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ELECTRIC TIMING DEVICE

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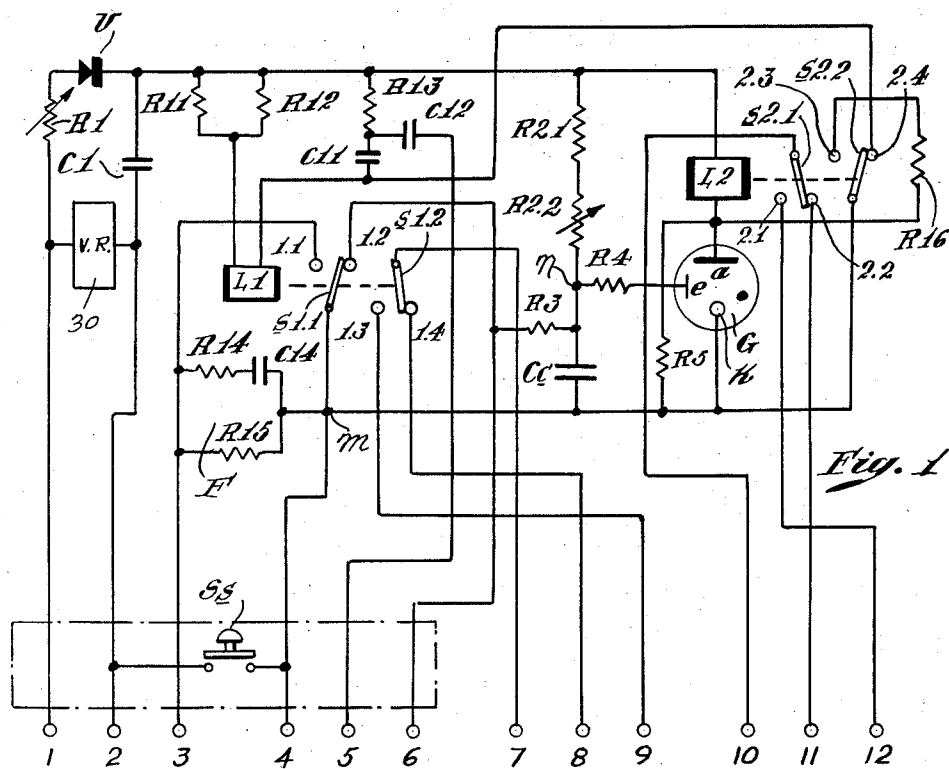


Fig. 1

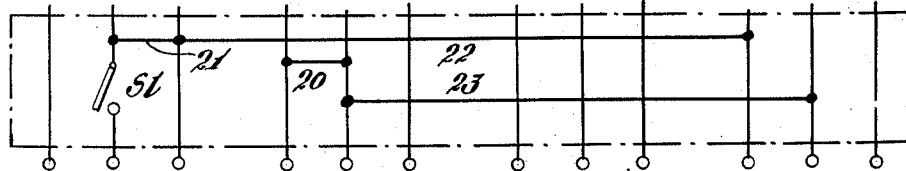


Fig. 2

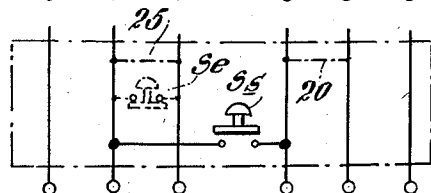


Fig. 3

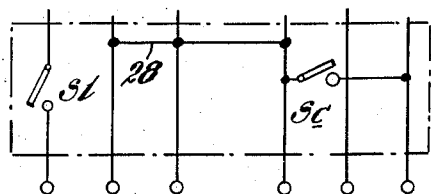


Fig. 4

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ELECTRIC TIMING DEVICE

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4 Claims. (Cl. 317-142)

The field of the present invention is generally that of electric timing devices, and more particularly that of electronic timers of the type wherein the time constant of a reactive network determines the time interval between the closing of a starting switch and a change in the conductivity of a cold cathode tube whose control electrode is connected to the timing network.

It is for various reasons desirable to employ cold cathode tubes in devices of this type, among others because they do not require stand-by heating current, are comparatively inexpensive and rugged and provides instantaneous on-off operation. However these tubes are not fully reliable under all operating conditions being affected by ionization from the outside and by transients on the starting discharge, being sensitive to polarity in case of some times unavoidable leakage through a starting switch, being subject to unpredictable firing of the control tube immediately upon operation of the starting component, and having sometimes a tendency to miss fire in spite of grounding of the negative supply terminal due to a residual charge on the timing capacitor. Several such disadvantages have been removed or at least alleviated by circuitry of the type disclosed in my Patent 2,650,301 of August 25, 1953, but others, the causes of some of which are not fully understood, have not been fully eliminated in hitherto available apparatus of this type.

Objects of the invention are accordingly to provide electric timing devices which avoid the above indicated defects to a heretofore unattainable degree, to provide electronic timers which employ only direct current relays of one and the same type including plastic enclosed plug-in relays in A.-C. energized circuits, and which prolong the life of the tube by cutting it out under stand-by conditions, to provide such devices which are very versatile, permitting by way of simple changes of terminal connections, operation for various purposes such as recycling, repeat cycle timing non-repeat operation, momentary start, sustained start with immediate reset, self or manual-resetting, emergency timing-out in the middle of a timing cycle, and various other functions which are desirable for industrial control purposes, to provide such devices which permit a choice between considerably different timing ranges (such as thirty seconds and two seconds) which allows application to all short interval timing problems, to provide timers which permit the use of load contacts that operate at the beginning and other load contacts that operate at the end of the time delay, to provide such devices whose load contacts are wholly independent of the timer circuit, and generally speaking to provide devices of this general character which are simple, rugged and optimally dependable because they eliminate or at least greatly alleviate uncertainties of operation due to little understood properties of cold cathode gaseous discharge tubes.

A brief summary of the invention which will serve to indicate its nature and substance in some of its principal aspects for attaining the above objects is as follows.

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Timing devices according to the invention comprise, arranged for complete direct current operation from an alternating current supply of any industrial frequency by means of a rectifying intermediary, a timing circuit including a cold cathode tube, a timing actuator, such as a solenoid, in series with the tube, a timing capacitor between the control electrode of the tube and one of the direct current supply terminals, and a normally closed discharging switch for shunting the timing capacitor, and a control circuit including a control actuator, such as a solenoid, arranged for operating the discharging switch, and a timer switch that is actuated by the timing actuator for normally connecting the control actuator with one of the two terminals. Load control switch means are associated with at least one of the two actuators and these switches are preferably double throw single pole switches. In many embodiments, a normally open starting switch is connected between one of the alternating current lines and the direct current timing and control circuits, but the timing can also be initiated by means of a switch in an alternating current supply line which is connected in series with the starting and timer switches. In other practically important aspects of the invention, the reliability of the timer is further materially enhanced by a delaying capacitor that is connected in parallel to the control circuit, by a hold-in capacitor that is arranged for charging during the time delay and is connected across the timing actuator by the timer switch, and by a filter network connected to the discharging switch and manifesting a decidedly beneficial effect probably by its absorption of transients due to the opening of the discharging switch. The filter includes a resistor which drains static charges from the tube in stand-by condition. The circuitry of the timer according to the invention is such that both timing and control may be advantageously carried out by single pole double throw switches; since the load control switches are preferably also single pole double throw switches in both relays, the latter can be of identical direct current design.

These and other objects and characteristic aspects of the invention will appear from the herein presented outline of its mode of operation and its practical possibilities together with a detailed description of several practical embodiments illustrating its novel characteristics.

The description refers to a drawing in which:

Fig. 1 is the circuit diagram of a practical embodiment of the invention; and

Figs. 2, 3 and 4 are diagrams illustrating additional embodiments and possibilities of using the timer according to the invention, Figs. 2, 3 and 4 being modifications of the block indicated by dot and dash lines in Fig. 1.

It will be noted that decimal numerals are herein used in some instances for denoting members of a group of elements with similar functions or of components of an assembly or subassembly, and that the common integer numeral is sometimes used for shortly and significantly denoting several members of the group or assembly.

In Fig. 1, numerals 1 and 2 denote terminals which can be connected to any standard, such as a 105 to 125 volt, 25 to 400 cycle, alternating current source, and terminals 3, 4, 5 and 6 provide for auxiliary connections adapting the device to various operating conditions four of which are mentioned in the above summary. The terminals numbered 7 through 12 permit the connection of the actuating switches of the device to suitable loads. The terminals are preferably arranged on a small panel which is attached to the chassis on which the device is mounted and to which the control knob for the timing resistor R2.2 is also fastened. Numeral 30 indicates a conventional voltage regulation circuit which can be used if very high accuracy is prescribed, but the device according

to the invention is sufficiently accurate for most purposes if directly connected to the usual commercially available alternating current supplies.

A conventional rectifier is indicated at U, a protective series resistor at R1, and a filter capacitor at C1. L1 and L2 are the magnets of relays of conventional type, each having two double throw, single pole contact systems; the device is conceived in such a manner that identical relays can be used in both places. The tube G is a conventional cold cathode discharge device with cathode *k*, anode *a* and control electrode *e*. Practical values or types of the above referred to components are given hereinbelow, together with those of the remaining conventional impedance elements whose nature and electrical connections are clearly shown in the figures. These structural characteristics are listed so far as essential for the proper operation of the device with reference to the numerals of the figures, it being understood that adjustments and mutual correlations have to be applied upon initial testing for proper performance, according to routine practice in the manufacture of devices of this type.

Resistors:

R1: 47 ohm, 1 w.	R11, R12: 8.2 K, 2 w.
R2.1: 10 K, 1 w.	R13: 330 ohm, 1.5 w.
R2.2: 10 megohm	R14: 1.5 K, .5 w.
R2, R13: 330 ohm, .5 w.	R15: 10 megohm, .5 w.
R4, R5: 56 K, .5 w.	R16: 1.5 K, 2 w.

Capacitor:

C1: 40 mfd., 150 v., electrolytic
 C11: .5 mfd., 200 v.
 C12: 8 mfd., 150 v., electrolytic
 C14: .1 mfd., 400 v.
 Cc: .5 to 4 mfd., 200 v., Mylar

Rectifier U: 75 ma., 130 v., selenium

Tube G: Cold cathode, Type 5823

Relays L1 and L2: 6500 ohm, 75 v. D.-C.

The above described device operates as follows.

Assuming that the starter switch Ss is depressed during the entire timing cycle, its closure energizes the control actuator solenoid L1 through circuit

1—L1—s2.2—m—4—Ss—2

Switches s1.1 and s1.2 transfer from the contacts 1.2 and 1.4 to the contacts 1.1 and 1.3. The control capacitor Cc, which was heretofore short-circuited through the contacts s1.1 and 1.2 and the resistor R3 begins to charge in the circuit 1—R2.1—R2.2—Cc—m—Ss—2. The timing cycle is now running and when the voltage at the point *n* reaches the firing potential of the tube G, the tube begins to conduct, the time interval from the closing of Ss to the firing being determined by the rate of charge that can be adjusted by means of the potentiometer R2.2. The tube current energizes the timing actuator solenoid L2, and the switches s2.1 and s2.2 transfer from contacts 2.2 and 2.4 to contacts 2.1 and 2.3. The opening of 2.4 de-energizes the control actuator L1 and the contacts s1.1 and s1.2 are transferred back to original position. The electrode *e* loses control of the tube G after it has fired and the tube is extinguished by shunting it with the resistor R16 which shunt reduces the voltage across cathode *k* and anode *a* below that required to maintain the conduction after the electrode *e* is again at cathode potential. L2 is then held energized through R16, until Ss is opened, which de-energizes L2, the timer being now reset for another timing cycle.

The load terminals 7 to 12 are connected or disconnected by the transfer of the movable contacts s1.2 and s2.1.

As mentioned in my above mentioned patent, the resistor R5 counteracts tendencies of the tube G to misfire. The contact s1.2 may be of the make-before-break type which prevents a small charge from entering the

timing capacitor Cc while the relay contacts transfer, which charge might slightly affect the timing interval.

In certain embodiments, the holding switch constituted by contacts s1.1 and 1.1 complements the starting switch.

The following features particularly distinguish the present invention from my above mentioned previously developed timer.

The arrangement of the starting switch Ss and of the control relay L1 on the direct current side assures with full safety instantaneous starting, and also permits the non-repeat and self-recycling operations which will be described hereinbelow. The load contacts 7 to 12 are fully isolated, and their operation is independent of the supply line frequency. The connection of one terminal of the starting switch to the moving contact s1.1 of the control actuator L1 permits the arrangement of a normally open fixed contact 1.1 which can be used as a holding contact as will be described with reference to Fig. 1. Current limiting resistors R11, R12 are respectively arranged in series with the solenoid L1 in order to permit the use of identical coil voltage ratings for both relays, these series resistors reproducing the voltage drop across the tube.

The auxiliary resistor R16 is connected across the tube G when the movable contact s2.2 transfers from 2.4 to 2.3 at the end of the time delay to de-energize L1 as above described; this insertion of the R16 reduces the voltage on the tube thus extinguishing it and preventing wear thereon.

By connecting the jumper 20 between terminals 4 and 5, the 8.0 microfarad hold-in capacitor C12 can be made effective such that it becomes fully charged during the time delay whereupon it is inserted across the coil L2 when the contacts s2.2 and 2.3 close at the end of the delay. This provides a momentary hold-in of the relay L2 at the end of the delay when the timer resets itself by opening the contact 1.1. This feature is particularly desirable when a solenoid or similar load is to be energized after delay with the timer modified for self-resetting operation according to the embodiment which will be discussed below with reference to Fig. 3.

The 0.5 microfarad delaying capacitor C11 slows down the release of the relay L1 so that the contacts s2.2 can transfer safely to 2.3 before L1 opens the holding contact 1.1, to de-energize L2.

The filter network F, composed of resistors R14, R15, and the capacitor C14 is particularly useful in connection with the arrangement of the contacts 1.1 and 1.2 for transfer therebetween by means of the single movable contact s1.1, these contacts forming a single pole double throw switch. This network practically eliminates the transient inductive kick due to the opening of contact 1.1 which might otherwise adversely affect the tube. The 10 megohm resistor R15 of the network F has the further beneficial effect of drawing static charges from the tube G when the latter is in stand-by condition. Needless to say this effect is present only if terminals 2 and 3 are interconnected, such as by a jumper as indicated at 21, 25, 28 of Figs. 2, 3, 4 respectively.

It will now be evident that the above described circuitry is peculiarly organized in such a manner that the holding contact 1.1 and the timing contact 1.2 on the one hand, and the auxiliary contact 2.3 for R16 and C12 and the control contact 2.4 on the other hand, can be associated with the moving contacts s1.1 and s2.2 to constitute single pole double throw systems. Since the load switches are advantageously also similar, and the coils can be made similar by means of the resistor R11, R12, the two relays can be identical which considerably simplifies the circuitry, the manufacture and the maintenance.

As pointed out above, the terminal arrangement according to Fig. 1, with the starter switch Ss between terminals 2 and 4 (for short referred to as "maintained start" arrangement) is used for operation with the start

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switch *S_s* remaining closed for the duration of the time delay. In this embodiment the contact *s1.2* transfers at the beginning of the delay period and returns to normal when contact *s2.2* transfers at the end of the delay. The opening of the starting switch *S_s* resets the timer and at the end of the time delay the contact *2.1* remains connected to *s2.1* and *2.2* remains open until the starting switch is released and opens.

The arrangement according to Fig. 2 incorporates a normally open line switch *S_l* on terminal 1 or 2, jumpers 20 and 21, and connecting wires 22 and 23 between terminals 3 and 10, and 5 and 11 respectively. In this embodiment ("repeat cycle" timer), closure of the line switch *S_l* transfers *s1.1* immediately. After the time delay, *s2.1* transfers from *2.2* to *2.1* for approximately 60 milliseconds. At the same time contact *s1.2* opens *1.3* and closes *1.4* for approximately 60 milliseconds. The cycle repeats so long as the line switch *S_l* remains closed. The time interval between the pulses produced by the relay contacts can be adjusted by means of the potentiometer *R2.2* as pointed out above.

The embodiment according to Fig. 3 ("momentary start, self-reset, non-repeat" circuitry) has a normally closed emergency stop switch *S_e* or instead a jumper 25, which alternatives are indicated in dot and dash lines. This circuit also has a starter switch *S_s* connected between terminals 2 and 4 as described above with reference to Fig. 1. In addition this embodiment can have the optional jumper 20 between terminals 4 and 5 which is required if the movable contact *s2.1* must remain on the contact *2.1* for about 60 milliseconds for energizing a load momentarily. In this embodiment the contact *s1.2* transfers at the start of the delay and resets at the end of the delay. The contact *s2.1* transfers at the end of the delay period. The timer according to this embodiment resets if the starting switch *S_s* is open at the end of the delay period, contact *s2.1* remains on *2.1* and transfers from *2.1* to *2.2* only when the starter switch is opened. The emergency stop switch *S_e* has the purpose of immediately stopping operation upon opening thereof.

The embodiment according to Fig. 4 ("stop motion control") embodies a line switch *S_l* in the position referred to above with reference to Fig. 2, a control switch *S_c* between terminals 4 and 6, and jumpers 28, 29 between terminals 2 and 3, and 3 and 4, respectively. In this embodiment the coil *L₁* is energized when *S_l* is closed whereupon switch *s1.2* immediately transfers from *1.4* to *1.3*. If the control switch *S_c* is open, the timer operates as usual. However, if the control switch *S_c* is closed, a new time delay is started, but *s1.2* remains on *1.3* with *1.4* open. If the control switch *S_c* is closed before the time delay has elapsed, the movable contact *s2.1* retains contact with *2.2*, but if the control switch is open, the timer is caused to end the cycle and *s2.1* transfers from *2.2* to *2.1*. In order to reset this embodiment the line switch must be opened whereupon *s1.2* and *s2.1* return into their normal position such as shown in Fig. 1.

Other modes of operation can be easily set up, and two possibilities will now be briefly indicated without illustration, as follows.

For starting by opening the starting switch, a normally closed starting switch is inserted between the terminals 3 and 4 and a normally closed emergency switch or jumper is connected between 2 and 3. In this case contacts *1.3* and *2.2* are open, and *1.4* and *2.1* closed at the start of the time delay. Momentary opening of the starting switch closes *1.3* and *2.2*, and opens *1.4*, *2.1* for the duration of the delay. At the end of the delay, all contacts return to their original position.

For instant timing out during a cycle, a starting switch is used between terminals 2 and 4, and a normally open emergency switch between 5 and 6. Closure of the starter transfers *s1.2* at once, and upon completed delay

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s2.1 transfers and *s1.2* transfers back. Closure of the emergency switch transfers *s2.1* at once and re-transfers *s1.2*. Release of the starter re-transfers *s2.1*. If the starter switch opens during the delay period, the timer is reset and contact *s1.2* re-transfers.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. A timing device comprising: direct current supply terminals; a timing circuit including a gaseous discharge tube of the cold cathode type having anode cathode and control electrode, a timing actuator in series with said anode and cathode, timing capacitor means between said electrode and one of said supply terminals, and single pole double throw discharging switch means for normally shunting said timing capacitor means and for establishing instead a holding connection for said timing actuator upon energization of the timing actuator; a control circuit including a control actuator arranged for connection to said terminals and for retaining said discharging switch means normally open, an auxiliary resistor connected on one side to said anode, and a single pole double throw timer switch means operated by said timing actuator for normally connecting said cathode with said control actuator and for connecting instead the other side of said auxiliary resistor to said cathode upon energization of said timing actuator; and load control switches of the single pole double throw type associated for operation with at least one of said actuators; whereby both actuators and the switch means can be of identical direct current construction for establishing a holding circuit, for extinguishing the tube to prolong its life while retaining the timing actuator energized, and for operating the load control switches upon energization of the respective actuators.

2. A timing device comprising: an alternating current source; rectifying means connected to said source and having direct current supply terminals; a timing circuit including a gaseous discharge tube of the cold cathode type having anode cathode and control electrode, a timing actuator in series with said anode and cathode, a timing capacitor between said electrode and one of said supply terminals, and normally closed discharging switch means for shunting said timing capacitor; a control circuit including a control actuator arranged for operating said discharging switch means, and timer switch means actuated by said timing actuator for normally connecting said control actuator with one of said terminals; load control switches associated for operation with at least one of said actuators; normally open starting contact means arranged in series with said anode, said cathode and said terminals and adapted to close the connection of said control actuator to both said terminals; a hold-in capacitor connected in series with said starting contact means between said timer switch means and one of said terminals; and a delaying capacitor connected between said timer switch means and said control actuator; whereby the actuators are completely direct current actuated, the release of the control actuator is slowed down by the delaying capacitor, and the actuation of the timer switch means is shortly delayed by the hold-in capacitor.

3. A timing device comprising: direct current supply terminals; a timing circuit including a gaseous discharge tube of the cold cathode type having anode cathode and control electrode, a timing actuator in series with said anode and cathode, a timing capacitor between said electrode of one of said supply terminals, and discharging switch means for shunting said timing capacitor; a control circuit including a control actuator arranged for retaining said discharging switch normally open, an auxiliary resistor connected on one side to said anode, and a single pole, double throw timer switch means

operated by said timing actuator for normally connecting said cathode with said control actuator and for connecting instead said auxiliary resistor to said cathode upon energization of said timing actuator; load control switches associated for operation with at least one of said actuators; a hold-in capacitor connected in series with said starting contact means between the movable contact of said timer switch means and one of said terminals; and a delaying capacitor connected between said movable contact of said timer switch means and said control actuator; whereby the tube is shunted upon termination of the time delay, the timing actuator is momentarily held in, and the release of the control actuator is slowed down.

4. A timing device comprising: direct current supply terminals; a timing circuit including a gaseous discharge tube of the cold cathode type having anode cathode and control electrode, a timing actuator in series with said anode and cathode, a timing capacitor between said electrode and one of said supply terminals, and single pole double throw discharging switch means for normally shunting said timing capacitor and for establishing instead a holding connection for said timing actuator upon energization of the timing actuator; a control circuit including a control actuator arranged for retaining said discharging switch normally open, an auxiliary resistor connected on one side to said anode, and a single pole double throw timer switch means operated by said timing actuator for normally connecting said cathode with said control

actuator and for connecting instead the other side of said auxiliary resistor to said cathode upon energization of said timing actuator; load control switches of the single pole double throw type associated for operation with at least one of said actuators; normally open starting contact means arranged in series with said anode, said cathode and said terminals and adapted for connection of said control actuator to both said terminals; a hold-in capacitor connected in series with said starting contact means between the movable contact of said timer switch means and one of said terminals; a delaying capacitor connected between said movable contact of said timer switch means and said control actuator; and a filter network for passing transient oscillations between said timer switch means and said discharging switch means; whereby both actuators and the switch means can be of identical construction for establishing a holding circuit, for extinguishing the tube to prolong its life while retaining the timing actuator energized, and for operating the load control switches upon energization of the respective actuators, the release of the control actuator is slowed down by the delaying capacitor, the actuation of the timer switch means is shortly delayed by the hold-in capacitor, and transients accompanying the actuation of the timer switch means are deviated from the tube.

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