

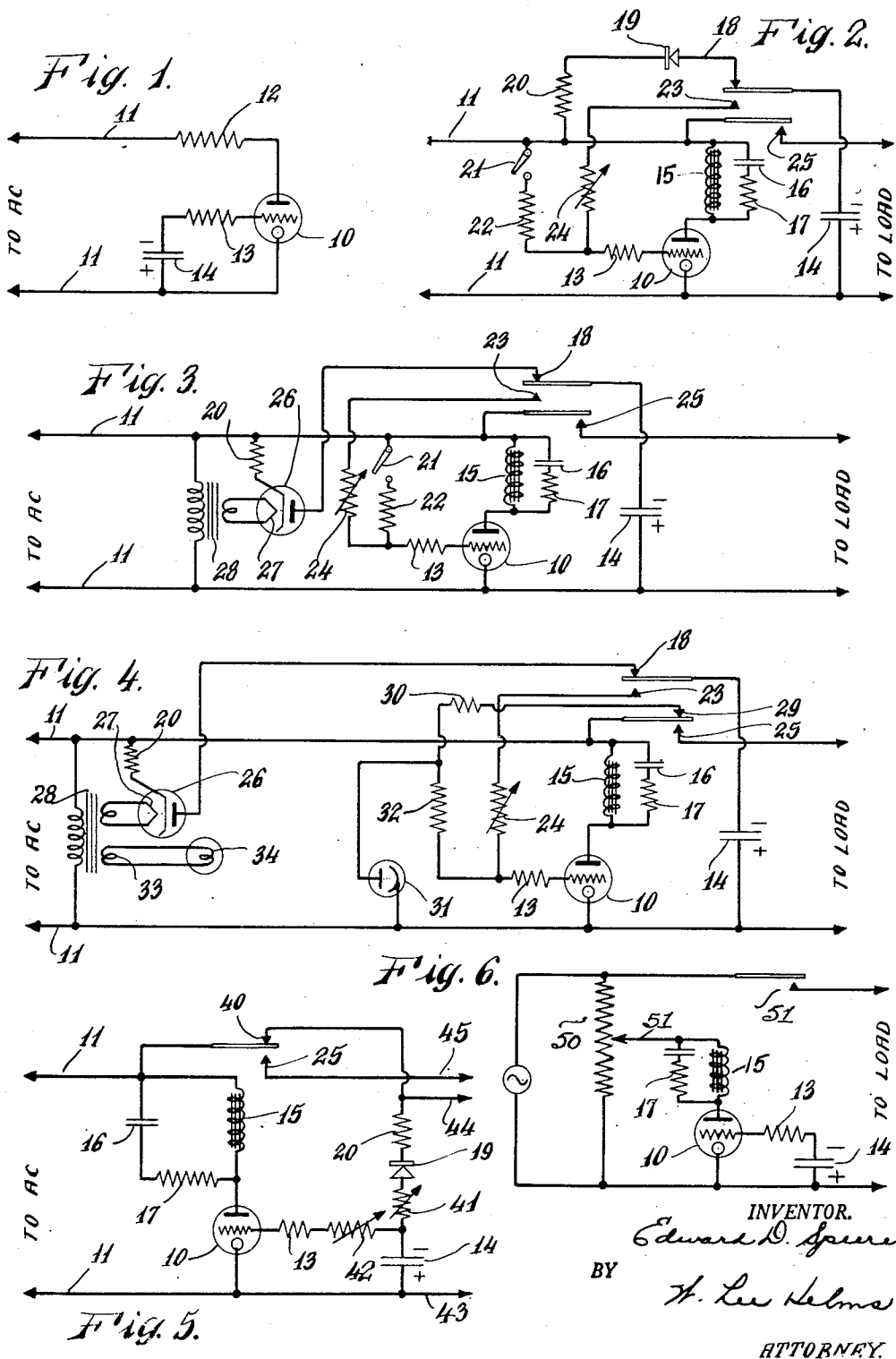
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COLD CATHODE TRIODE ELECTRONIC TIMER

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COLD CATHODE TRIODE ELECTRONIC
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This invention relates to electrical circuits in which electronic tubes of the gas filled, cold cathode type are employed to accomplish various timing operations.

It is well known in the electrical art to employ electronic tubes in conjunction with so-called RC circuits, to secure electrical timing of an operation. Such circuits employ a capacitor which is charged or discharged through a resistor. This combination of elements presents what is termed a time constant, which is the determining element in controlling the timing cycle. However, the electronic tubes hitherto employed in connection with such circuits have been of the hot cathode type, such as those employed in radio reception, or those known as thyatrons.

In the present invention, such time constant circuits are employed in conjunction with electronic tubes of the gas-filled cold cathode type. Such tubes usually contain at least a cathode, a main anode and a starting electrode, this last element being operated at such potentials that it is positive with respect to the cathode. The gas filling is usually neon, argon or krypton, each of these gases giving a characteristically colored discharge, upon operation of the tube.

The relay action of such tube is due to the fact that a relatively small amount of electrical energy supplied to the starter electrode will determine an ionization of the gas within the tube, which, in turn will initiate an electrical discharge, representing a much greater amount of energy, between the cathode and the main anode. This main discharge represents a current sufficiently intense to operate electro-mechanical devices connected in an external circuit extending from cathode to main anode, such as a relay capable of handling considerable power.

The circuits in which tubes of this type have been employed have hitherto been so arranged that the starting potential applied to the starter electrode has been positive with respect to the cathode, at the same instant that the main anode has been positive.

In the tubes of the prior art, such as the types known as OA4G and 1C21, there has been required a starting potential of about 85 volts, applied through not more than 20 megohms.

With the connections just described, a positive potential, applied to the starting electrode, causes an actual electronic flow from the cathode to the starting electrode, which later is energized in phase with the main anode voltage.

In the device of the present invention, a gas-filled, cold cathode tube is so connected that the instantaneous potential of the starting electrode is negative with respect to the cathode at the same time that the main anode has a potential positive in relation to the cathode. This method of connection allows the main discharge to be

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initiated by the application of a potential of 65 volts, to the starting electrode, through as much as 100 megohms, and yields a relay tube circuit of greater sensitivity and of smaller power consumption than has hitherto been found necessary, when such tubes are used.

One object of the present invention is to provide a timing circuit using a gas-filled, cold cathode relay tube, capable of operation with starting or triggering potentials of relatively low value.

Another object of the present invention is to supply a relatively simple timing circuit in which the only moving elements are one or more armatures of a relay.

Yet another object of this invention is to provide a timing circuit which is set into operation by the momentary closure of an electrical contact, and which is automatically re-set, after the conclusion of a single cycle of operation.

Still another object of this invention is to provide an electronic timing circuit in which there is substantially no consumption of electrical energy during the quiescent intervals between timing cycles.

Another purpose of this invention is to provide an electronic timing device, in which the interruption of a beam of light will initiate a timing cycle.

Yet another purpose of this invention is to provide a time-cycle system in which the relative duration of the intervals, during which a load circuit is closed and is opened, is capable of being easily varied between predetermined limits, thereby affording a simple method of determining the "on" and "off" portions of a complete timing cycle.

Additional purposes and advantages of this invention will be apparent to those skilled in the art from the following specification, and from reference to the hereunto annexed schematic drawings, in which:

Fig. 1 shows the basic circuit of this invention;

Fig. 2 shows the circuit of a complete timer;

Fig. 3 shows a variant circuit, using a tube type rectifier;

Fig. 4 shows a timer photoelectrically controlled;

Fig. 5 shows yet another form of timer in which more than one portion of the time-cycle is electrically controlled; and

Fig. 6 shows a circuit adapted for relatively high voltage A. C. lines.

Referring now to Fig. 1, the gas-filled, cold cathode tube 10 is fed with alternating current of sufficiently great potential, e. g., 110 volts, via leads 11, having a load 12 in the anode circuit and also having a limiting resistor 13 and condenser 14 in series between the grid and cathode.

Consider that condenser 14 is charged to any voltage not less than the tube ignition voltage; it will slowly discharge through resistor 13 and the electronic path afforded within the tube. When the potential of condenser 14 falls below that needed to maintain cyclic discharge transfer to the main cathode-anode circuit, the tube will be extinguished. The time required for this process is according to the equation $T=kCR$, where C is the capacity of condenser 14, R the resistance of resistor 13 and k is a constant. Load 12 may be the coil of a relay to control an external circuit at a higher power level.

Referring now to Fig. 2, the similarly numbered elements to be found in Fig. 1 are here shown connected in a complete timer circuit. The load is the coil of a relay 15, shunted by a conventional holding circuit, comprising condenser 16 and resistor 17. When the relay 15 is not energized, an upper control 18 of relay 15, normally closes the charging circuit to condenser 14, via rectifier 19, of any suitable form such as the solid-couple type, and current limiting resistor 20.

Condenser 14 charges to approximately the peak line voltage, the rectifier being poled to give the condenser charge the polarity indicated by the conventional signs shown in the drawings. A momentary closure of switch 21 allows the line potential to be applied to the starter element of tube 10, via limiting resistor 22. This initiates ionization of the gas content of the tube and causes the flow of current to the anode thereof via relay 15. This current flow actuates the armature of the relay, thereby disconnecting condenser 14 from the charging circuit and connecting it, via lower contact 23, adjustable resistor 24 and limiting resistor 13 to the tube control electrode.

Condenser 14 now discharges via the series path comprising the two last-mentioned resistors and the internal ionized gas path within tube 10. Relay 15 is held energized during the half-cycles when the internal tube discharge ceases, thus keeping closed the external control circuit via lower control 25, by virtue of the holding circuit comprising condenser 16 and resistor 17. When condenser 14 is no longer able adequately to energize the tube starting electrode, current flow through relay 15 will cease, as already described in connection with Fig. 1. The relay armature will be retracted to again couple condenser 14 to the charging circuit, and the timer is again re-set, it being assumed that switch 21 is again open, as it was closed but momentarily, merely long enough to start the cycle described.

Adjustable resistor 24 allows the tube discharge period to be varied within predetermined limits, and the previously mentioned greater tube sensitivity obtained by the use of the relative polarities here shown, permit resistor 24 to assume a much greater value than would be possible with the polarities hitherto employed, thereby allowing the temporal value of the tube discharge period to be greatly increased beyond that otherwise obtainable. If the capacity of condenser 14 and the resistance of resistor 13 be maintained substantially constant, then the effective time constant, T , of the device will correspond to the equation $T=k'R$, where R' is the resistance of element 24 and k' is a constant, as previously explained in connection with Fig. 1.

It is to be remarked that the power consumption of this device, during periods when the tube is not discharging, is practically nil, except for the extremely brief surge of current through the

rectifier, to re-charge condenser 14, just subsequent to the completion of a discharge cycle. Likewise, this last mentioned operation is so brief in duration that the re-setting of the device may be considered to be practically instantaneous.

Reference is now made to Fig. 3, showing the use of an alternative form of rectifier for charging the main condenser of this device. The cold cathode tube 10, anode relay and holding circuit, starting circuit and time constant circuit, are here shown as identical with the same elements of Fig. 2. In lieu of rectifier 19 of Fig. 2, is substituted a monanodic ionic rectifier 26, limiting resistor 20 performing the same function as previously described. The heating element 27, of this rectifier is conveniently fed from a transformer 28, which latter derives its energy from the alternating current mains 11.

In Fig. 4 the timer proper is connected to charge condenser 14 and to discharge it through tube 10, thus closing the load circuit at contact 25, in the same manner as described in connection with Fig. 2. However, the lower armature in relay 15 is provided with an additional upper contact 29. This contact, when relay 15 is deenergized, provides a path for the line current via limiting resistor 30 to a photoelectric cell 31, the current passing through his cell to the other supply lead. The end of resistor 30 which is connected to cell 31, is also connected via another resistor 32 and thence through resistor 13, to the starting electrode of tube 10.

Transformer 28 is provided with an additional winding 33, to which is connected a suitable electric lamp 34. In the case that lamp 34 operates upon the same voltage as the heater 27 of rectifier 26, a single secondary winding may be employed to feed both these elements. Under normal conditions the light proceeding from lamp 34 falls upon photocell 31, and the flow of current through this cell, from resistor 30, keeps the voltage developed across photocell 31 below a value sufficient to initiate the main discharge of tube 10. When the light beam reaching photocell 31 is interrupted, the current through the cell is decreased substantially to zero, thereby raising the voltage developed across photocell 31 and impressed upon the starting electrode of tube 10 via resistor 13 to a value sufficient to trigger this tube. Closure of the armatures of relay 15 causes the discharge of condenser 14 through adjustable resistor 24 in the same manner as previously discussed. The opening of contact 29 removes the photocell from effective control of the circuit, until discharge of condenser 14 has proceeded to the point where the armatures of relay 15 are again retracted; at which time the device is automatically re-set by re-closure of contact 29. In lieu of ionic rectifier 26, there may be employed a rectifier of the solid-couple type, already shown in Fig. 2. Such rectifiers, using copper oxide, silicon, selenium, magnesium sulphide, etc., are well known in the art, so that detailed description thereof is unnecessary.

Referring now to Fig. 5, the elements bearing similar reference numerals are identical with those already described in discussion of the previous figures of the drawings, and function in a generally similar manner. When contact 40 is closed, relay 15 being deenergized, rectifier 19 passes current at a rate determined by the value of variable resistor 41, and charges condenser 14. When the potential across this condenser is sufficient to fire tube 10, via variable resistor 42 and protective resistor 13, relay 15 closes, is held

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closed during inactive half cycles by holding circuit 16, 17, the armature shifts to contact 25, and condenser 14 ceases to charge. The condenser now discharges via resistors 42 and 13 and via ionized gas conduction within tube 10. The rate of this discharge may be determined by varying the value of resistor 42.

According to the position assumed by the armature of relay 15, output terminals 44 and 45 will alternately be connected to one side of the A. C. line, while output terminal 43 is at all times connected to the other side of the supply line. A circuit for controlling an external load (not shown) from terminals 43 and 45 will be energized or have "on" periods determined by adjustments of variable resistor 42, and will be de-energized or have its "off" periods determined by resistor 41. Alternatively, two external load circuits may be connected to terminals 43-44 and 43-45 and be alternately energized with the energized periods for each circuit independently adjustable.

Fig. 6 shows how my control circuit may be connected to an A. C. line carrying a potential too great to be directly applied to the tube. A voltage divider 50, has an adjustable contact 51, which feeds relay 15 and the anode of tube 10, connected to a point along the divider yielding a potential suitable for proper tube operation. The remaining elements here shown are similar to those shown in Fig. 2, the condenser charging and discharging circuits being here omitted, for purposes of clarity. Since the relay armature is connected directly to the A. C. line, the load circuit will receive full voltage, when using this method of connection.

While there have been shown and described certain embodiments of this invention, it is to be understood that many variations thereof will be apparent to those skilled in the art and accordingly the scope of this invention is limited only by the hereunto appended claims.

Having described my invention, what I claim and desire to secure by Letters Patent, is as follows:

1. A timing device, comprising a gas-filled, cold cathode type tube having a cathode, an anode, and a control electrode, an anode circuit energized from a source of alternating voltage connected to said cathode and said anode, a condenser, circuit means including a series-connected rectifier and said condenser for charging said condenser from said source of alternating voltage, circuit means connected to said cathode and including said condenser and a resistor which is series-connected between the negative side of said condenser, as charged through said rectifier, and said control electrode for predetermining the time period a negative potential is impressed on said control electrode by the discharging of said condenser through said resistor for maintaining the firing of said tube, and means responsive to the firing of said tube for interrupting the first named circuit means to prevent the charging of said condenser during the period that said tube is firing, whereby the time period during which the tube will fire is determined by the value of said resistor.

2. A timing device, comprising a gas-filled, cold cathode type tube having a cathode, an anode, and a control electrode, an anode circuit energized from a source of alternating voltage connected to said cathode and to said anode, a condenser, circuit means including a series-connected rectifier and said condenser for charging said

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condenser from said source of alternating voltage, circuit means connected to said cathode and including said condenser and a variable resistor which is series-connected between the negative side of said condenser, as charged through said rectifier, and said control electrode for variably predetermining the time period a negative potential is impressed on said control electrode by the discharging of said condenser through said variable resistor for maintaining the firing of said tube, and means responsive to the firing of said tube for interrupting the first named circuit means to prevent the charging of said condenser during the period that said tube is firing, whereby the time period during which the tube will fire is adjustably determined by the value of said variable resistor.

3. A timing device according to claim 1, wherein said means for interrupting the first named circuit means comprises a switch actuated by a relay in the anode circuit of said tube.

4. A timing device, comprising a gas-filled, cold cathode type tube having a cathode, an anode, and a control electrode, an anode circuit energized from a source of alternating voltage connected to said cathode and to said anode, a condenser, circuit means including a series-connected rectifier and said condenser for charging said condenser from said source of alternating voltage, circuit means connected to said cathode and including said condenser and a resistor which is series-connected between the negative side of said condenser, as charged through said rectifier, and said control electrode for predetermining the time period a negative potential is impressed on said control electrode by the discharging of said condenser through said resistor for maintaining the firing of said tube, circuit means connected between said control electrode and the terminal of said source of alternating voltage which is connected to said anode and including a switch for impressing a starting potential across said control electrode and said cathode of said tube when said switch is closed, and means responsive to the firing of said tube for interrupting the first named circuit means to prevent the charging of said condenser during the period that said tube is firing, and during this period for connecting said negative side of said condenser to said control electrode, whereby the time period during which the tube will fire is determined by the value of said resistor and is independent of said switch being continuously closed following the initial closing thereof required for initiating the firing of said tube.

5. A timing device in accordance with claim 4, wherein one terminal of said source of alternating voltage is connected to said cathode and to the positive side of said condenser, wherein a plate relay is connected in series between said anode and the other terminal of said source of alternating voltage, a single pole, double throw switch including two alternatively connected switch points and a movable switch armature controlled by said plate relay, a connection from said switch armature to the negative side of said condenser, a connection from one of said switch points with which said armature contacts when said relay is deenergized to said rectifier, and a connection from the other of said switch points to said control electrode, and means including an additional switch means actuated by said plate relay for controlling the energization of an external electrical load.

6. A timing device, comprising a gas-filled cold cathode type tube having a cathode, an anode, and a control electrode, an anode circuit energized from a source of alternating voltage connected to said cathode and said anode, a condenser, circuit means including a series-connected rectifier and said condenser for charging said condenser from said source of alternating voltage, circuit means connected to said cathode and including said condenser and a resistor which is series-connected between the negative side of said condenser, as charged through said rectifier, and said control electrode for predetermining the time period a negative potential is impressed on said control electrode by the discharging of said condenser through said resistor for maintaining the firing of said tube, means responsive to the firing of said tube for interrupting the first named circuit means to prevent the charging of said condenser during the period when said tube is firing and during this period for connecting said negative side of said condenser to said control electrode, and means for initiating the firing of said tube, comprising an impedance path which is closed at least when said tube is not firing, said path being connected between the terminals of said source of alternating voltage and having a point on said path connected to said control electrode, and said path including a light-sensitive cell for controlling the potential of said control electrode in accordance with the amount of light to which said cell is exposed, so that on said cell attaining a predetermined impedance value, the potential at said point on said path which is connected to said control electrode will be such as to initiate the firing of said tube.

7. A timing device in accordance with claim 6, wherein there is a plate relay connected in series in the anode circuit of said tube, a double throw switch controlled by said plate relay connected to make contact between said negative side of said condenser and said rectifier when said tube is not firing and connected to make contact between said negative side of said condenser through said series-connected resistor to said control electrode when said plate relay is energized by firing of said tube, and a second double throw switch actuated by said plate relay connected to complete a circuit through said light-sensitive cell only when said tube is not firing and said relay is deenergized and connected to close a circuit for the control of an external electrical load when said plate relay is energized by the firing of said tube.

8. A timing device, comprising a gas-filled cold cathode type tube having a cathode, an anode, and a control electrode, an anode circuit energized from a source of alternating voltage connected to said cathode and said anode, a condenser, series-connected circuit means including a rectifier, a first resistor, and said condenser for charging said condenser from said source of alternating voltage, a switch in said series-connected circuit means for interrupting current flow therethrough, continuously connected circuit means connected to said cathode and including said condenser and a second resistor which is series-connected between the negative side of said condenser, as charged through said rectifier, and said control electrode for predetermining the time period a negative potential is impressed on said control electrode by the discharging of said condenser through said second resistor for main-

taining the firing of said tube, and means responsive to the firing of said tube for opening said switch to interrupt the first named circuit means to prevent the charging of said condenser during the period that said tube is fired, whereby the time period during which the tube will fire is determined by the value of said second resistor and the time period required for the charging of said condenser while the tube is not firing and between each firing thereof is measured by the value of said first resistor.

9. A timing device in accordance with claim 8, wherein there is a plate relay connected in series in said anode circuit, a double throw switch controlled by said plate relay and connected to close a circuit through one external electrical load when said relay is deenergized during the time said tube is not firing and also connected to close a circuit through a second external electrical load when said relay is energized during the firing of said tube, whereby said electrical loads are alternatively energized for time periods independently predetermined by the values by the two resistors aforesaid respectively.

10. A timing device in accordance with claim 8, wherein said first resistor is a variable resistor for variably predetermining the time period said tube is not firing independently of the duration of each firing time of the tube.

11. A timing device in accordance with claim 8, wherein both said first and said second resistors are variable resistors, whereby the duration of time of each firing of said tube and the duration of each time period between each successive firing thereof may be independently determined.

12. A timing device in accordance with claim 8, wherein there is a plate relay connected in series in said anode circuit, a double throw switch actuated by said plate relay and including an armature and a pair of switch points alternatively engaged thereby when said plate relay is energized and deenergized respectively, a conductor connecting said armature to one terminal of said source of alternating voltage, a conductor connecting the other terminal of said source of alternating voltage to said cathode, to the positive side of said condenser, and providing a connection serving as one terminal for each of two external electrical loads, a conductor connecting one of said switch points to the other terminal of one of said electrical loads and to the negative side of said condenser through said rectifier and said first resistor, the other of said switch points serving as the second terminal of the second external electrical load, and a conductor connecting the negative side of said condenser through said second resistor to said control electrode.

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