

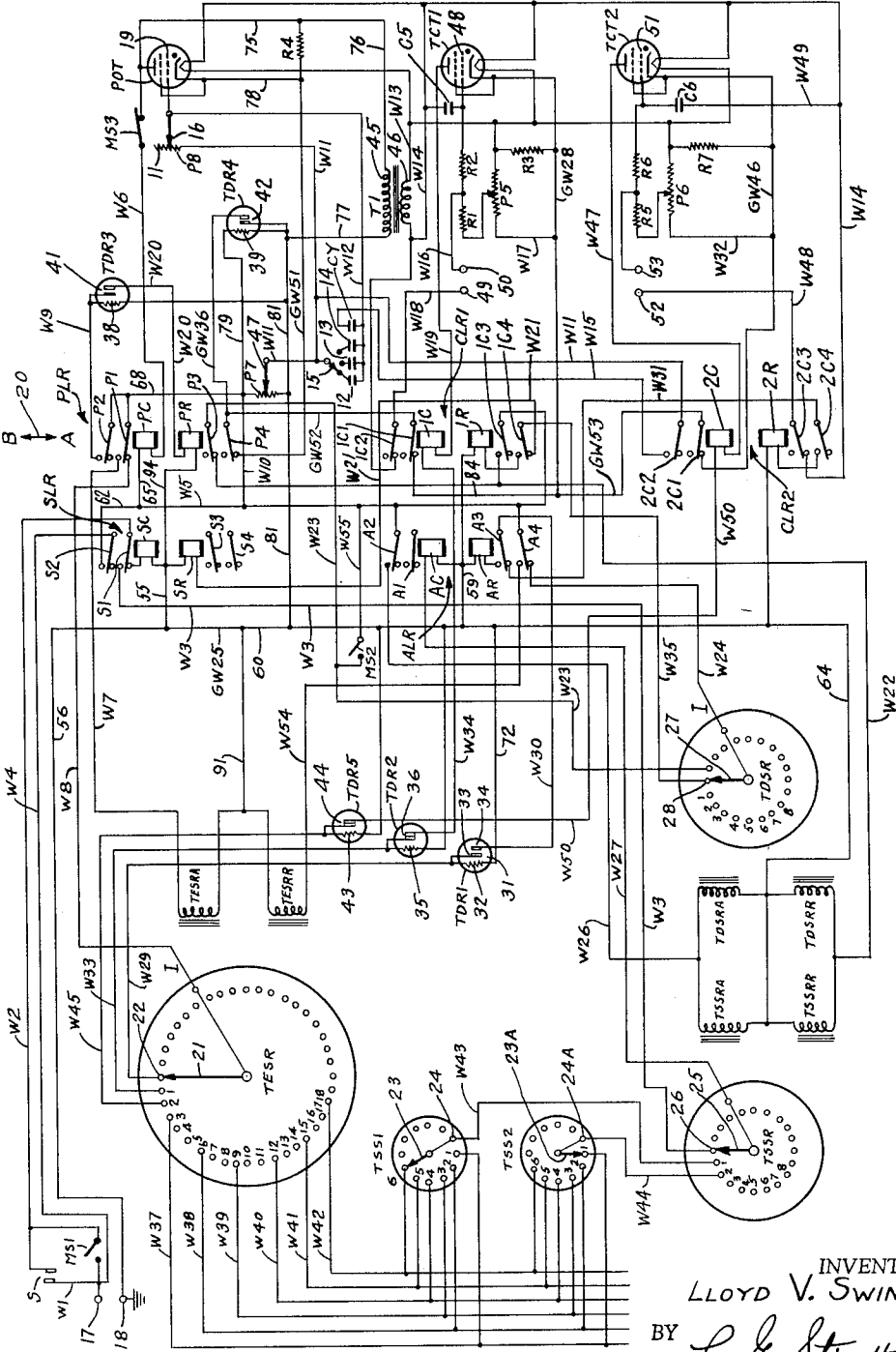
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SEQUENTIAL TIMER AND CONTROLLER

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SEQUENTIAL TIMER AND CONTROLLER

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This invention relates to time control and concerns particularly arrangements for effecting sequential control.

An object of the invention is to set up time intervals of predetermined length in sequence for controlling a plurality of devices.

A further object is to provide convenient and quick adjustment of lengths of time intervals.

Still another object is selectively either to adjust the length of all time intervals in a program without changing the proportions or to change the proportionate lengths of any one or more intervals in the program.

Still another object is to provide either automatic termination of a program of time intervals, adjustment or extension of time in each case responsive to surrounding conditions such as moisture, temperature, light, etc., which affect a device being controlled. Another object is to provide manual interruption at any point in the program and restart at the point of interruption or returned to beginning of sequence.

Still another object is to provide compensation for variations in such surrounding conditions.

Another object is sequential control of sprinklers in different areas responsive to weather conditions.

Other and further objects, features, and advantages of the invention will become apparent as the invention proceeds.

In carrying out the invention in accordance with a prepared form thereof, a basic interval timer is provided which takes the form of a resistance-condenser time delay circuit. There is a source of charging current for the time delay circuit and a discharge device for discharging the circuit whenever voltage reaches a predetermined magnitude. Grid rectification of a thyatron type of electronic discharge device may be employed for charging the circuit from the charging source. In order to protect the thyatron discharge device from excessive current load, a delay relay may be provided for initially heating the thyatron before connecting it in the charging circuit. There is a pulse latching relay having forward and return positions responsive to the delay circuit for reconnecting the discharge circuit after successive basic time intervals have been defined by the delay circuit.

A time extending stepping relay is utilized responsive to position of the pulse latching relay. The time extending stepping relay has a home position and a plurality of other positions, any one of which may be selected for defining a predetermined multiple of the basic time interval defined by the time delay circuit. A time setup stepping relay is provided having a plurality of contacts cooperating with a plurality of selector switches, one for each such contact. Each selector switch has contacts selectively connected to contacts of the time extending stepping relay to enable a series of time intervals to be produced, each constituting a selected multiple of the basic time interval of the time delay circuit, the successive time intervals being the same or different according to the setting of the selector switches. An actuator latching relay is provided under control of the time setup relay, and there is a time distribution relay also actuated by the actuator latching relay. The time extending stepping relay has a coil responsive to the actuator relay for immediately returning the time extending stepping relay to a home position. The time distribution relay has a connection to the home position for shutting off the pulse latching relay and terminating the time cycle.

Provision is made for terminating any of the time

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intervals and then recommencing the cycle in the event of an event such as the occurrence of an excess or deficiency of moisture, light, temperature or the like, and further provision is made for extending any of the time intervals automatically in response to the occurrence of such a condition.

A better understanding of the invention will be afforded by the following detailed description considered in conjunction with the accompanying drawing, the single figure of which constitutes a circuit diagram, partially schematic, of a sequential timer in accordance with the invention.

As shown in the drawing a resistance-condenser discharge circuit including a resistor 11 and a selected one of a group of condensers 12, 13, and 14 is provided for determining a pulse time, which constitutes the basic time interval in the system. The condensers have different values of capacity and there is a selector switch 15 for selecting whichever one of the condensers will give the desired time-constant, for the pulse length desired. To this end, also, the resistor 11 is provided with a resistance-varying sliding tap 16.

There is a starter latching relay SLR for connecting one of the selected condensers such as 12 to a charging circuit energized by alternating-current supply input terminals 17 and 18.

For actuating the starter latching relay SLR and connecting it to the source 17-18, either a manual switch MS-1 or contacts S of a controlling device (not shown) are provided.

There is a pulse latching relay PLR for actuating subsequent mechanism in response to termination of a pulse as measured by the charging time of one of the condensers 12, 13, and 14. For energizing the relay PLR a pulse originating thyatron POT is provided having a grid 19 through which the condenser is charged by grid rectification.

A time-extender stepping relay TESR is provided which has successive positions to which it is moved by the successive actuations of the pulse latching relay PLR. There is also a time setup stepping relay TSSR with a plurality of time selector switches, only two of which, TSS1 and TSS2, are shown, interposed between the stepping relays TESR and TSSR.

There is a time distribution stepping relay TDSR for actuating at different times determining by the setting of the apparatus a plurality of electrical devices (not shown) adapted to be connected to it.

An actuator latching relay ALR is provided for simultaneously advancing the stepping relays TSSR and TDSR at times determined by the settings of the stepping relays, TESR, TSSR, and TDSR and the time selector switches TSS. A plurality of control latching relays CLR1 and CLR2 are provided for enabling the apparatus to respond automatically to various external conditions. For actuation of the latching relay CLR1 and CLR2 trigger control thyatrons TCT1 and TCT2 are provided with control circuits electrically responsive to conditions such as moisture and temperature, for example. A plurality of thermal delay switches TDR-1, 2, 3, and 4 are provided for introducing delay in various parts of the circuit.

A filament transformer T is provided with a relay connection to permit heating thyatron filaments before the apparatus is energized.

The latching relays are all four-pole double-throw relays with actuating coils and return coils.

For example, the pulse latching relay PLR has movable contacts P1, P2, P3, and P4 cooperating with a corresponding set of lower or "A" position stationary contacts P1A, P2A, P3A, and P4A, respectively. There are also corresponding "B" position stationary contacts P1B, P2B, P3B, and P4B. There is an actuating coil PC for lifting the movable contacts P1-P4 to the stationary

contacts P1B-P4B, respectively. There is also a return coil PR for restoring the movable contacts to the position illustrated, viz., in contact with the "A" position stationary contacts. For convenience in describing the operation, the position of the movable contacts illustrated is referred to as the "A" position and the opposite position with movable contacts lifted is referred to as the "B" position as indicated by the double-ended arrow 20. For simplification of the drawing, reference characters for the stationary contacts are omitted, and they are identified by the corresponding movable contacts and position-identifying letters A or B, referring to the arrow 20.

Corresponding elements of the other latching relays SLR, ALR, CLR1 and CLR2 are identified by the reference characters:

S1-S4, S1A-S4A, S1B-S4B, SC, SR
A1-A4, A1A-A4A, A1B-A4B, AC, AR
1C1-1C4, 1C1A-1C4A, 1C1B-1C4B, 1C, 1R
2C1-2C4, 2C1A-2C4A, 2C1B-2C4B, 2C, 2R, respectively.

The time extender stepping relay TESR comprises a rotatable contact arm 21 having a normal position in contact with a stationary home contact 22 adapted to cooperate with a plurality of other stationary contacts TESR1 to TESR18, for example. There is an actuating coil TESRA for advancing the contact arm 21 one stationary contact at a time for each energization of the actuating coil TESRA. There is also a return coil TESRR for returning the contact arm 21 to the home position 22 when the coil TESRR is energized.

Each of the time selector switches TSS1, TSS2, etc., the others not being shown, is provided with a rotatable contact arm 23, 23A etc., and a plurality of stationary contacts, marked 1, 2, 3, etc., with which the contact arm 23 or 23A is adapted to cooperate. The contact arm 23 is electrically connected to a stationary terminal 24. Corresponding parts of the time selector switch TSS2 are designated by the same reference numerals as in connection with the switch TSS1 except for the addition of the suffix letter A. The number of stationary contacts in the time selector switches TSS1, TSS2, etc., is selected according to the number of different lengths of time intervals which it may be desired to provide in an adjustable program. The number of such switches is determined by the number of different devices to be controlled.

The time setup stepping relay TSSR is provided with a rotatable contact arm 25 having a normal position in contact with a home contact 26. In addition, there are a plurality of stationary contacts marked 1, 2, 3, etc. For each one of the stationary contacts 1, 2, 3, etc., there is a separate time selector switch TS1, TS2, etc., the additional time selector switches not being illustrated in the drawing for the sake of simplicity. The number of stationary contacts is thus determined by the number of devices to be controlled.

For actuating the movable contact arm 25 of the time setup stepping relay TSSR, there is an actuating coil TSSRA which is adapted to advance the arm 25 from one stationary contact to the next upon each energization of the coil TSSRA. There is also a return coil TSSRR for returning the rotatable contact arm 25 to the home position 26 when the coil TSSRR is energized.

The time distribution stepping relay TDSR is similar in arrangement and construction to the time setup stepping relay TSSR having a rotatable contact arm 27 movable from a home stationary contact 28 over a plurality of other stationary contacts. There may be any desired number of stationary contacts, but the number that is selected is made the same for the time setup stepping relay TSSR and the time distribution relay TDSR. The stationary contacts 1, 2, 3, etc., are connected to devices not shown which it is desired to energize or cause to be actuated at the predetermined times for which the sequential timer or controller is set or adjusted.

The thermal delay relays may be of conventional construction, some being normally open and some normally closed. For example, the thermal delay relay TDR1 comprises an evacuated envelope 31 containing a resistance-type heater 32 for actuating a pair of contacts 33 and 34, the contact 33 being of the bimetallic type so as to be moved into contact with the contact 34 after current has flowed in the heater 32 long enough to raise the temperature the requisite amount. The thermal delay relay TDR1 thus has contacts of the normally-open type.

The thermal delay relay TDR2 is similar in construction except for being of a normally-closed contact type having a heater 35 with normally-closed contacts 36. The thermal delay relays TDR3 and TDR4 are of the normally-open contact type having heaters 38 and 39 respectively and normally-open contacts 41 and 42 respectively. The thermal delay relay TDR5 is of a normally-closed contact type having a heater 43 and normally-closed contacts 44. A second manual switch MS2 may be provided and preferably there is a filament heating transformer T1 for the filaments or heaters of the thyratrons POT, TCT1, and TCT2. The filament transformer T1 has a primary winding 45 adapted to be connected to the input terminals 17 and 18 by means of suitable contacts, as will be explained in greater detail hereinafter, and a secondary winding 46 to which the filaments of the thyratrons POT, TCT1, and TCT2 are connected in parallel.

For adjustment of the voltage for charging the condensers 12 to 14, a potentiometer P7 is provided having an adjustable contact or tap 47.

The trigger control thyatron TCT1 is provided with a control grid 48 connected through a resistance network, including resistors R1, R2, and R3 and a potentiometer P5, to a pair of signal input terminals 49 and 50 adapted to be connected to either a voltage generating or resistance-varying control device such as a humidity indicator, thermometer, lightmeter, or other control device.

Likewise, the trigger control thyatron TCT2 has a control grid 51 connected through a resistance network including resistors R5, R6, R7, and a potentiometer P6 to a pair of signal input terminals 52 and 53 to which another voltage-generating or resistance-varying control device may be connected.

In order to place the apparatus in operation, it is connected to the voltage supply input terminals 17 and 18. This may be accomplished either by the closure of the switch S automatically in response to the operation of other apparatus (not shown) or may be accomplished manually by closing the manual switch MS1. A circuit is then completed from the terminal 17 through the switch S or MS1, a conductor W2, the contacts S1 and S1A of the starter latching relay SLR, the coil SC of that relay, and grounded conductors 55 and 56 to the terminal 18 which is a ground terminal.

Current through the conductor W2 energizes the coil SC, moving the contacts S-1, S-2, S-3, and S-4 from the A position illustrated to the opposite or B position where they make contact with the stationary contacts S1B, S2B, S3B, and S4B, respectively.

This completes a circuit from the terminal 17 through the switch S, conductor W2, contacts S1 and S1B of the starter latching relay SLR, the conductor W3 to the home stationary contact 26 of the time setup stepping relay TSSR, its contact arm 25, an output conductor W27 through the coil AC of the actuator latching relay ALR and conductors 59, 60, and GW25 to the grounded conductor 56. The flow of current through the coil AC moves its contacts to the opposite position from the one illustrated. This completes a circuit from input terminal 17 through a conductor W4 and contacts S2 and S2B of the starter latching relay SLR through conductor 62 and W5 to contacts A2 and A2B of the actuator latching relay ALR and conductor W26 through the coils TSSRA and TDSRA in parallel of the time setup stepping relay TSSR and the time distribution relay TDSR through con-

ductors 64, 60 and GW25 back to the grounded conductor 56. The flow of current through the actuator coils TSSRA and TDSRA simultaneously moves the contact arms 25 and 27 from the home positions 26 and 28 to the number 1 positions making contact with number 1 stationary contacts.

A circuit is also completed from the terminal 17 through conductor W4, contacts S2 and S2B of the starter latching relay SLR, conductors 62, W5, W10 and 68, contacts P1 and P1A of pulse latching relay PLR, conductor W8, contact arm 21 of the time extender stepping relay TESR to home position contact 22, conductor W29, thermal element 32 of relay TDR1, conductors 72, 60, GW25, back to grounded conductor 56. After the rated time the contacts 33 and 34 of the thermal delay relay TDR1 close. This connects the previously traced circuit through the conductor W29 through the thermal delay relay contacts 33 and 34, a conductor W30, contacts A3, A3B, of the actuator latching relay ALR, coil AR thereof, and conductors 59, 60, GW25, 56 to terminal 18. This returns the movable contacts of the relay ALR to that illustrated.

A circuit is completed also from the input conductor W4 through contacts S2, S2B of the starter latching relay SLR, conductors 62 and 65, coil PC of the pulse latching relay PLR, a conductor W6 to the plate of the pulse originator thyatron POT, conductors 75 and 76, primary winding 45 of the filament transformer T1, conductor 77 to a conductor 81 connected to grounded conductors 60 and GW25.

The closing of the contacts 42 of the thermal delay relay TDR4 occurs after the rated time as a result of formation of a circuit through the heater 39 as follows: terminal 17 and elements W4, S2, S2B, 62, W5, W10, a conductor 79, heater 39, the conductors 81, 60, GW25, 56 to terminal 18. After the contacts close, the cathode of the thyatron POT and the conductors 78 and GW51 are grounded through the elements P4A, P4, a conductor GW36, contacts 42, and conductors 81, 60, GW25, 56. The thermal delay relay TDR4 serves to allow sufficient time for all thyatron filaments to heat prior to loading of their respective circuits.

Ground for the cathode of the thyatron TCT1 is provided through conductors GW28 and 84, contacts 1C1A, 1C1, a conductor GW52, and elements GW36, 42, 81, 60, GW25, 56 to the terminal 18.

Ground for the thyatron TCT2 is provided through elements GW46, 2C1A, 2C1, GW53, 84, 1C1A, 1C1, GW52, GW36, 42, 81, 60, GW25, and 56 to 18.

The grid circuit of the pulse originator thyatron POT consists of the elements 17, W4, S2, S2B, 62, W5, W10, P7, 47, 15, one of the condensers 12, 13, or 14, and the resistor 11 of potentiometer P8.

The pulse originator circuit operates as follows: The condenser 12 with the switch 15 in position shown is charged by grid rectification in a circuit from the potentiometer P7, including condenser 12, a conductor W12, grid 19, cathode of POT, conductor 78, resistor R4, conductor 76, winding 45, and conductors 77, 81, 60, GW25, 56, and 18. The potentiometer P7 provides coarse adjustment of the potentiometer P8, fine adjustment of delay time.

The condenser 12 discharges at a slow rate until the grid of the pulse originator thyatron POT becomes sufficiently positive to allow the thyatron POT to conduct through a circuit completed through the coil PC of the pulse latching relay PLR from the terminal 17, through elements W2, S2, S2B, 62, and 65. The relay PLR is thereby energized, moving its contacts P1, P2, P3, P4, from the position illustrated.

Thereupon a circuit is completed from the input terminal 17 through conductor W4, contacts S2 and S2B, conductor 62, W5, W10, 68, contacts P1, P1B of relay PLR, conductor W7, time extender stepping relay actua-

tor coil TESRA, and conductors 91, GW25, 56, to ground terminal 18.

In consequence the contact arm 21 of the time extender stepping relay TESR moves from the home position 22 to the number 1 position.

A circuit is also completed through the conductor W4, through contacts S2 and S2B of the relay SLR, conductors 62, W5, W10, 68, contacts P2, P2B of the relay PLR, through a conductor W9, thermal element 38, and conductors 81, 60, GW25, and 56 to terminal 18. After the rated time delay the contacts 41 close. The circuit from the conductor W9 is now connected through contacts 41, a conductor W20, return coil PR of the relay PLR, a conductor 94 and the conductor 55 to the ground conductor 56. The relay PLR, in consequence, returns to the position illustrated.

There is now a circuit from conductor W4, contacts S2 and S2B of the relay SLR, conductors 62, W10, 68, contacts P1, P1A of the relay PLR, conductor W8, and arm 21 to contact 1 in the first position of the time extender stepping relay TESR. Assuming that no outside variable such as light, temperature, moisture, etc., has at this time reached a stage to make an appreciable effect on terminals 49 and 50 of the trigger control thyatron circuit TCT1, the circuit for contact TESR1 remains incomplete.

As before the ground circuit of the pulse originator thyatron POT is made complete through conductors 56, GW25, 60, 81, contacts 42 of the delay relay TDR4, conductor GW36, contacts P4 and P4A, and conductors GW51 and 78. Grid rectification again takes place. After the delay developed through the condenser 12 and the potentiometers P7 and P8 the thyatron POT conducts, the pulse latching relay PLR is again energized moving its contacts from the position illustrated. A pulse, the duration of the time delay relay TDR3, passes through the contacts P1 and P1B of the relay PLR and the conductor W7 to the actuator TESRA moving the contact arm 21 to the second position.

Assuming no outside variable such as light, temperature, moisture, etc., has reached a stage to make an appreciable effect upon terminals 52 and 53 of the circuit of the trigger control thyatron TCT2, the circuit from the second position of the time extender stepping relay TESR is incomplete.

After another cycle is passed through by the pulse originator circuit, the contact arm 21 is moved to position 3 of the relay TESR.

Tie-in of the terminals of the relay TESR is optional according to whether short or long programming is desired. At position 3, as the drawing shows, a conductor W37 is connected to TESR terminal 3 as well as to the number 1 terminal of all the time selector switches TSS1, TSS2, etc. (the remaining time selector switches not being shown). One time switch may accommodate each position of the time setup stepping relay TSSR; or may be used for several positions as required by the system being controlled.

Since, as shown in the drawing, time selector switch TSS1 is not set on position 1 but on position 6, contact arm 21 of time extender stepping relay TESR will have to move to position 18 before a circuit will be complete to position 1 of time setup stepping relay TSSR. The terminals from time selector switches TSS to time extender stepping relay terminals need not be held to three positions apart but may be set up to the type of programming required by the system under control of the unit.

With each cycle of pulse originator, contact arm 21 of time extender stepping relay TESR continues to move over open positions and wired positions until said contact arm 21 reaches position No. 18 of time extender stepping relay.

As said arm reaches position 18 and pulse latching relay contacts are moved back to A position through action of time delay relay TDR3: A circuit is again com-

plete from input wire W4; through contacts 2, B position, starter latching relay SLR; through wires W5, W10; through contacts 1, A position, pulse latching relay PLR; through wire W8; through input I of time extender stepping relay TESR; through contact arm 21 of said relay; through position 18 of said relay; through wire W42; through position 6 time selector switch TSS1; through switch arm 23; through wire W43; through position 1 time setup stepping relay TSSR; through 25 of said relay (this arm had been moved to position 1 at start of unit) through output of said relay; through wire W27; through coil AC of actuator latching relay, conductors 59, 60 to ground wire GW25. Current through circuit energizes coil AC, connecting contacts 1, 2, 3, and 4 at B position.

Circuit now completed through input wire W4 through contacts 2, B position starter latching relay; through wire W5; through contacts 2, B position actuator latching relay ALR; through wire W26; through time setup stepping relay actuator TSSRA and time distribution stepping relay actuator TDSRA (wired in parallel); through conductors 64 and 60 to ground wire GW25. Current through circuit energizes coils time setup stepping relay activator TSSRA and time distribution stepping relay activator TDSRA. Simultaneously, respective contact arms 25 and 27 of said relays move to their respective positions 2. Timing of position 1 time distribution stepping relay TDSR has been completed and time is now set up on position 2 of time setup stepping relay TSSR for distribution of current through No. 2 position of time distribution stepping relay TDSR.

Circuit also completed through input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 4, B position actuator latching relay ALR; through wire W54; through time extender stepping relay return TESRR and conductor 91 to ground wire GW25. Current through circuit energizes said return coil of said relay. Contact arm 21 of said relay is moved back to home H position 22.

Circuit now completed through input wire W4; through SLR contacts 2, B position; through wire W5; through wire W10; through contacts 1, A position of pulse latching relay PLR; through wire W8; through input I of time extender stepping relay TESR; through contact arm 21 of said relay; through home position 22; through wire W29; through thermal element of time delay relay TDR1; to ground wire GW25. Current through circuit causes contacts of said delay relay to close after rated time. Circuit now continues; through contacts of said delay relay; through wire W30; through contacts 3, B position of actuator relay through coil AR of actuator latching relay ALR to ground wire GW25. Current energizes coil of said relay moving contacts 1, 2, 3, and 4 to A position.

Circuit now completed from contacts of time delay relay TDR1; through wire W30; through contacts 3, A position of actuator latching relay ALR; through wire W31 to contacts 4, A position of control latching relay CLR2. Circuit incomplete from this position on, at this time.

Circuit completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 4, A position of actuator latching relay ALR; through wire W24; through input I of time distribution stepping relay TDSR; through contact arm 27 of said relay to position 2 of said relay.

Pulse originator circuit has again started through its cycle and after the preset time interval; set up by condenser 1, 2, or 3 and potentiometers P1 and P2; the pulse originator thyatron POT starts conducting through circuit input wire W4; contacts 2, B position of starter latching relay SLR; through coil PC of pulse latching relay through wire W6 to plate of pulse originator thyatron POT. Current through coil PC energizes same. Contacts 1, 2, 3, and 4 of pulse latching relay PLR moved to B position. Breaking circuit of pulse originator thyatron.

Circuit is again complete from input wire W4; through contacts 2, B position, starter latching relay SLR; through wire W5; through wire W10; through contacts 1, B position of pulse originator latching relay; through wire W8; through time extender stepping relay activator TESRA; to ground wire GW26. Current through activator coil energizes same moving contact arm 21 of time extender stepping relay to No. 1 position.

Circuit also completed from wire W10; through contacts 2, B position pulse latching relay; through wire W9; through thermal element of time delay relay TDR3 to ground wire GW25. Current through said thermal element, at end of rated time, causes contacts of said relay to close completing circuit from wire W9; through wire W20; through coil PR of pulse latching relay PLR to ground wire GW25. Current through said coil energizes same moving contacts 1, 2, 3, and 4 to A position. A circuit is now completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through wire W10; through contacts 1, A position of pulse latching relay PLR; through wire W8; through input I to time extender stepping relay TESR; through contact arm 21 of said stepping relay to position 1.

Circuit at this time considered incomplete from position 1; through trigger control circuit No. 1.

Pulse originator circuit repeats cycle and contact arm 21 of time extender stepping relay TESR is again moved. This time to position 2 of said stepping relay.

Circuit at this time considered incomplete from position 2 through trigger control circuit TCT2.

Pulse originator circuit repeats cycle and contact arm 21 of time extender stepping relay TESR is again moved, this time to position No. 3.

In A position pulse latching relay PLR a circuit is now completed through contacts 1; through wire W8; through input of time extender stepping relay TESR; through contact arm 21 of said relay through position 3 of said relay; through wire W37 through position 1 of time selector switch TSS2 through arm 23A of said switch; through wire W44; through position No. 2 of time setup stepping relay; through contact arm 25 of said relay; through output of said relay; through wire W27; through coil AC of actuator latching relay ALR; to ground wire GW25. Current through coil energizes same moving contacts 1, 2, 3, and 4 of said relay to B position.

Circuit now completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 2, B position actuator latching relay ALR; through wire W26; through time setup stepping relay actuator TSSRA and time distribution stepping relay actuator TDSRA to ground wire GW25. Current through said actuator coils energizes said coils simultaneously as they are connected in parallel. Contact arms 25 and 27 of said stepping relays are moved simultaneously to their respective No. 3 positions.

Circuit also completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 4, position B of actuator latching relay ALR; through wire W27; through time extender stepping relay return TESRR to ground wire GW25. Current energizes coil of said return and contact arm 21 of time extender stepping relay is returned from position No. 3 to home position 22 of said relay.

Circuit now completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through wire W10; through contacts 1, B position of pulse latching relay PLR; through wire W8; through input to time extender stepping relay TESR; through contact arm 21 of said relay; through home position 22; through wire W29; through thermal element of thermal time delay relay TDR1 to ground wire GW25. Contacts of said thermal relay close after

rated time. Circuit completed; through wire W29; through contacts of said thermal relay; through wire W30; through contacts 3, position B of actuator latching relay; through coil AR of said relay to ground wire GW25. Current through coil energizes same, moving contacts 1, 2, 3, and 4 to A position.

Circuit now completed from wire W30; through contacts 3, A position of actuator latching relay ALR; through wire W31 to contact 4, A position of control latching relay CLR2. Circuit incomplete at this point at this time.

Circuit completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 2, A position actuator latching relay ALR; through wire W24; through input I of time distribution stepping relay TDSR; through contact arm 27 of said relay to position 3 of said relay.

Cycling operations of pulse originator circuit and time extender will continue unless interrupted by trigger control system TCT1. The number of times the time extender will cycle is determined by the number of time selector switches TSS1, 2, etc., as required for the system under control of the programmer and the number of contacts on time setup stepping relay system and on time distribution stepping relay system that are wired in as required for the system under control of the programmer.

Following the last position wired in on the time distribution stepping relay TDSR, a control output wire W23 is terminated. When the contact arm 27 of said relay reaches this position, the unit is returned to starting position on all phases and shut off in the following manner.

At the time contact arm 27 of time distribution stepping relay TDSR reaches the position wire W23 is wired in, contact arm 21 of time extender stepping relay is returned to home position 22 in the manner prescribed following each movement of contact arms 26 and 27 of time setup stepping relay TSSR and time distribution stepping relay TDSR leaving contacts of actuator latching relay ALR in A position.

On reaching the position at which wire W23 is terminated, a circuit is now completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 4, A position of actuator latching relay ALR; through wire W24; through input I of time distribution stepping relay TDSR; through contact arm 27 of said relay; through position wire W23 terminated; through wire W23; through contacts 3, A position of pulse latching relay PLR; through wire W22; through time setup stepping relay return TSSRR and time distribution stepping relay return TDSRR; through conductors 64 and 60 to ground wire GW25. Current through coils of said returns, energizes both simultaneously as they are in parallel. Contact arms 25 and 27 of time setup stepping relay TSSR and time distribution stepping relay are returned to their respective home positions 26 and 28 simultaneously.

Circuit is now complete from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 4, A position of actuator latching relay; through wire W24; through input I of time distribution stepping relay TDSR; through contact arm 27 of said relay; through home position 28 of said relay; through wire W35; through contact 4, A position control latching relay CLR1; through wire W21; through coil SR of starter latching relay conductor 55 to ground wire GW25. Current through coil energizes same moving contacts 1, 2, 3, and 4 from B to A position, breaking input circuit to pulse originator circuit, and leaving all contacts in A position, and all contact arms of all stepping relays at home position of respective said relays. Thus set up for the next time, switch 1 is activated by the starting device, or manual switch MS1 is activated.

As explained, when the arm 27 of the relay TDSR reaches the position of conductor W23, all relays are restored to their initial position. Manifestly, the same result may be accomplished by closing the manual switch MS2, which completes a circuit between the conductors W5 and W23.

Consequently, the apparatus can be interrupted at any time interval and returned to start by manipulation of the manual switch MS2 and will start again at the beginning of the sequence by manipulation of the manual switch MS1. The operation may be stopped manually at any point in the cycle and started at the point of interruption by opening and thereafter reclosing the manual switch MS3.

The function of trigger control thyatron TCT1 is as follows: after the starter switch S has been moved to on position by starting device; starter latching relay SLR contacts 1, 2, 3, and 4 moved to B position; and pulse originator circuit has activated time extender stepping relay activator coil TESRA; through pulse latching relay PLR; contact arm 21 of time extender stepping relay TESR is on position No. 1 of said stepping relay.

After duration of first pulse and pulse latching relay PLR has returned contacts 1, 2, 3, and 4 of said relay to A position, a circuit is completed through input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through wire W10; through contacts 1, A position of pulse latching relay PLR; through wire W8, through input I of time extender stepping relay TESR; through contact arm 21 of said relay; through position 1 of said relay; through wire W33; through thermal element of thermal delay relay TDR2 to ground. Circuit also continues through contacts of said delay relay through wire W34; through coil 1C of control latching relay CLR1 to plate of trigger control thyatron TCT1. Should the proper amount of resistance be placed across terminals 49 and 50 through a control sensitive to light, temperature, moisture or some other variable that might affect, directly or indirectly, the function of the system being controlled and it is desirable to return unit to starting position and shut said unit off; it functions in the following manner.

When the grid circuit, composed of resistors R1, R2, and R3 and potentiometer P5 becomes complete, the grid is made sufficiently positive for trigger control thyatron TCT1 to conduct and energize coil 1C, control latching relay CLR1, and moving contacts 1, 2, 3, and 4 of said relay to B position.

A circuit is then complete from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 3, B position of control latching relay CLR1; through wire W22; through return coils of time setup stepping relay return TSSRR and time distribution stepping relay return TDSRR to ground wire GW25. Current passing through coils energizes both simultaneously as they are connected in parallel. Contact arms 25 and 27 of time setup stepping relay TSSR and time distribution stepping relay TDSR are returned simultaneously to their respective home H positions.

A circuit is now completed from input wire W2; through contacts 1, B position of starter latching relay SLR; through wire W3; through home position 26 of time setup stepping relay TSSR; through contact arm 25 of said relay; through wire W27; through coil AC of actuator latching relay ALR; to ground wire GW25. Current through circuit energizes coil AC of said relay moving contacts 1, 2, 3, and 4 of said relay to position B.

Circuit now complete from input wire W4; through contact 2, B position of starter latching relay SLR; through wire W5; through contacts 4, B position of actuator latching relay ALR; through wire W54; through time extender stepping relay return coil, to ground wire GW25. Current through circuit energizes said return coil

returning contact arm 21 of time extender stepping relay TESR to home position 22.

Current still through circuit from control latching relay CLR1, B position, holding returns of time setup stepping relay TSSR and time distribution stepping relay TDSR in position so that they are unaffected by circuit completed through input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 2, B position of actuator latching relay ALR; through wire W26 to time setup stepping relay activators TSSRA and time distribution stepping relay activator TDSRA. Current through this circuit is being counteracted upon by current through returns of same said stepping relays.

Circuit completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through wire W10; through contacts 1, A position of pulse latching relay PLR; through wire W8; through input 1 of time extender stepping relay TESR; through contact arm 21 of said relay; through home position 22 of said relay through wire W29; through thermal element of thermal time delay relay TDR1 to ground wire GW25. After rated time, contacts of thermal delay relay TDR1 close. Circuit continues through contacts of said delay relay through wire W30; through contacts 3, B position of actuator latching relay ALR; through coil AR of said relay to ground wire GW25. Current through circuit energizes coil AR of said latching relay moving contacts 1, 2, 3, and 4 to A position.

Circuit now continues from wire W29; through contacts of thermal delay relay TDR1; through wire W30; through contacts 3, A position of actuator latching relay through wire W31 to contacts 4 of contact latching relay CLR2. If contacts happen to be in B position due to activation from trigger control thyatron TCT2 circuit, circuit would continue through coil 2CR of control latching relay CLR2; to ground wire GW25. Current through circuit would energize said coil 2CR and move contacts 1, 2, 3, and 4 of control latching relay CLR2 to A position.

Circuit also completed from input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through contacts 4, of actuator latching relay ALR; through wire W24; through input of time distribution stepping relay TDSR; through contact arm 27 of said relay; through home position 28 of said relay; through wire W35; through contact 4, B position of control latching relay CLR1; through coil 1CR of said relay; to ground wire GW25. Current through circuit energizes said coil moving contacts 1, 2, 3, and 4 to A position.

Circuit now completed from wire W35; through contact 4, A position of control latching relay; through wire W21; through coil SR of starter latching relay; to ground wire GW25. Current through circuit energizes said coil moving contacts 1, 2, 3, and 4 to A position.

All contacts 1, 2, 3, and 4 of starter latching relay SLR; of pulse latching relay PLR of activator latching relay SLR; of pulse latching relay PLR of activator latching relay ALR; of control latching relay CLR1; and of control latching relay CLR2 are now in A position.

Contact arms 25 and 27 of time setup stepping relay TSSR; of time distribution stepping relay TDSR; are at home positions.

Circuit through input wire W4; contacts 2, starter latching relay SLR is broken. Starter circuit through wire W2 contacts 1 of starter latching relay SLR; is completed.

Unit set to start at time clock or other devices closes switch S1 or manual closing of manual switch MS1.

The purpose of trigger control thyatron TCT2 is as follows: After the starter switch has been moved to on position by the starter device, or after the unit has been started manually; the pulse originators circuit cycles the time extender stepping relay TESR, contact arm 21

to position 1 of said stepping relay. Providing no action at this point is taken by trigger control thyatron TCT1 circuit due to moisture, light, temperature of other variable affecting above-mentioned circuit, the contact arm 21 of time extender stepping relay moves to position 2 of said stepping relay at the next cycle of the pulse originator circuit.

Contacts 1, 2, 3, and 4 are returned to position A after duration of pulse. A circuit is then completed through input wire W4; through contacts 2, B position of starter latching relay SLR; through wire W5; through wire W10; through contact 1, A position of pulse latching relay; through wire W8; through input of time extender stepping relay TESR; through contact arm 21 of said relay; through position 2 of said relay; through wire W45; through thermal element of thermal delay relay TDR5 to ground wire GW25. Contacts on said relay normally closed for rated time. Thermal element is heated by current through said circuit. Until contacts open circuit continues through wire W50; through coil 2C of control latching relay CLR2; through wire W47; to plate of trigger control thyatron TCT2.

Should the proper amount of resistance (controlled by some device responsive to light, moisture, temperature or some other variable that might affect directly or indirectly the function of the system being controlled by the programmer and it is necessary to extend the time further for safety factor or other reasons) be developed across terminals 52 and 53, the grid circuit made up of resistors R5, R6, R7, and potentiometer P6 becomes complete, the grid becomes sufficiently positive for trigger control thyatron TCT2 to conduct. As a result coil 2C of control latching relay CLR2 becomes energized moving contacts 1, 2, 3, and 4 of said relay to B position.

A circuit is now completed through contacts B position of control latching relay CLR2 from a condenser CY to grid circuit of pulse originator through wires W15 and W11. Said condenser is now in parallel with that condenser of 12, 13, 14, etc., that is at this time a part of the grid circuit of the pulse originator system.

An inquiry is made to the trigger control circuit each time during cycle of time extender stepping relay TESR that contact arm 21 of said relay stops on position 2 of said relay.

Each time contact arm 21 of time extender stepping relay TESR reaches home position 22 of said relay a circuit is completed from input wire W4; through contacts 2, B position of pulse latching relay PLR; through wire W5; through wire W10; through contact 1, A position of pulse latching relay; through wire W8; through input I of time extender stepping relay TESR; through contact arm 21 of said relay; through home position 22 of said relay; through wire W29; through thermal element of thermal delay relay TDR1 to ground wire GW25. After rated time contacts which are normally open now close and a circuit is continued from wire W29; through contacts of said thermal delay relay; through wire W30; through contact 3, A position of actuator latching relay; through wire W31; through contact 4, B position of control latching relay CLR2; through coil 2CR of said relay; to ground wire GW25. Current through circuit energizes coil 2CR of said relay moving contacts 1, 2, 3, and 4 to move to A position, thus removing condenser CY from circuit until next inquiry is made at position 2 of time extender stepping relay at next cycle of said relay.

It will be seen therefore that the magnitude of the capacity of whichever one of the condensers 12 to 14 is connected and the resistance of the potentiometers P7 and P8 determines the length of the basic time interval. In other words, the resistance-capacity time constant determines the interval between successive current pulses which actuate the pulse latching relay PLR for energizing the time extender stepping relay actuator TESRA to advance the contact arm 21 successive steps. On the other hand, the time delay of the thermal delay relay TDR3 determines the length of the current pulse.

The length of the multiplied time interval, that is the multiple of the basic interval of the time delay circuit of the condensers, is determined by the setting of one of the time selector switches TSS1, TSS2, etc., which determines which of the stationary contacts of the time extender stepping relay TESR is connected to any one of the stationary contacts of the time setup stepping relay TSSR. The order in which the successive multiple time intervals are produced is determined by the order in which the various terminals of the time extender stepping relay TESR are connected to the terminals of the time setup stepping relay TSSR.

Each of the stepping relays as shown has actuator coils responsive to the actuating relay ALR for advancing it a step at a time. The time setup stepping relay TSSR and the companion time distribution stepping relay TDSR are advanced one position only whenever the time extender stepping relay TESR has reached the position which determines the end of the time interval in question. The return coils TESRR, TSSRR, and TDSRR serve to return the movable contact arms of the stepping relays to their home positions when each arm has reached the intended limit of its travel. In the case of the time extender stepping relay TESR, this is the position of the stationary contact which is connected to the stationary contact of the time setup stepping relay TSSR at which the contact arm 25 is then located.

The starter latching relay SLR serves merely to start each cycle whenever the switch S or MS1 is closed, and the control latching relays CLR1 and CLR2 serve to produce either a cycle terminating or time interval extending response, if any is needed, depending upon the condition of the control device connected between the terminals 49 and 50 or 52 and 53 as the case may be.

It is apparent therefore that a time controlling device of great flexibility has been provided in which the length of the basic time interval, and, therefore, the total length of the cycle or the sequence, may be varied by varying the constants of the time delay circuit including the condensers 12, 13, or 14 and the proportionate length of any interval within the total cycle may be adjusted independently of the others by adjusting the setting of the appropriate one of the time selector switches TSS1 or TSS2, etc. in relation to the points to which the conductors W37 to W42 are connected at the time extender stepping relay TESR. Moreover, provision is made for automatic extension of time intervals, as well as manual or automatic terminal of the cycle.

While the foregoing specification illustrates and describes what I now contemplate to be the best mode of carrying out my invention, the construction is, of course, subject to modification without departing from the spirit and scope of my invention. Therefore, I do not desire to restrict the invention to the particular form of construction illustrated and described, but desire to cover all modifications that may fall within the scope of the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. A timer, comprising in combination, a resistance-condenser time delay circuit, a source of charging current therefor, a discharge device for discharging the delay circuit whenever voltage reaches a predetermined magnitude, a delay relay for connecting the delay circuit to the charging current source to form a charging circuit, a pulse-latching relay having forward and return positions responsive to the delay circuit for reconnecting the charging circuit, a time-extending stepping relay responsive to movement of the pulse latching relay having a home-position and a plurality of other positions, a time-setup stepping relay having a plurality of contacts, a plurality of selector switches, one for each such contact, each selector switch having contacts selectively connected to contacts of the time-setup stepping relay, an actuator-latching relay with a coil connected to the time

setup relay, the latter having an advancing coil controlled by the actuator-latching relay, a time distribution relay also actuated by the actuator-latching relay, the time-extending stepping relay having a coil responsive to the actuator relay for immediate return to home position, said time distribution relay having a connection at home position for shutting off the pulse-latching relay, and a thyatron control having independent input terminals responsive to a controlling phenomenon for exciting the thyatron control to perform one of the actions of shutting off the pulse-latching relay and extending time.

2. A timer, comprising in combination, a resistance-condenser time delay circuit with a source of charging current, a starter-latching relay for connecting the resistance-condenser time delay circuit to the source of charging current, a discharge device for discharging the circuit whenever voltage reaches a predetermined magnitude, a time-extending stepping relay responsive thereto having a plurality of positions and means for moving to successive positions in response to successive chargings and dischargings of said delay circuit, a time-distribution, device-controlling stepping relay responsive to said time-extender stepping relay for connecting a device to be controlled when the time-extender stepping relay is initially energized and disconnecting the device when the time-extender stepping relay has advanced to a predetermined position.

3. Apparatus as in claim 2 in which the time distribution stepping relay has successive positions for controlling a plurality of different devices.

4. Apparatus as in claim 3 wherein the time-extender stepping relay has a plurality of different positions to which the time-distribution stepping relay is successively responsive for producing different time intervals in succession.

5. Apparatus as in claim 4 in which the resistance condenser delay circuit is adjustable for varying the length of basic time intervals without varying the relative lengths of successive intervals.

6. A sequential timer comprising, means for producing an electrical current at the termination of a time interval referred to as a basic time interval, a switch having a plurality of successive contacts, means for advancing the switch from one contact to the next in response to successive electrical currents to form longer time intervals, means for returning the switch to a predetermined position, current supply terminals, and a relay connected in series with such current supply terminals and a predetermined contact of such switch for energizing the returning means for terminating such longer time interval.

7. A sequential timer comprising, apparatus as is claim 6 wherein means are provided successively responsive to the attainment of any selected one of the contact positions by said switch to form a sequence of longer time intervals, each determined by the number of basic time intervals required for the switch to travel to a selected contact thereof.

8. Apparatus as in claim 6 having means responsive to the presence of an external condition for restoring the switch to its initial position to terminate the time interval before the switch has reached the end of its travel.

9. Apparatus as in claim 6 having means responsive to the presence of a condition for increasing the length of the basic time interval to increase the length of the total time interval.

10. Apparatus as in claim 7 having means responsive to the presence of a condition for increasing the length of the basic time interval to increase the length of the total time interval without changing the proportionate lengths of successive longer time intervals within the sequence.

11. In a sequential timer, voltage supply terminals, a thyatron having an anode, a cathode and a control grid, a resistance and a condenser connected in a circuit in series with the control grid and cathode adapted to be connected to the voltage supply terminals for grid recti-

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fication charging of the condenser to define a basic time interval, a stepping relay having a plurality of contacts in successive positions for selectively defining a longer time interval, current-responsive means for actuating the stepping relay, said thyatron, anode and cathode being serially connected with said current-responsive means to said voltage supply terminals, whereby the attainment of a predetermined voltage by the condenser fires the thyatron and actuates the stepping relay, said stepping relay having a returning coil, a selector switch for connection to one of the stepping relay contacts, and a relay energized in series with the selector switch and the returning coil, for returning the stepping relay to a previous position upon attainment of a preselected position.

12. Apparatus as in claim 11 having a delay relay with a current responsive actuating member connected to said voltage supply terminals and normally-open contacts responsive to said delay relay actuating member serially connected between said voltage supply terminals and said thyatron for protectively delaying the carrying of load current by said thyatron.

13. In a sequential timer for apparatus to be controlled a time delay circuit comprising, a condenser and a resistor for defining the basic time interval, charging and discharging means therefor, whereby condenser potential repeatedly varies, stepping relay means responsive to successive attainment of predetermined condenser potential for multiplying said time interval to produce a longer time interval for maintaining the apparatus in operation, and means for selectively connecting an additional condenser in parallel with the first-mentioned condenser for increasing the basic time interval and thereby lengthening the control interval.

14. In apparatus for maintaining operation of a plurality of different devices for selective predetermined times in sequence, means responsive to successive elapsing of basic time intervals for defining a basic time interval, means for selectively multiplying said basic time interval for producing a series of longer time intervals in se-

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quence, each constituting a multiple of the basic time interval, control means responsive thereto for maintaining operation of a different one of the devices for a time interval determined by the successive time intervals in the sequence, and means for terminating any one of said time intervals and interrupting the sequence to shorten operation period of any device and thereby advance the sequence.

15. A sequential timer, comprising in combination, first and second input terminals for connection to a source of current, first and second input conductors connected to the first and second terminals respectively, a third conductor connected to the first terminal with a connecting switch interposed, a starter-latching relay having a coil connected to said third and second conductors and a normally-closed contact in series therewith, said starter-latching relay having also a normally-open contact in series with the first of the supply conductors, a pulse-latching relay with a circuit including the first and second conductors, whereby it is responsive to actuation of said normally-open contact, means for defining a basic time interval responsive to said pulse-latching relay for producing a current pulse at the end of a basic time interval, an actuator-latching relay responsive to said normally-open contact and said pulse-latching relay, a time-extender stepping relay responsive to said actuator-latching relay for multiplying the basic time interval of said basic time interval, and means responsive to the attainment of a predetermined position by the stepping relay for producing a control signal at the termination of a predetermined multiple of the basic time interval, and returning the time extending stepping relay to a previous position.

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