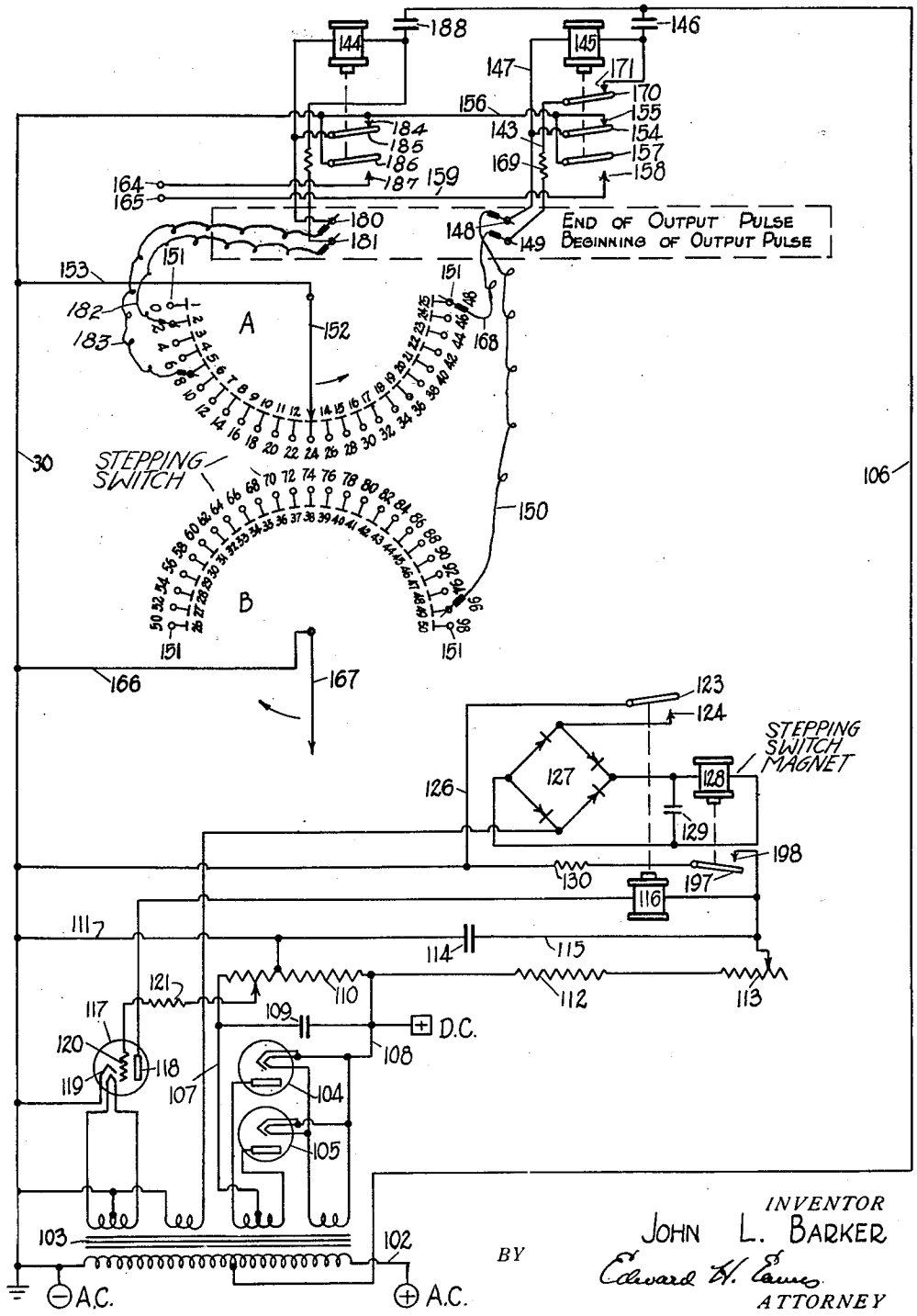
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CONTROL APPARATUS

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CONTROL APPARATUS

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This invention relates to electric switching equipment and the like and contemplates provision of a novel arrangement in which successive impulses of the same character and from the same source may successively energize and deenergize a relay in selected parts of a time cycle. Apparatus constructed in accordance with the present disclosure is of great utility for purposes of synchronization or coordination of units of electrical apparatus, as for governing operation of a plurality of traffic signals or traffic signal controllers or other machines, or for controlling any plurality of operations which it is desired shall occur in predetermined relation with one another.

It is a primary object of this invention to provide an improved circuit controlling device for opening or closing a plurality of circuits for time periods in predetermined time relation in which some of the periods may overlap, and also to provide ready adjustment of the length and time relation of such periods.

Another object is to provide improved apparatus of this character capable of producing a cycle of similar spaced impulses, and a relay, and arranged so that the relay will be connected to be energized by a predetermined impulse in the cycle and maintained energized and then deenergized by a later impulse in the cycle and maintained deenergized until the cycle is repeated.

One feature of applicant's apparatus is a circuit arrangement of a type in which successive impulses from the same source but over alternative circuits to a relay may produce different effects on the condition of the relay depending upon whether the relay is in an energized or deenergized condition when the impulse is produced.

It is another object of the invention to provide in combination with a circuit arrangement of aforesaid type for operating relays a cyclic multiposition switching mechanism which is advanced through its cycle by a timing device and which mechanism transmits one impulse in one selected position in its cycle serving to energize a relay and another impulse in another selected position serving to deenergize the relay.

Still another object is that apparatus of this type will be so constructed that the proportion of the number of pulses in the cycle during which the relay is energized to the number of pulses the relay is deenergized may readily be adjustable so that the period of energization (or deenergization) may easily be determined for any desired percentage part of the time cycle.

A further object is to provide apparatus of this type in which the energized and deenergized periods of a plurality of relays may be determined by impulses of the same type repeated thru a cycle, and in which cycle if desired, one or more of such relays may be energized and deenergized for the duration of varying predetermined numbers of impulses more than once per cycle.

The invention will be described and its operation explained in connection with the accompanying sheet of drawings comprising a circuit diagram of a preferred form of the invention.

Briefly, the apparatus shown in the drawing comprises a rotary stepping switch, having a driving magnet, of a type widely used in telephone practice and conventionally shown herein, a timing circuit for periodically operating the driving magnet of the stepping switch, and circuits including relays each of which relays is arranged to be energized in a certain position of the switch and deenergized in another position of the switch by connection of an impulse over one of the contact banks of the switch.

In accordance with the invention the energizing circuit for each of the relays is completed across an alternating current supply in series with a condenser whose value of capacitance is chosen so that with the inductance of the relay coil the circuit has resonant or near-resonant characteristics. This circuit is completed by momentarily connecting one end of the relay coil to one side of the power supply which is accomplished by the stepping switch in a predetermined position of the switch. The relay momentarily energized completes over one of its armatures a lock-in circuit to this same side of the power supply which maintains the relay energized.

When the stepping switch reaches a subsequent position the same side of the power supply is connected, via an armature of the relay in its energized position, to the other end of the relay coil thereby short circuiting the coil, and the relay will be deenergized. This short circuit contains a current-limiting resistor in order to prevent damage to the condenser, which at this time will be connected directly across the power supply.

Since a connection to the same side of the power supply is involved in each case through the contacts of the stepping switch, the same contact bank and wiper may be employed both to energize and to deenergize the relay or any other similarly arranged relay, and by means of two cross-connecting wires to select the proper bank contacts, the switch positions and corresponding periods of energization and deenergization of

several relays can be independently selected and readily changed.

Each relay in either its energized or deenergized condition, or both, is arranged to connect via one of its armatures a signalling circuit to one of the machines whose operation it is desired to control, so that where a number of relays are arranged to be energized and deenergized in a predetermined relation, a similar or greater number of machines or operations may be controlled in like sequence.

In the preferred embodiment of the invention shown the stepping switch is of the well-known type in which the wiper arms 152 and 167 are advanced step by step across banks of contacts A and B with which they cooperate. A cycle of energization and deenergization of a driving magnet 128 advances the wipers on each bank of the switch from one contact to the next. The driving magnet herein is energized periodically by a condenser gas discharge tube timing circuit. The latter is of the type comprising a condenser 114 connected between the plate and filament of a three-electrode gaseous discharge tube 117, a source of direct current for charging the condenser and for supplying a small grid bias for the tube, resistance 112—113 in the charging circuit of the condenser, and a terminating relay 116 operated at the end of the timed interval.

In order to provide great flexibility for cross-connecting in determining in which positions of the stepping switch each of the several relays should become energized and in which positions the relays should become deenergized contacts on the stepping switch have been wired to a group of pin jacks, one corresponding to each position of the stepping switch, and another group of pin jacks which are properly connected to the relay coil circuits, one jack for the energizing circuit for each relay and a second jack for the deenergizing circuit for each relay. A pair of jumper wires with pin plugs is provided for each of these relay jacks. By inserting one end of one jumper of the pair into the jack for the deenergizing circuit of the relay (which in the drawing is suitably marked to indicate the beginning of the control pulse to the outside machine) and the other end of the jumper in a suitable jack connected to a bank contact on the stepping switch, and by making similar connection of the other jumper of the pair into the other relay jack (marked to denote the end of the control pulse) and the desired stepping switch contact jack the stepping switch positions and corresponding period of energization of each relay and the time and duration of its control pulse may be easily varied.

A standard 25-point rotary stepping switch may be utilized. In this type of switch each contact bank is ordinarily equipped with a cooperating pair of wiper arms each of the arms being 180 degrees from the other so that as one wiper of the pair passes off the 25th and last contact of the bank the other wiper rotates into engagement with the number 1 contact. In the present apparatus however, it has been found advantageous to have a 50-point cycle, so that fifty divisions of the cycle and fifty pin jacks may be provided. This may be done by utilizing a 50-point stepping switch or, as in the present embodiment, utilizing a 25-point switch having but one wiper arm on each bank and the arms on adjacent contact banks spaced 180 degrees apart. Accordingly, two banks are used in place of one, the wipers of each being connected together and the contacts of the second bank being contacts 26 through 50. In the drawing wiper arms are for illustration shown engaging contact 13 on bank A, it being appreciated that meanwhile the wiper of bank B is not in engagement with any of its contacts.

With reference now to the drawing, rectifier tubes 104, 105 supply unidirectional current from secondary coils of transformer 103 to leads 107 and 108 and a filter condenser 109 maintains a near-constant voltage value. A potentiometer 110 is connected between said leads and an intermediate point on the potentiometer is grounded by leads 111, 30. The positive end of this potentiometer is connected over resistances 112, 113, the latter of which may be manually adjusted, to complete a charging circuit for timing condenser 114 over leads 111, 30 to ground. By lead 115 and the coil of relay 116 the positive side of the condenser 114 is connected to the plate 118 of tube 117, the negative side of the condenser is connected to grounded lead 30 as is the cathode 119 of tube 117. This tube may for example be of the indirectly heated type in which case it is heated by current from suitable taps on transformer 103. From an adjustable tap on potentiometer 110 and grid resistor 121 the bias of grid 120 may be controlled.

By means of armature 123 and contact 124 on the terminating relay 116 of the timing circuit, circuit may be completed from grounded leads 30, 126, armature 123, contact 124 to energize rectifier 127 which may for example be of the copper sulphide or oxide type. This rectifier when energized supplies current to operate motor magnet 128 of the stepping switch. A condenser 129 across the output of the rectifier lessens the intensity of current fluctuations therein. Energization and deenergization of magnet 128 causes the pawls and ratchet forming a part of the line switch to advance the wipers on each bank one contact position. In the energized position of the magnet 128 a discharge circuit for condenser 114 is completed through low resistance 130, armature 197, contact 198 for resetting this condenser to time the next interval.

For illustration only two relays 144 and 145 are shown to govern the connection of control impulses to the outside machines and in this embodiment for this purpose each relay is arranged to connect grounded power over an armature and back contact to a terminal to which a suitable conductor may be fixed to transmit the impulse to the controlled machine. Other suitable forms of control pulse could be supplied in lieu of the grounded power connection shown herein. It will also be obvious that any number of such relays may be provided along with their associated contact jacks and jumper wires. In relay 144 there appears no contact and armarure corresponding with the contact 171 and armature 170 of relay 145 as such contact and armature have been replaced by a direct connection as an alternative arrangement. The make contact 171—170 on relay 145 permits the circuit thru this contact to be broken by the contact itself rather than by contacts of the stepping switch, but if the latter contacts are adapted for interrupting currents of the values required without harm, the direct connection shown on relay 144 may be used as described in place of this contact and armature. Operation of relays 144 and 145 is similar and therefor operation of relay 145 will be explained in detail for example.

From a tap on transformer 103 a circuit for

energizing relay 145 extends over lead 106, condenser 146, coil of relay 145, lead 147, pin jack 148, jumper 150, one of pin jacks 151 and corresponding contact of bank A or B of the rotary switch. For example, this circuit may include pin jack 96 (which number represents percent of total cycle) and corresponding contact 49 on bank B of the stepping switch. When wiper 167 is advanced to engage contact 49 this circuit for energizing relay 145 is completed over lead 166 to grounded lead 30.

The capacitance of condenser 146 is chosen in consideration of the inductance of the coil of relay 145 so that the circuit through the coil and condenser will have resonance or near-resonance characteristics. Accordingly, if for example, the alternating current voltage between leads 106 and 30, across the relay coil and condenser, be only 55 volts, the voltage across either the relay coil or the condenser alone may be considerably more, for example, 100 volts, and capable of energizing the relay coil, which is designed for this voltage. When the relay is energized (for "end of output pulse") at armature 154 a circuit is completed from the negative side of the relay coil over wire 147, armature 154 contact 155 and lead 156 to grounded lead 30 to maintain relay 145 energized.

In its former deenergized position relay 145 closed over armature 157 and contact 158 from grounded leads 30 and 156, an outgoing control circuit via lead 159 to terminal 165, and upon energization of relay 145 this control circuit is interrupted at armature 157. This control circuit as explained before is connected with whichever other machine it is desired to be governed by the output pulses.

To deenergize relay 145 (for "beginning of output pulse") grounded lead 30 is connected via lead 153, wiper 152 and contact 25 of bank A, associated with pin jack 48 (which represents per cent of cycle) selected for purpose of example, and the corresponding one of pin jacks 151 via jumper 168, pin jack 149, low resistor 169, armature 170, contact 171 to the positive side of the relay coil. Thereupon grounded lead 30 is connected to both sides of the relay coil reducing the voltage across the coil substantially to zero. Resistor 169 serves to limit current thru and to prevent damage to the condenser 146 which when armature 170 is engaging contact 171 is directly across the line.

Similarly by connecting pin jack 181 by a jumper 182 to the desired one of pin jacks 151 relay 144 may be deenergized and its control pulse initiated at any desired point in the stepping switch cycle, pins jacks 151 being labelled herein in percentage of the total cycle to facilitate such connection. Another jumper 183 connecting a suitable one of pin jacks 151 to jack 180 determines in which switch position relay 144 and any other similar relays will be energized for terminating their respective control pulses. Contacts 184, 187 and armatures 185, 186 of relay 144 correspond to contacts 155, 158 and armatures 154, 157 of relay 145. Condenser 188 for relay 144 corresponds to condenser 146 for relay 145. When it is desired that two or more jumpers be placed in the same one of pin jacks 151 in order to initiate or terminate the output pulse to two or more machines simultaneously, it will be obvious that such jumpers may be spliced with a single pin plug or the common end, or a plurality of pin jacks for such switch position may be provided and connected together. A further alternative in the event that the control pulse is to be initiated or terminated simultaneously at two or more machines is for the pulse transmitted from terminal 165 for example, to operate a relay over the contacts of which suitable pulses are extended to the machines. Terminals 164 and 165 are the output points for the pulses controlled by relays 144 and 145 respectively.

Operation of the switching device through one cycle of the stepping switch will now be explained, assuming that wiper 152 cooperating with bank A of the stepping switch is engaging contact position 13, as shown. From potentiometer 110 a negative bias is maintained on the grid 120 of the tube 117, so that no current flows in the plate circuit of the tube. The circuit will be completed for charging a timing condenser 114 from the direct current positive terminal of the rectifier via resistors 112, 113 through condenser 114 to grounded leads 111 and 30, charging the condenser at a rate which depends upon the capacity of the condenser, the supply voltage and the resistance of the circuit. In the present instance, the first two factors are constant, only the last, the quanity of resistance, is manually adjustable, and this alone regulates the rate of charging of the condenser, and consequently adjusts the time interval. The latter gradually acquires across its plates a potential difference approaching the supply voltage, this charging occurring at a rate proportional to the amount of resistances 112, 113. The plate 118 of tube 117 is connected to the positive side of condenser 114 through the coil of relay 116. When condenser 114 has attained a certain voltage value, the potential difference between the plate and filament of tube 117 has reached the same value and eventually the potential therebetween is sufficient to ionize the gas in the tube, whereupon the tube instantly becomes conducting and a current sufficient to energize relay 116 flows. Thus the condenser, tube and relay serve as a timer.

This tube is of such a type that the potential of the grid determines the ionizing or breakdown potential of the tube, but under normal conditions of operation once discharge in the tube has commenced, the grid has substantially no control over current in the anode-cathode circuit. If direct current is used in the latter circuit, as in the present case, the discharge in the tube ceases when the potential across the condenser is no longer sufficient to maintain the discharge.

From the drawing, it may be seen that the amount of grid bias may be varied by an adjustment tap on potentiometer 110. Increasing the negative grid bias in this type of tube increases its ionizing potential substantially proportionally, but in the present embodiment the length of time before operation of relay 116 is adjusted by variable resistance 113 and the grid bias adjustment is provided to compensate for circuit errors or inaccuracies in the size of the charging resistance.

Considering again operation of the timer, the energy accumulated in condenser 114 is dissipated during the discharge of the tube in the circuit which parallels the condenser 114 through relay 116. Relay 116, momentarily operated, at armature 123 completes a circuit for energizing rectifier 127 from grounded lead 30 over lead 126, armature 123, contact 124, to one side of rectifier 127, the other side being permanently

connected to a secondary coil of transformer 103. This momentary operation of armature 123 momentarily energizes rectifier 127 which operates motor magnet 128. Upon being energized and deenergized magnet 128 notches the wipers of the stepping switch ahead one position into engagement with contact 14 on bank A at armature 197. Magnet 128 when energized completes a discharge circuit for condenser 114 via contact 198, armature 197, low resistance 130, leads 30 and 111, so that the condenser will dissipate any residual charge and the device will accurately measure time in the next position as soon as this discharge circuit is broken by the dropping back of armature 197 from contact 198. Advancing of the stepping switch wipers in this manner will be repeated with repeated operations of the timing device, as described.

When the wiper on either banks A or B engages a contact whose associated pin jack is connected by a jumper to one of the terminals marked "Beginning of output pulse", as for instance when wiper 152 engages contact 25 on bank A, grounded lead 30 will be connected via lead 153, wiper 152, contact 25 of bank A, jumper 168, pin jack 149, resistor 169, armature 170, contact 171 to the positive end of the coil of relay 145, since as will subsequently appear this relay 145 will be in its energized position when the stepping switch moves into position 25. Grounded power meanwhile is connected via leads 30, 156, contact 155, armature 154, to the negative end of the coil of relay 145 so that the coil of relay 145 is shunted through low resistance 169 and relay 145 becomes deenergized.

The pulse to the outside machine governed by relay 145 will now be transmitted over the circuit now completed from grounded lead 30, lead 156, armature 157, contact 158, and terminal 165. Since the lock-in circuit to relay 145 is now broken between armature 154 and contact 155, when the stepping switch advances the wiper 152 out of engagement with contact 25, relay 145 will remain deenergized.

As wiper 152 moves off contact 25, wiper 167 which cooperates with bank B will be revolved into engagement with contact 26 thereon. Successive operations of the timing circuit as described continue periodically to advance the wipers step by step. As shown in the drawing, when wiper 167 engages contact 49 circuit is completed from grounded leads 30, 166 over wiper 167, contact 49 of bank B, pin jack 96, jumper 150, pin jack 148, lead 147 to negative side of relay 145. Relay 145 will thereby be energized since the positive side of its coil is connected via condenser 146 and lead 106 to the other side of the power line. Energization of this relay causes armature 154 to engage contact 155 completing a lock-in circuit from the negative side of the relay coil via lead 156 to grounded lead 30 for maintaining the relay energized. At armature 157 and contact 158 the control pulse transmitting circuit to terminal 165 is broken. Obviously, by other pairs of jumpers connecting the pin jacks labelled respectively "End of output pulse" and "Beginning of output pulse" to pin jacks 151 as desired, relay 144 and other relays similar to 145 may be operated to be deenergized and energized at selected points in the stepping switch cycle.

Where it is desired that one relay be deenergized and energized more than once each cycle, it will be obvious that the jumpers from its "Beginning of output pulse" and "End of output pulse" jacks may have two or more pin plugs on their other end and fitted into suitable numbers of jacks 151.

It will be appreciated that the device described is but one embodiment of the invention and that the invention may take other forms than the one shown. For example, any of the well known types of timing devices for generating intermittent impulses may be employed for advancing the stepping switch in place of the condenser type timer shown. It will also be understood that an apporpriate resistance might be substituted for the condenser 146 to cause the relay 145 to be energized and deenergized by the respective circuits 147 and 143 as hereinbefore described. Further, a switching arrangement might be substituted for the pin plugs and jacks illustrated or other changes in the design or rearrangement of the parts might be made, as the substitution for a stepping switch of cam contacts operated at desired positions of cams on a cam shaft actuated periodically by a solenoid, without departing from the spirit of the invention as defined by the following claims.

I claim:

1. An electric switching apparatus for controlling operation of a relay including a rotary switching mechanism having a cycle comprising a plurality of positions and contacts on said mechanism adapted to be closed one in each position, means for advancing said mechanism from one position to the next in its cycle, a circuit closed in one position of said mechanism for energizing said relay, a lock-in circuit for said relay, a circuit closed in another position of said switch for short circuiting the coil of the said relay to deenergize said relay, said energizing and deenergizing circuits including selective means for connecting the respective circuits to any of said contacts of said mechanism.

2. An electric switching apparatus for controlling operation of a relay including a rotary switching mechanism having a cycle comprising a plurality of positions and contacts on said mechanism adapted to be closed one in each position, means for advancing said mechanism from one position to the next in its cycle, a circuit closed in one position of said mechanism for energizing said relay, a lock-in circuit for said relay, a circuit closed in another position of said switch for short circuiting the coil of said relay to deenergize said relay, said energizing and deenergizing circuits including selective means for connecting the respective circuits to any of said contacts of said mechanism, said selective means comprising pin jacks connected with the respective said contacts in the respective switch positions and means including jumper wires fitted with pin plugs for cooperating with said pin jacks for connecting the relay energizing and deenergizing circuits in any desired positions of the switching mechanism.

3. In an electric switching apparatus for energizing a plurality of control circuits cylically for time periods of independently adjustable time lengths and time relation, a plurality of relays each having a coil and a plurality of contacts some of which are connected to such control circuits and having an impedance connected between one side of the coil and one terminal of an alternating current power supply, a plurality of energizing circuits one for each relay connected to the other side of its coil, and connectible to the other side of the power supply, a stick circuit for each relay including a make con-

tact thereof to maintain its coil energized after the energizing circuit is made and broken, a plurality of deenergizing circuits one for each relay and connected between said one side of its coil and said impedance, and connectible to said other terminal of the power supply to short circuit said coil and deenergize its relay, a cyclic switching device having a plurality of contacts and corresponding contact positions through which it operates at a time rate to close the latter contacts one at a time, one side of each of said latter contacts being connected to said other side of the power supply, a plurality of connecting jacks corresponding and connected to the other side of said latter contacts, and a plurality of connecting plugs cooperating with said jacks and connectible to the respective energizing and deenergizing circuits of the respective relays to selectively connect the last named circuits to certain of the switching device contacts, whereby said relays and their associated control circuits may be individually energized and deenergized for selected time periods in selected time relation with each other.

4. In an electric switching apparatus for energizing a relay cyclically throughout a time period from one selected point in such cycle to another selected point in such cycle, said relay having a coil and a plurality of contacts, a cyclic switching device having a plurality of contacts and corresponding contact positions through which it operates to close said contacts one at a time, a condenser connected between one side of said relay coil and one terminal of an alternating current power supply, said condenser having a capacity suitable for tuning said relay coil for substantial resonance with said power supply a circuit having a plug terminal connected with the other side of said relay coil and connectible momentarily to the other terminal of the power supply to energize the relay, a stick circuit for said relay including a make contact of the relay for connecting said other side of said coil to said other terminal of the power supply to maintain said coil energized after the said momentary connection is broken, a circuit having another plug terminal connected with said one side of said coil and connectible momentarily to said other terminal of the power supply to short circuit said coil and reenergize said relay and jack terminals connected individually to the contacts of said cyclic switch device and connected to said other terminal of the power supply when the respective contacts are closed, said plug terminals adapted to cooperate with said jack terminals whereby the positions of said cyclic switch cycle at which the relay will be energized and those at which the relay will be deenergized may be selected.

JOHN L. BARKER.

CERTIFICATE OF CORRECTION.

Patent No. 2,178,112. October 31, 1939.

JOHN L. BARKER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 57, for the word "pins" read pin; page 4, second column, line 12, for "apporpriate" read appropriate; page 5, second column, line 20, claim 4, for "reenergize" read deenergize; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 26th day of December, A. D. 1939.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.