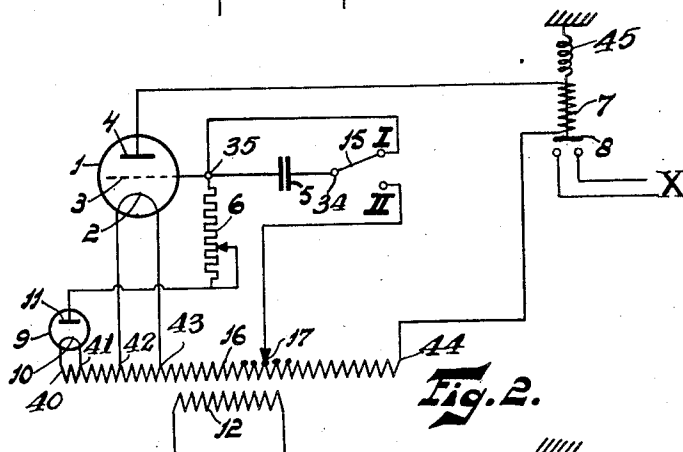
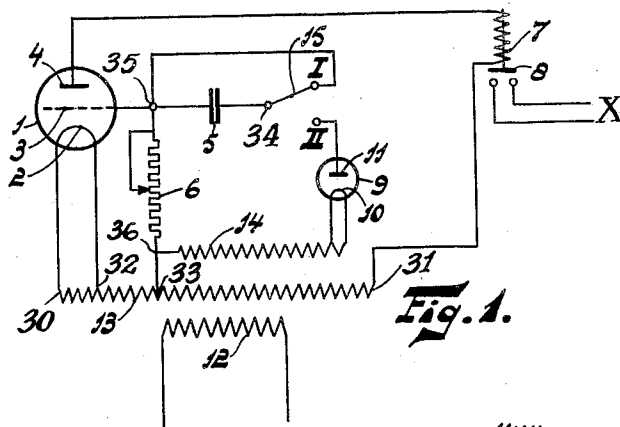
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2,061,011

CIRCUIT ARRANGEMENT FOR ELECTRICAL TIME CONTROL

Filed July 10, 1933

2 Sheets-Sheet 1



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CIRCUIT ARRANGEMENT FOR ELECTRICAL TIME CONTROL

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2 Sheets-Sheet 2

Fig. 4.

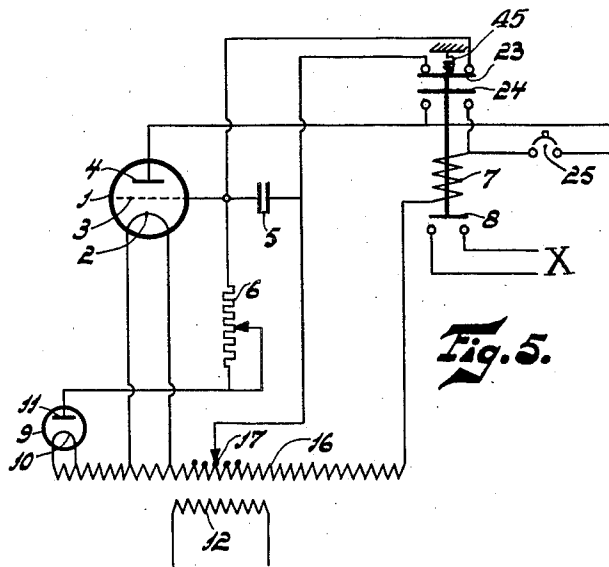
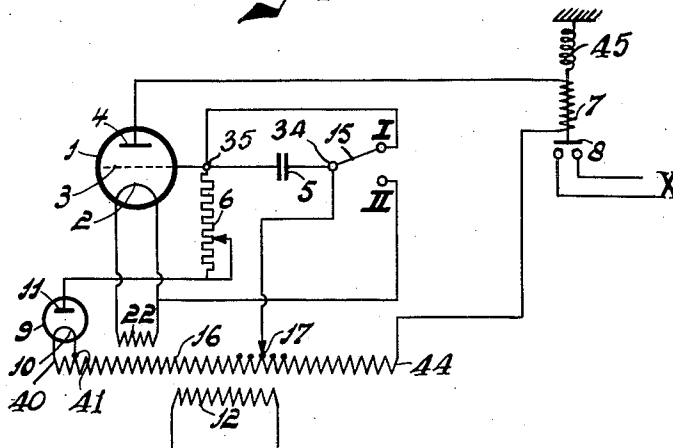


Fig. 5.

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CIRCUIT ARRANGEMENT FOR ELECTRICAL
TIME CONTROL

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13 Claims. (Cl. 250—27)

My invention relates to novel circuit arrange-
ments for electrical time control.

My invention broadly applies to circuit arrange-
ments for the electrical control of the duration of
processes, and is specially adapted for such control
of processes of very short duration.

A special and important application of my invention
is in connection with X-ray installations,
and specially with short time radiographic exposures,
and I shall describe my invention primarily
in connection with such use. However, it should
be well understood that manifold other applica-
tions of my invention may suggest themselves.
My invention can be used irrespective whether the
process, the duration of which is to be controlled,
is an electrical, other physical, chemical, or other
kind of process for example in electric signaling
devices, in making photographic prints from nega-
tive images, in electrical therapy, etc.

Various means have been suggested for the control
of the duration of short time processes and
also in connection with the taking of short time
X-ray exposures. Clock switches, for instance,
have been widely used. Such switches after a
given time interval may act on a relay or other-
wise make or break electrical circuits. Clock
switches have, however, various disadvantages,
among others, they require the winding of springs,
are comparatively expensive, etc.

In view of the inherent drawbacks of such clock
switches, various other time control means have
been already suggested.

For instance, in U. S. Patent 1,819,999 to Kears-
ley, a timing device has been suggested in which
a three electrode tube is used as the time control
means, in which tube the grid potential is
varied in accordance with the change of voltage
of a previously charged condenser.

The potential of the grid thereby varies accord-
ing to an exponential function between two val-
ues, which are so selected that at one value a
current may flow through the tube, whereas at
the other value the current is suppressed.

The above arrangement has, however, serious
drawbacks. As this arrangement requires the
pre-charging of the condenser, in alternating
current installation, when the discharge is initiated,
the condenser is liable to lose part of its
charge before the alternating anode-voltage has
assumed a sufficiently high value to effect the discharge
through the tube. This requires the use
of auxiliary control means, to insure that the discharge
of the condenser may only start at a moment
when the anode voltage has assumed a sufficiently
positive value.

A further disadvantage is that with the above
arrangement special provisions have to be taken
to prevent the discharge of the condenser through
the grid of the tube.

Also, the arrangement requires the charging of
the condenser every time prior to the use of the
device, which consumes considerable time in view
of the pulsating character of the rectified current
used for this purpose and the electrical constants
of the charging circuit.

The present invention relates to an arrange-
ment in which all of the above drawbacks are
avoided and which arrangement has further im-
portant advantages.

According to the invention the potential of a
condenser during its charging is used to influence
the potential of the auxiliary electrode or
grid of a three-electrode discharge tube.

Furthermore, by using the same alternating
current source both for the anode voltage of the
tubes as well as for the charging of the condenser
through a rectifier, and by providing for the
proper phase-connections, it is possible accord-
ing to the invention to have the starting of the
charging of the condenser automatically coincide
with the starting of a positive half-wave of the
anode voltage.

Various embodiments of my invention are possible.
For instance, an arrangement can be provided
in which the condenser is charged through a
resistance which is connected to the grid of the
discharge tube and affects the potential of same
in such a manner that the decreasing voltage drop
in the resistance during the charging of the
condenser affects the bias of the grid. For instance,
while the charging current is high and the voltage
drop in the resistance large, this large voltage
drop negatively biases the grid, thereby blocking
the discharge current through the tube. As
the condenser gradually charges, the voltage drop
in the resistance decreases and the grid bias
increases until finally a value is obtained at which
the discharge through the tube is established.
Or inversely the voltage drop in the resistance
may apply a positive bias to the tube which sets
in the discharge and the charging of the
condenser gradually decreases this positive bias until
the current through the tube is blocked.

Again in another embodiment of my invention,
the potential variations of the charging condenser
may be used to directly control the biasing of the
grid of the discharge tube in a somewhat similar
manner.

In the first case it is necessary, in the second
case it is advantageous to so interconnect the al-

ternating current which supplies the anode potential for the discharge tube and the alternating current used for the charging of the condenser through a half-wave rectifier, that the operative half-waves of the charging current coincide with the positive half-waves of the charging current. Thus the charging of the condenser always starts at the right moment, namely, at that instant when the anode voltage enters its positive or operative phase.

Preferably the same transformer winding is used to supply the anode current as well as the charging current.

Usually I provide a switch in the circuit arrangement by means of which the condenser is normally short-circuited and which switch in another position closes the charging circuit of the condenser. It should be noted that the discharge of the condenser consumes practically no time, as the condenser is directly short-circuited and thus the device is well adapted for quick repeated use.

The invention will be more fully described with reference to the accompanying drawings showing arrangements illustrating various embodiments of my invention and in which:

Figure 1 is a diagram of an arrangement in which the discharge tube acts as a relay through which normally the current flows, the current being interrupted to control the duration of the process to be controlled and to achieve this the bias of the grid is varied by the voltage drop in a resistance which is connected in series with the charging condenser.

Figs. 2, 3, 4 and 5, show various modifications of my invention, in which the current through the discharge tube is normally suppressed and is only permitted to flow during the control time interval, the bias for the grid being directly affected by the voltage of the charging condenser.

Referring to Figure 1, a discharge tube 1 is provided which acts as a relay and which comprises an incandescent cathode 2, an auxiliary electrode or grid 3 and an anode 4.

The discharge tube 1, is preferably a gas-filled arc-discharge tube, although a high-vacuum tube may be also employed which, however, should be operated preferably at saturation voltage. As a rule, I prefer to use gas-filled tubes, as high vacuum tubes have the drawback that their anode current varies with the potential applied to the grid.

As is known, as long as the anode potential has a constant value in an arc discharge tube, limited variations of the grid potential do not interrupt the current through the tube. However, if the anode voltage is an alternating voltage, the arc is interrupted in each half-wave, and re-ignition of the arc depends on the potential applied to the grid. If during a positive half-wave the potential of the grid is sufficiently high, the tube is ignited and the full current permitted to pass. Thereby, the voltage drop in the tube is of no importance. However, if during a positive half-wave the potential of the auxiliary electrode is but slightly less than that required for the ignition of the tube, the current is altogether interrupted or at least practically suppressed.

A transformer is provided for the energy supply of the arrangement, the primary winding 12 of which is connected to the supply of alternating current, and which transformer has two secondary windings 13 and 14.

The winding 13 supplies the voltage for the anode circuit of the tube 1 and is connected with

its two end terminals 30 and 31 across this circuit. The winding 13 is also provided with two intermediate taps 32 and 33.

Across the portion 30 to 32 of the winding 13 is connected the incandescent cathode 2 of the tube 1.

The anode circuit of the discharge tube 1 comprises a magnet coil 7, the armature of which actuates a contact 8, which serves for either the closing or the opening of a circuit to be controlled, marked X, which circuit in turn controls the process, the duration of which it is desired to control. If this process is an X-ray exposure, the contact 8 may serve to close the primary circuit of the high voltage transformer of the X-ray tube. In Fig. 1, the relay 7 is shown as normally energized and the contact 8 normally open, this contact being closed upon the deenergization of the magnet coil 7.

A condenser 5 is provided with one of its electrodes, which as will appear is the negative electrode, in permanent electrical connection at 35 with the grid 3. The other electrode of the condenser 5 is connected to the heel 34 of a two-position switch 15, the free end of which switch may be brought into contact with either one of the contacts marked I and II, these switch positions being hereafter referred to as positions I and II respectively.

The contact I is connected to the point 35, and while the switch 15 is in position I, the condenser is short-circuited.

When the switch 15 is moved into position II, the charging circuit of the condenser 5 is established. This circuit comprises a half-wave rectifier tube 9—having an incandescent cathode 10 and an anode 11—the transformer winding 14, a variable resistance 6, and the condenser 5.

The cathode 10 of the rectifier 9 is heated from a tapped portion of the winding 14.

Upon closure of the charging circuit, the condenser is gradually charged up by the rectified current, the charging time depending on the electrical constants of the circuit and may be adjusted by varying the resistance 6.

The junction point 36 of the resistance 6 and of the winding 14, is connected to the tap 33 of the transformer winding 13, thus to a point the potential of which lies between that of the anode and that of the cathode; the other end of the resistance 6 is connected to the junction point 35 and is thus also connected to the auxiliary electrode 3. It will thus appear that while the condenser charges the potential of the auxiliary electrode is rendered less positive, by the extent of the voltage drop in the resistance 6.

As long as the charging circuit is open, the potential of the auxiliary electrode 3 is sufficiently high to provide for the ignition of tube 1 during each positive half-wave of its anode voltage.

When the charging circuit is closed, provided the arrangement and connections of the windings are such that the operating half-waves or current flow through the charging circuit coincides with the positive half-waves of the anode voltage of tube 1, the potential of the auxiliary electrode will be decreased below the value required for the ignition of the tube 1.

This interrupts the current flow in the anode circuit and deenergizes the magnet 7, which in the arrangement shown then will cause the contact 8 to close the circuit X controlled by same.

However, with the gradual charging of the condenser 5, the voltage drop in the resistance 6

decreases and the extent by which this voltage drop reduces the potential of the auxiliary electrode gradually diminishes. After a given time interval, the value of which can be adjusted with great precision and in a simple manner by the proper adjustment of the variable resistance 6, the auxiliary electrode again assumes a sufficiently positive potential to allow the ignition of the tube 1.

10 The current flow through the anode circuit is thereby reestablished, the magnet coil 7 reenergized and the contact 8 opened.

It is evident that the energization of magnet coil 7 instead of being used to effect the opening of the contact 8, can be used in an analogous manner to effect the closure of a similar circuit control contact.

For the proper adjustment of the duration of the suppression of the anode current, and thus of the closure or opening of the contact 8, besides making the resistance 6 variable, the capacity of the condenser 5 may also be made adjustable, which makes it possible to obtain a very fine adjustment. Such a circuit arrangement is therefore exceedingly well suited for a time switch for X-ray installations, especially for taking exposures of very short duration, in which case the exact adjustment of the exposure time is of very great importance.

30 It should be, of course, understood that the magnet switch 7-8 has to be of such character as to respond to the pulsatory current passing through the anode circuit.

Between successive uses, the switch 15 is placed in the position I, whereby the condenser 5 is short-circuited and loses its charge almost instantaneously.

Instead of providing a separate transformer winding to supply the charging current, it is also possible to use for this purpose the same winding which feeds the anode circuit of the tube 1. This is illustrated in Fig. 2, the arrangement of which, however, differs from that of Fig. 1, also in several other respects. While in the arrangement of Fig. 1, the anode circuit 1 is energized all the time except when suppressed during the charging of the condenser and thus the tube 1 acts as a normally energized or "closed circuit" relay, in the arrangement of Fig. 2, the current through tube 1 is always suppressed except for the duration of the charging of the condenser, thus the tube operates as a normally deenergized or "open circuit" relay.

While the discharge circuit of the condenser 5 and the connections to the junction point 35 are unaltered in Fig. 2, the other end of the resistance 6 instead of being connected to an intermediate tap of the secondary transformer winding 16—which in this case feeds both the anode circuit of tube 1 as well as the charging circuit—is connected to the anode 11 of the rectifier tube 9. The cathode 10 of the tube 9 is connected to the end terminal 40 of the winding 16, close to which a tap 41 is provided, the portion 40 to 41 of the winding supplying the heating current for the rectifier cathode 10.

The winding 16 is furthermore provided with two closely spaced taps 42 and 43, which supply the heating current for the cathode 2 of tube 1, the tap 42 also serving as the cathode terminal of the anode circuit.

Furthermore, between the tap 43 and the terminal 44 of winding 16, there is provided a tap 17, or to permit adjustment of the voltage pref-

erably a plurality of taps—the tap 17 being connected to the contact II of the charging circuit.

The anode 4 of the tube 1 is connected as before through the magnet winding 7 to one end terminal (44) of the transformer winding 16.

Normally, the switch 15 occupies the position I, and the condenser 5 is short-circuited. The charging circuit being open, no current flows through the rectifier tube 9, but its heated cathode 10 emits electrons and impresses upon the grid 3, with which it is in electrical connection, a charge which gives the grid a negative bias with respect to its cathode 2. As a result, the anode current through the tube 1 is blocked.

The charging circuit goes through winding 16, rectifier 9, resistance 6, condenser 5, switch 15, contact II, and tap 17. It will be noted that in this arrangement the rectifier is connected to a point of the winding, the potential of which is further away from that of the anode 4 than is the potential of the cathode tap 42. Thus the charging circuit and the anode circuit are in phase opposition.

When the switch 15 is brought in position II, a voltage is applied to the grid 3, which corresponds to the voltage induced in the winding portion 42-17 and which in the operative half-wave of the anode voltage increases the grid potential above the ignition value. However, as the condenser charges, the potential applied to the grid 3 is gradually reduced, and in a predetermined time interval the grid potential falls below the value required to permit the ignition of the tube. Thus the anode current is interrupted and the contact 8 is actuated.

In this arrangement, the negative electrode of the condenser is connected to the auxiliary electrode 3, the potential thereof being thus directly dependent on the condenser voltage.

It should be noted that the duration of the current through the anode circuit of tube 1 is not affected by the instantaneous value of the anode voltage at which the switch 15 closes the charging circuit, as the charging of the condenser can only start in the operative half cycle of the anode potential.

The proper adjustment for the duration of the anode current can be obtained by either the adjustment of the resistance 6, or that of the condenser 5 or of the tap 17 or by a combination of these adjustments.

In the arrangement of Fig. 2, if energization of coil 7 should cause the closure of contact 8, a biasing spring 45 serves to hold the contact 8 normally open. When the coil 7 is energized, the pull of the magnet overcomes the spring 45 and the contact 8 is closed.

Figure 3 shows a further modification of my invention, which gives an arrangement similar to that of Fig. 2 except for the provision of a three-position instead of a two-position switch and the addition of a resistance 20 connected across a portion of the winding 16.

The switch 18 contacts with a segment 19 in the positions I and III, the segment 19 being connected to the junction point 35. In position I, the switch short-circuits the condenser 5 in the same manner as in the previous figures.

In position II, the switch establishes the charging circuit of the condenser in the same manner as in Fig. 2, except that contact II instead of being connected to a tap of the winding 16 is now connected to a movable contact 21 of the resistance 20, which is connected as a potentiometer across part of the winding 16. This pro-

vides for a more convenient variation of the bias voltage to be applied to grid 3.

Preferably, the resistance 20 is shunted across a portion of the winding 16, which portion extends on both sides of the taps 42 and 43 for the cathode 2. Thereby, it is made possible, to better adapt the bias voltage to the characteristic of the tube 1, and if required, the tube may be operated without grid bias, or with negative grid bias.

In the position III, the condenser remains short-circuited, but the contact III, being connected to the movable contact 21, the grid is kept continuously at a sufficiently high potential to maintain the ignition of tube 1. Thus, a current is maintained in the anode circuit as long as the switch is kept in position III.

The arrangement shown in Fig. 3 thus permits to effect either a short time control of predetermined duration or may perpetuate a desired condition. For instance, when applied to X-ray installations, the arrangement may be used both for short radiographic exposures and for continuous fluoroscopic work. In such case, I prefer to combine with the switch 18 other regulating means which upon movement of the switch into the positions II and III respectively, cause the establishing of the proper voltage and current values of the X-ray for radiographic and fluoroscopic work respectively.

The arrangement of Fig. 4 is similar to that of Fig. 2, except for the following. A separate winding 22 is used for the heating of the cathode 2 of tube 1, the contact II is connected to the winding 22 instead of to the tap 17, whereas the latter is connected to the heel 34 of the switch 15.

In this arrangement, the anode circuit of tube 1 is altogether interrupted, until the charging circuit is closed when the switch 15 takes the position II. This arrangement has the advantage that undesired ignition of the relay tube 1 is avoided even if—due to some uncontrollable circumstances, for instance, due to extraneous reasons—a high voltage impulse is induced in the anode circuit which otherwise might ignite the tube in spite of the sub-ignition potential applied to the grid.

In this arrangement the charging of the condenser starts as soon as the switch leaves the contact I, whereas the anode circuit only closes when the switch has contacted with II.

In the arrangement of the Figures 2 to 4 the drawback may occur that the end of the time interval during which the switch 8 should remain closed is not exactly defined and that current impulses which, due to the lower grid potential, start at a later phase, become transitory, so that the switch 8 instead of being positively actuated is caused to chatter over a plurality of cycles.

This drawback is entirely avoided and the advantages of the arrangement of Fig. 4 maintained by the arrangement shown in Fig. 5.

In this arrangement, the cathode 2 is again connected to the winding 16, whereas the electrode of the condenser 5 is connected to the tap 17, similarly to Fig. 4.

The switch 15 is omitted, and the armature of magnet coil 7 is provided with two additional contacts 23 and 24. Furthermore, there is provided in the anode circuit a manually operable switch 25. The contact 23 is adapted to short-circuit the condenser 5, whereas the contact 24 is in multiple with the switch 25 and serves as a stick contact for the magnet 7.

As long as the switch 25 is kept open the anode

circuit is interrupted and the spring biased armature of magnet coil 7 is in its upper position, whereby contact 23 short-circuits the condenser, whereas contacts 24 and 8 are open.

When switch 25 is closed, the anode circuit is immediately established as the grid 3 assumes simultaneously with anode 4 a positive potential, coil 7 is now energized and breaks contact 23 and makes contact 24 and 8. The switch 25 may be now released as contact 24 retains the anode circuit closed.

The condenser 5 being no more short-circuited charges up in the same manner as described in connection with Fig. 2 and after having charged to a given value causes a drop of the grid potential, thereby interrupting the anode current and deenergizing the relay coil 7. Once the anode current is interrupted the magnet 7 cannot be re-energized and the chattering of the contact 8 is thus prevented.

It should be noted that in this arrangement the short-circuiting and discharging of the condenser takes place automatically.

To insure that the contact 24 be closed before the manual switch 25 is opened, the latter is preferably designed as an automatically opening switch provided with sufficient delay to insure the closure of the anode circuit until the magnet coil 7 has attracted its armature.

The automatic opening of the switch 25 is also desirable to prevent the prolonged closure of this switch which otherwise might again cause chattering of contact 8, due to the fact that after the magnet controlled switch has returned to its normal position and the condenser partly discharged closure of the switch 25 would re-establish the anode current.

In a specific embodiment used for controlling X-ray exposures, where the relay contact 24 required .05 second for its closure (after the switch 25 has been closed) and with a required minimum exposure time of .1 second, the automatic closure time of the switch 25 was selected to be .07 second. Or generally the time of closure effected by the switch 25 has to be larger than the time required for the closure of switch 24 and smaller than the minimum time during which the condition effected by contact 8 should persist.

As there are various known switch constructions suitable for this purpose and no novelty is claimed for this switch per se, its detailed description and illustration is not believed to be necessary.

It might be mentioned that a suitable construction for this switch is the one used in automatic telephone apparatus, which comprises a rotary disc which upon manual displacement is returned by a biasing spring at a fixed speed and during such return establishes and breaks certain circuit connections.

As stated, instead of using a gas-filled discharge tube for the relay tube 1, a high vacuum electron discharge tube may be used. In this case, the lowering of the grid potential instead of suppressing the ignition of the discharge tube, cuts off the current flow through the tube.

While I have described my invention in connection with certain embodiments and in certain applications, I do not wish to be limited to such embodiments and applications, but desire the appended claims to be construed as broadly as permissible in view of the prior art.

What I claim is:

1. A circuit arrangement for automatically

limiting the duration of an electrically controlled process, comprising a discharge tube having a cathode, an anode and a grid, a circuit for said tube, and means to initiate said process by the application of a potential of a given value to said grid and to interrupt said process by the application of a potential of a different value to said grid, said means comprising an electrical condenser and a normally open charging circuit for said condenser, and a variable resistance in said charging circuit, said resistance and one electrode of the condenser being interconnected with said auxiliary electrode, a transformer winding to supply the current to the tube circuit and to the charging circuit, a potentiometer connected across a portion of said winding and a switching device to connect the movable contact of said potentiometer to the other electrode of the condenser for the charging of said condenser.

2. A circuit arrangement for automatically limiting the duration of an electrically controlled process, comprising a discharge tube having a cathode, an anode and an auxiliary electrode, an anode circuit for said discharge tube and an alternating current supply for said circuit, a condenser and a charging circuit for same, means to apply a potential to the grid which is sufficiently high to permit the current flow through said anode circuit during the positive half-wave of said alternating current, and a three-position switch which in one of its positions short-circuits said condenser and in its second position applies said potential to the auxiliary electrode, and in its third position short-circuits said condenser and simultaneously applies said potential to the auxiliary electrode.

3. A circuit arrangement for automatically limiting the duration of an electrically-controlled process, comprising an arc discharge tube having a cathode, an anode, and an auxiliary electrode, a condenser and a charging circuit therefor, an anode circuit for said discharge tube including electro-responsive means, and a two-position switching device having a normal position in which it interrupts the anode circuit at a point outside the tube and a second position in which it establishes said anode circuit and initiates charging of said condenser, said condenser during the charging thereof impressing upon said auxiliary electrode a varying potential which after a predetermined time interval assumes a value at which current in the anode circuit is suppressed and said electro-responsive means is deenergized to cause interruption of the process.

4. A circuit arrangement for switching on an electric current and automatically limiting the duration thereof, comprising a transformer having a primary winding, a secondary winding and a tertiary winding, a gas-filled electric discharge tube having a filamentary cathode, an anode and an auxiliary electrode adapted to control the starting of the discharge of the said tube, said cathode being connected to said tertiary winding so as to be energized thereby, a second discharge tube having a filamentary cathode which is energized from a portion of said secondary winding and an anode, a variable resistance connecting said latter anode and said auxiliary electrode, an electromagnetically actuated relay switch having a magnet coil, the anode of said first discharge tube being connected through said coil to said secondary winding, said secondary winding having an intermediate tap between the connection to the anode

of said first discharge tube and the connection to the cathode of said second discharge tube and a condenser connected between said auxiliary electrode and said tap, a two-way switch connecting said tap in one position to the cathode of said first discharge tube and in a second position to said auxiliary electrode, thereby short-circuiting said condenser.

5. A circuit arrangement for switching on an electric current during a predetermined time, comprising a transformer having a primary winding, a gas-filled electric discharge tube having a filamentary cathode, an anode and an auxiliary electrode adapted to control the starting of the discharge in said tube, said cathode being connected over a portion of said secondary winding so as to be energized therefrom, a relay switch actuated by a magnet coil which is connected in series with a manually actuated switch between said anode and one point of said secondary winding, a tap intermediate between said point and said portion of the secondary winding and a condenser connected between said tap and said auxiliary electrode, said auxiliary electrode being further connected through a variable resistance and a second electric discharge tube having an anode and a filamentary cathode to a point of said secondary winding in opposite phase as said first point of this winding with respect to the portion energizing the cathode of said first tube, said second discharge tube being connected with its anode turned to the auxiliary electrode of said first tube and its cathode turned to the secondary winding, said relay switch comprising three circuit breakers one of which is normally closed and short-circuits said condenser, the second of which is normally open and forms a stick contact for the said coil and the third of which controls the current to be switched on by the circuit arrangement during a predetermined time.

6. In a timing device, an arc discharge tube having an anode, a cathode and a control electrode, a normally open anode circuit for said tube, means to gradually vary the control electrode potential from a definite value which is positive with respect to the cathode and makes the tube conductive to a lower value which makes the tube non-conductive, said means comprising an electrical condenser and a normally inoperative charging circuit therefor, and switching means connected to said two circuits to simultaneously switch on the charging current through said condenser and close the anode circuit at a point outside the discharge tube.

7. In a timing device, an arc discharge tube having an anode, a cathode and a control electrode, an anode circuit for said tube having an interruption outside said tube, a second circuit comprising an electrical condenser and means to normally maintain said condenser discharged, a transformer winding common to said two circuits and having a variable intermediate tap, a rectifier in said second circuit having its negative side connected to said winding on one side of said tap, said anode being connected to said winding on the other side of said tap, said condenser being connected between said control electrode and said mid tap, and means connected with both said circuits to simultaneously permit charging of said condenser and remove the interruption in the anode current circuit.

8. In combination, an electric discharge tube having an anode and an incandescent cathode spaced apart to form a discharge path, and a

control electrode in said path, a condenser having one electrode connected to said control electrode, an anode circuit for said tube including the discharge path and current responsive means, a charging circuit for said condenser and including same, a heating current circuit for energizing said cathode and including same, said circuits having common portions, and switching means connected to said charging circuit and to a point of said anode circuit outside said discharge path to selectively make said charging circuit operative or inoperative and to establish said anode circuit when said charging circuit is made operative.

9. In combination, an electric discharge device having an anode, a cathode and a control electrode, means for supplying anode current to said tube, means for applying to the control electrode a potential of such value as to render said discharge device normally conductive, means comprising a condenser to vary the potential of said control electrode between said value and a second value at which the tube is non-conductive, and means for switching on the condenser to gradually change the potential of the control electrode from the first value to the second value and for simultaneously establishing the connections to permit the flow of anode current.

10. In combination an electric discharge device having an anode, a cathode and a control electrode, a rectifier having a cathode and an anode, a series circuit including said condenser and said rectifier, a point in said circuit between said condenser and said rectifier being connected to said control electrode, means for supplying an alternating electromotive force to said circuit and between the anode and cathode of said discharge device, and a circuit arrangement including a two-position switching device, said switch in one position permitting the application of electromotive force to said rectifier and condenser and between the anode and cathode of said discharge device, said switching device in its other position preventing the application of electromotive force to said condenser and between the anode and cathode of said discharge tube.

11. In a timing device an arc discharge tube having an anode, a cathode and a control electrode, a transformer winding having an intermediate tap, an anode circuit for said tube com-

prising a magnetic relay coil and a portion of said winding to one side of said tap, a series circuit comprising a rectifier, a variable resistance, a condenser, and a portion of said winding at the other side of said tap, and a two-position switch included in the connection from the cathode of the tube to said winding, said switch in one position establishing said anode circuit and in the other position interrupting the anode circuit at a point outside the discharge tube and short-circuiting said condenser.

12. In a timing device, an arc discharge tube having an anode, a cathode and a control electrode, a source of alternating current comprising a transformer winding having an intermediate tap, a rectifier having an anode connected through a variable resistance to said control electrode, and a cathode connected to said winding at one side of said tap, a condenser connected between said tap and said control electrode, a current responsive device connected between the anode of said tube and a point on said winding at the other side of said tap, and a two-position switching device which in one position connects said tap to said cathode to establish the anode circuit of said tube and in its other position disconnects the tap from the cathode to interrupt the anode circuit and connects same to the control electrode to short-circuit the condenser.

13. In a timing device, an arc discharge tube having an anode, a cathode and a control electrode, a source of alternating current comprising a winding having an intermediate tap, a condenser connected between said control electrode and said tap, a rectifier having an anode connected through a resistance to said control electrode and a cathode, an open circuit relay switch having a coil connected with one end to a point on said winding on the other side of said tap and with its other end connected through said switch to the anode of said arc discharge tube, a second switch connected in multiple with said condenser and interconnected with said first switch, said second switch being closed when said first switch is open and being open when said first switch is closed, and an auxiliary switch connected in parallel with said first switch.

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