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CONTROL CIRCUIT FOR HIGH SPEED SELECTOR

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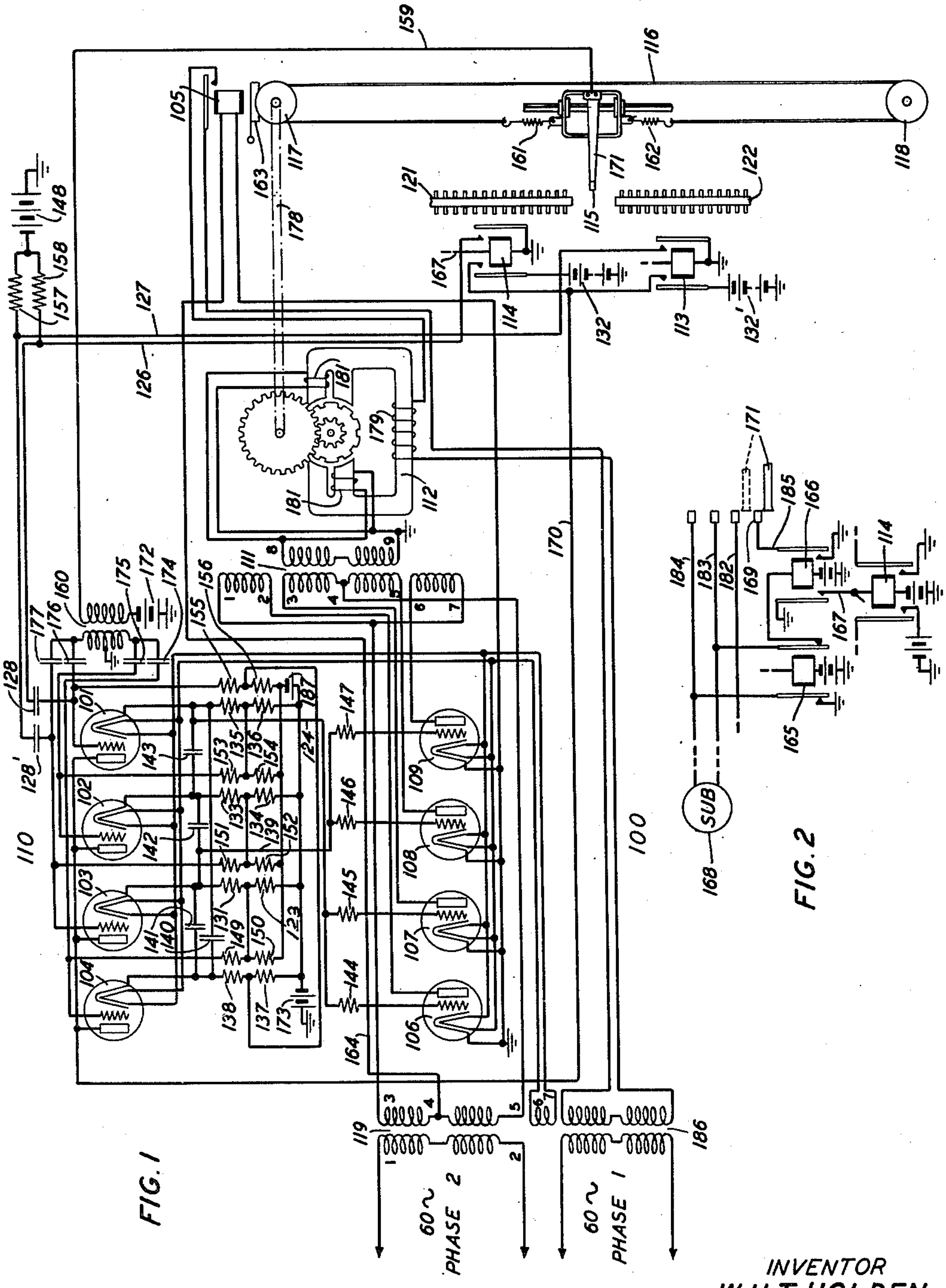

FIG. 1

FIG. 2

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CONTROL CIRCUIT FOR HIGH SPEED SELECTOR

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15 Claims. (Cl. 179—25)

This invention relates to motor control devices and more particularly to an arrangement for controlling the direction of current flow in alternating current light-duty motors, preferably of the polyphase type which requires sensitive start-stop control.

More especially the present embodiment of the invention is adapted to the control of the driving motor of a selector switch of the type disclosed in an application of W. W. Carpenter, Serial No. 133,969, filed March 31, 1937, Pat. No. 2,123,228, granted July 12, 1938. This switch is a high-speed selector of the panel type and comprises a single brush set which is driven by a steel tape in either direction to traverse two banks of terminals. The tape passes over a driving pulley at the end of one bank of terminals and an idling pulley oppositely disposed at the end of the other bank of terminals. An alternating current motor geared to the driving pulley provides the necessary power to pull the tape in either direction while a brake associated with it normally holds the tape against movement when the brush set is in contact with a set of terminals.

This switch is capable of traveling at very high speeds, hunting speeds of 250 terminals per second being easily attainable and hunting speeds of 400 terminals per second being possible. It becomes necessary, therefore, that, in order to insure that the brush set shall be quickly stopped and accurately centered on the terminal set which has been marked with a calling condition, a particularly sensitive control circuit be provided which is adapted to respond quickly to the test condition on the marked terminal, to open the circuit of the motor in response thereto, to apply it again in the reverse direction if the brush overrides the marked terminal, and to repeat these operations in both directions of travel as often as necessary to accurately center the brush set on the terminal set with which it is to be connected.

One of the objects of the invention, as adapted to the operation and control of the above-described type of switch, is, therefore, to provide means for applying current of proper phase relationship to the motor on a signal that a line terminating in either bank of the switch is calling, for supplying power to the brake magnet to release the driving tape when the switch is about to move, for shutting off current to the motor when the brush set contacts with the terminals of the calling line, and for reapplying the current in alternately reverse directions as often as necessary if the brush set rides beyond the wanted terminal while attempting to stop thereon or beyond the wanted terminal when the direction of travel is reversed to bring the brush set into connection with said terminal.

To attain these ends, one feature of the present invention is a novel arrangement of four thyratron tubes rotatively arranged in pairs and so electrically interconnected that each pair will control, in sequence, the movement of the selector in the opposite directions of travel. Thus the first tube in each pair is responsive to a signal from a calling line in the bank in which the line appears, and the second tube is responsive to the electrical condition imposed upon the test terminal of that line. Now the first tube, upon being ionized, controls a source of power which causes the motor to be operated in the appropriate direction to move the brush set over that bank of terminals in which the calling line appears, and, at the same time, "primes" the second tube of the pair in order that it may respond to the terminal signal when the brush connects with the line terminal, an operation which, when it occurs, will have the effect of extinguishing the first tube to stop the motor and of priming the first tube of the second pair of tubes in readiness to control the operation of the motor in the reverse direction should the brush set ride over the terminal on which it is to come to rest and thus break contact with it. Should this come to pass, however, an impulse of current will be produced that will ionize the primed tube, the effect of which will be, first, to cause a reversal of current flow in the motor to drive the brush set in the opposite direction to reengage the terminal and, second, to prime the next tube of the second pair. When the brush set again engages the terminal, an impulse of current is again produced which ionizes the primed tube, extinguishes the conducting tube which thereby shuts off the power to the motor to stop the movement of the brush set, and further reprimes the succeeding tube of the first pair in readiness once more to apply power to the motor in the reverse direction should the selector, in advancing, fail to stop on the wanted terminal and thereby produce another impulse that will render the primed tube conducting.

Thus with an electrical guard provided which controls a thermionic device that will cause the selector to move in alternate directions, should the brush set overrun the terminal to be selected in either direction of its movement, over-stepping is practically impossible and accurate terminal selection is thereby insured.

A second feature of the invention is the provision, in combination with the thermionic control circuit, of a full wave rectifier which provides current of proper phase relationship to the motor on signal from the thermionic device, and further provides rectified current to the brake magnet of the selector at the time said magnet must disengage the brake clutch to permit the tape to pass freely over the driving and driven pulleys when moving in either direction of travel. This rectifier comprises a pair of thyratron tubes for each direction of phase displacement of the motor current, having paralleled grids which are connected to the cathodes of the alternate thyratrons of the control circuit to render these rectifying thyratrons conducting on the signal produced by said alternate thyratrons when they become ionized either on the original signal produced when a line initiates a call in either bank of the selector or on the succeeding signals produced by the test brush of the selector making and breaking the opposite edges, respectively, of the marked terminal in the operation of centering thereon. The cathodes of the rectifying thyratrons are connected to a suitable source of power and, if they are of the "heater" type, to a suitable source of alternating current power, while the anodes are each connected to terminals of separate primary windings of a transformer whose other terminals extend to the first phase of the current supply, while the secondary windings of said transformer are connected to a set of phase windings of the selector motor the other phase winding of which is connected to the second phase of the current supply.

Before proceeding with the detailed description of the invention, it would be desirable to mention a few of the properties of the thyratron tube of which use is made both in the control circuit and rectifier. This tube is a three-element valve containing a cathode heated by a filament, a grid and an anode. The enclosing envelope, however, instead of being completely evacuated, as would ordinarily be the case with the conventional vacuum tube, contains a trace of mercury vapor or some inert gas such as argon, at low pressure, which, when ionized, reduces the space charge and causes an arc to strike which, in reality, is but a heavy anode current that passes between the cathode and anode. The arc can be prevented from striking, however, if the grid potential is less, that is, less negative, than a certain critical value. In this way, a small negative voltage on the grid can control a much larger positive voltage on the anode. If, however, the grid be made very slightly more positive than the critical negative voltage, the anode current starts immediately and, once started, it continues until either the anode circuit is broken for a fraction of a second or the potential drop across the cathode and anode is reduced or reversed by some means for a time long enough for the positive ions which have formed around the grid to diffuse to the walls of the tube.

Having given a brief summary of the main features of the invention and of the control element which is used to attain them, we may now obtain a clearer conception of the scope and purpose of the invention from the following detailed description of the operation of the invention, taken in connection with the appended claims and the attached drawing in which Fig. 1 shows the control circuit 110, the full wave rectifier 100 and a skeletonized form of the selector, briefly described above and chosen to illustrate the application of the invention, while Fig. 2 shows the relationship between one of the brushes of the brush set of the selector and one of the terminals of the terminal set to be selected.

Referring to Fig. 1, reference character 115 indicates the brush set of the switch, movable over the terminal banks 121 and 122 by means of the metallic tape 116, driven by pulley 117 and passing over the idler pulley 118. The tape is maintained in a state of sufficient tension by springs 161 and 162 connecting its ends to the brush carriage. Pulley 117 is driven by the reversible polyphase induction motor 112 through shafting 178. This motor has two sets of windings, the lower or main winding 179 being supplied with current from transformer 186, which is connected to one phase of a sixty-cycle current supply, and the auxiliary windings 181 being supplied with current from winding 8—9 of transformer 111 which, in turn, receives the current from the second phase of the sixty-cycle power supply connected to the primary of transformer 119 at terminals 1—2 thereof. The secondary winding of transformer 119 is tapped at its midpoint 4 by conductor 164 and extends to the winding of the brake magnet 105 the other side of which extends to the cathodes of all the rectifier thyratrons 106, 107, 108 and 109 which, when operating in pairs in the manner to be presently described, provide rectified current to operate said brake magnet.

It will be observed that the circuit of the main winding 179 of the motor is carried through a set of contacts on the brake magnet 105 and, therefore, this circuit will be ineffective until these contacts are closed, which occurs, as will be presently explained, a short time after the current has been applied to the secondary windings 181. The reason for this is, of course, to keep the main winding open-circuited so long as the motor is not in use.

Terminal 3 of the secondary winding of transformer 119 is connected to terminal 1 of the primary winding 1—2 of transformer 111 and also to terminal 7 of the primary winding 6—7 of the same transformer. Terminal 2 of winding 1—2 of transformer 111 is connected to the anode of tube 106, while terminal 6 of winding 6—7 of said transformer is connected to the anode of tube 109. Terminal 5 of the secondary winding 4—5 of transformer 119 is connected to terminal 4 of the primary winding 3—4—5 of transformer 111. Terminal 3 of this winding is connected to the anode of tube 107, while terminal 5 of this winding is connected to the anode of tube 108.

Let us suppose that the cathode heaters of thyratrons 106, 107, 108 and 109 are heated to incandescence from the alternating current obtained through the secondary winding 6—7 of transformer 119, that the grids of the thyratrons 106 and 107 are at cathode potential or positive thereto, while those of thyratrons 108 and 109 are at a sufficiently negative potential with respect to their cathodes to be non-conducting at any point in the voltage cycle. Assume, further, that, at a given instant, terminal 3 of the secondary of transformer 119 is positive. Then current will flow thence to terminal 1 of the winding 1—2 of transformer 111, through this winding to the terminal 2 thereof and thence to the anode of tube 106, in which an arc will strike and current will flow as soon as the anode reaches a certain potential value positive with respect to the cathode, the current path being then completed through winding of magnet 105 to the terminal 4 of the secondary winding of transformer 119. One half-cycle later in the voltage cycle of the second phase of the voltage supply, terminal 3 will be negative and terminal 5 will be positive whereupon current will then flow from terminal 5, through winding 4—3 of transformer 111, and thence to the anode of tube 107 in which an arc will strike between the anode and cathode thereof when the anode reaches a certain positive potential value, the current path again being completed through the winding of brake magnet 105 to terminal 4 of the secondary of transformer 119. Now since the terminals of the various transformers are so numbered as to indicate series aiding connections, it is apparent that in the first case noted the current flows through winding 1—2 of transformer 111 while one half-cycle later the current flows through winding 4—3 of said transformer, the sequential order of the terminals of the transformer here given indicating the direction of current flow in each case, it being observed that the current flow through winding 1—2 is opposite to that through winding 3—4. Furthermore, windings, 1—2, 3—4, 4—5 and 6—7 of transformer 111 are all equal, windings 1—2 and 3—4 being connected, respectively, to the anodes of rectifier tubes 106 and 107 while windings 4—5 and 6—7 are connected, respectively, to the anodes of rectifier tubes 108 and 109. Hence, there will be an alternating current flux set up in the core of transformer 111 when either pair of thyratrons are rectifying which will induce a voltage in winding 8—9 of said transformer that will supply current to the auxiliary windings 181 of motor 112. The main winding 179 of motor 112 will be energized with current from the first phase of the alternating current supply through the contacts on brake magnet 105, which operates when the direct current flows through it. The motor will thus start and run in a direction predetermined by the phase sequence between its two windings.

Now if the grids of tubes 106 and 107 are made strongly negative with respect to the cathodes thereof, and the grids of tubes 108 and 109 are given a potential which is either zero or positive with respect to their cathodes, and, as before, the current at terminal 3 of transformer 119 is positive, current will flow from terminal 3 on said transformer to terminal 7 of winding 6—7 of transformer 111, through the arc path of tube 109, through the winding of brake magnet 105 and back to terminal 4 on the secondary of transformer 119 as already described. It will be observed that, in this case, the flux produced in the core of transformer 111 is the reverse of the flux produced when tube 106 was conducting since the current which flows through windings 6—7 in the 7 to 6 direction is opposite to that which flows through the winding 1—2 in the 1 to 2 direction. One half-cycle later current will flow from terminal 5 on the secondary of transformer 119, which is now positive, to terminal 4 on the winding 3—4—5 of transformer 111, terminal 5 to the anode of tube 108, through the arc path thereof and back to the terminal 4 of the secondary of transformer 119 through the winding of magnet 105. As before, the flux now produced in the core of transformer 111 is the reverse of that produced when tube 109 was conducting, so that an alternating flux is set up which induces a voltage in winding 8—9 that will operate the motor 112. But the phase of the voltage, however, is now shifted 180 degrees from that set up when tubes 106 and 107 were allowed to conduct. Hence there is a reversal in the direction of phase sequence and, therefore, a reversal in the direction of rotation of the motor 112.

It is thus apparent that the motor 112 can be started, stopped and reversed by controlling the grid voltages applied to the tubes 106—107 or 108—109, because the supply of current to the windings of the motor, fed from winding 8—9, results from the operation of either of the full wave rectifiers 106—107 or 108—109, which also release the brake 163 by operating the brake magnet 105 and further closes the circuit at the brake magnet contacts to the winding of motor 112, fed from the first phase of the current supply by transformer 186.

The grids of the rectifying tubes 106 and 107 are connected, respectively, to protective resistances 144 and 145 and the grids of tubes 108 and 109 are similarly connected to protective resistances 146 and 147. Except when these tubes are required to operate, as more particularly described hereinafter, tubes 108 and 109 receive a negative grid bias from positively grounded battery 173 through the following path: battery 173, resistances 123 and 131, conductor 139 to resistance 146 and 147, respectively; and tubes 106 and 107 receive a negative grid bias from battery 173, resistances 136 and 135, conductor 124 to resistances 144 and 145, respectively. The cathodes of tubes 106 and 109, inclusive, are grounded as indicated.

The four thyratrons 101, 102, 103 and 104 are parts of the control circuit 110. These tubes are electrically arranged to operate in a sequence and adapted, when operated, to prime the succeeding tube for operation, which latter tube, when it does operate, extinguishes the preceding tube that primed it. A common grid battery 187 provides negative bias to the grid of each of the tubes through resistances 155 and 156 for the grid of tube 101, through resistances 153 and 154 for the grid of tube 102, through resistances 151 and 152 for the grid of tube 103 and through resistances 149 and 150 for the grid of tube 104. There are, further, two resistances in series with each of the tube cathodes extending from negative battery supply 173 as follows: resistances 135 and 136 for the cathode of tube 101; resistances 133 and 134 for the cathode of tube 102; resistances 131 and 123 for the cathode of tube 103; and resistances 137 and 138 for the cathode of tube 104. The anodes of the tubes 101, 102, 103 and 104 are all connected together, and may be connected to the negative grounded battery 132 through the contacts of relay 114 or to the negative grounded battery 132 through the contacts of relay 113, while extinguishing condensers 143, 142, 141 and 140 are connected between the respective cathodes to quench the arc of one tube when the succeeding tube operates, as will be described hereinafter.

The function of this control circuit is to apply suitable voltages to the conductors 124 or 139 so as to influence the operation of rectifier tubes 106 and 107 or 108 and 109 and thus control the movement of the switch brush set 115. The operation of the switch depends, naturally, upon the direction of rotation of the motor 112, and since the brush set 115 is normally located midway between the upper and lower terminal banks 121 and 122, the operation of the motor will have to be determined by the terminal bank in which the calling line appears. This initial directional control is accomplished by the operation of either relay 114 or relay 113, the former being responsive to a calling line located in the upper terminal bank 121 and the latter to a calling line located in lower terminal bank 122.

An inspection of Fig. 2 will make this operation clear. This figure shows the subscriber's line circuit and the relation between the line, the terminal bank and the relay which initiates the switch operations. If we assume, for example, that the line appears in the upper bank 121, then the conductors 182, 183, 184 and 185 are connected to a group of terminals in said bank. These terminals are horizontally aligned and the brushes of the brush set 115 which are also horizontally aligned, will engage the various terminals at approximately the same time. In the figure, the various terminals are shown vertically displaced for convenience, and the test brush 171 of brush set 115 is shown in full below the terminal it engages and in broken lines above. The other brushes, which are not shown, will, of course, engage their corresponding terminals at approximately the same time that brush 171 engages the terminal of the bank to which conductor 185 extends.

It will be seen from Fig. 2 that the line circuit comprises the usual line relay 166 and the cut-off relay 165. To the inner contact of the left set of contacts of the line relay 166 is wired conductor 167 which extends to the winding of the bank relay 114. This relay is, of course, commoned to the line relays of all other line circuits terminating on the upper bank of the switch so that, when any line in the bank initiates a call, the relay will operate to produce the signal which controls the rotation of the motor 112 in the direction appropriate to move the switch brush set 115 upwards over the terminals of bank 121.

Similar circuit arrangements prevail with respect to the lines which are connected to the terminals of the lower bank 112, bank relay 113 being commoned to all the line relays of the respective line circuits therein and operating whenever any of said lines call to produce the signal which will operate the motor to move the switch brush set 115 downwards over the terminals of bank 122 in search of the terminals of the calling line.

Thus when subscriber 168 initiates a call by lifting the substation receiver off the switchhook, a circuit is completed for line relay 166 which extends from positive grounded battery through the winding of said relay, right contacts of relay 165, over the line loop, to ground through the left contacts of relay 165. The line relay, upon operating, closes an obvious circuit to the winding of the bank relay 114 and, over its right contacts, connects ground to the terminal 169 in the bank as a marking condition of the calling line.

Referring to Fig. 1, the operation of bank relay 114, in response to a line initiating a call in the upper bank 121, connects ground to conductor 126 which extends to one side of condenser 128 and to resistance 158 to initiate the operation of control circuit 110 in the manner to be shortly described. Relay 114, through conductor 170, further connects positive battery to the anodes of thyratrons 101, 102, 103 and 104 which are all commoned. It will be observed that the grid of tube 101 is maintained at a negative bias by the battery 187 feeding through resistances 155 and 156, as already explained, and that the mid-points of the cathode series resistances of one tube, such as tube 101, for instance, is connected to the mid-point of the grid biasing resistance of the next tube 102. Hence when relay 114 operates and grounds conductor 126 and, therefore, one side of condenser 128, a strong positive surge will be created through this condenser which will render the grid of tube 101 positive and cause it to become conducting. Similarly, if the calling line had been located in the lower bank, the result of which would have been the operation of relay 113, ground would have been connected to conductor 127 and to one side of condenser 128' creating therein a positive surge which would render the grid of tube 103 positive and cause it to break down and become conducting. However, due to the fact that the mid-point of the cathode resistances 135 and 136 of tube 101 is connected to the mid-point of the grid resistances 133 and 134 of tube 102, the fact that the tube 101 becomes conducting and, therefore, produces a current flow through resistances 135 and 136, the voltage drop through resistance 136 will reduce the negative bias on the grid of tube 102 to the point just above conducting, that is, "primes" the tube so that any slightly positive surge thereafter will cause it to break down and become conducting except as noted hereinafter.

As before stated, conductor 124 is connected to the cathode of tube 101 and to the grids of the rectifier tubes 106 and 107 through resistances 144 and 145, respectively. When, therefore, tube 101 becomes conducting, the voltage drop in resistances 135 and 136, which will be the sum of the voltages of batteries 173 and 132 less the arc drop in the discharge path of tube 101, will be applied to conductor 124 and is of a polarity which opposes the negative voltage of battery 173. This will bring the voltage between the conductor 124 and ground to a slightly positive value, allowing the rectifier tubes 106 and 107 to conduct and cause the motor 112 to operate and drive the brush 115 upwards as previously described.

Similarly, if tube 103 becomes conducting as a result of ground being applied to conductor 127, a positive voltage to ground will be applied to conductor 139, connected to the cathode of tube 103, and this will allow thyratrons 108 and 109 to conduct, causing motor 112 to rotate in the opposite direction and drive the brush set 115 downwards over the terminals of bank 122.

It is thus seen that the operation of relay 114 starts the switch upwards towards the marked terminal of the calling line by causing tube 101 to operate and hence allow thyratrons 106 and 107 to conduct thereby releasing the brake 163 through the operation of magnet 105, and causing motor 112 to rotate in a counterclockwise direction. When the hunting brush 171 in the brush assembly 115 engages the marked terminal, which is grounded, in bank 121, as shown, for instance, in Fig. 2, a circuit will be completed from ground on said terminal extending thereto from the right contacts of relay 166, brush 171, conductor 159, the primary winding of transformer 160, to positive grounded battery 172. The current which builds up in this circuit causes a negative voltage to appear momentarily at the lower terminal of the secondary winding of said transformer, the current produced by which is transmitted through blocking condensers 174 and 175 to the grids of tubes 102 and 104 which are thus rendered positive and will strike an arc if in a critical or primed condition. The center tap of the secondary winding of transformer 160 being grounded, a positive pulse is produced at its upper terminal and is applied through blocking condensers 176 and 177 to the grids of tubes 101 and 103 which are thus rendered more negative. Transformer 160 is so proportioned that the make or break pulses from its secondary, resulting from the make or break of the primary circuit will operate only the tube primed for operation, as previously explained. Inasmuch as tube 102 is the one which was primed by the tube 101 when it became conducting, tube 102 will operate on the positive pulse transmitted through condenser 175, causing it to apply negative voltage to the grids of tubes 106 and 107 which are thereby disabled to prevent first phase current from being applied to the primary windings of transformer 111, and to prevent rectified current from being applied to the brake magnet 115. The result is that the motor stops and the brake 163 is released to grip the tape 116.

The operation of tube 102 causes tube 103 to be primed in the same manner as tube 102 was itself primed, that is, by applying the voltage drop through resistance 133 to the grid of tube 103. Tube 101, however, is extinguished at the time when tube 102 becomes conducting because, when tube 101 became conducting, a difference of potential was established across each of the two condensers 143 and 140 connected to the cathode of this tube. But when the impulse through condenser 175 causes tube 102 to arc, its cathode potential will suddenly rise from the potential value prevailing in its primed condition to a value measured by this potential and that of the potential difference in the two condensers. Accordingly, a positive potential surge is transmitted by condensers 142 and 143 connected to either side of the cathode of tube 102 which will have the effect of momentarily raising the potentials of the cathodes of tube 101 and 103, which means that the potential drop between the anode and cathode of tube 101 is momentarily lowered below the normal value necessary to maintain the arc.

Tube 103 remains primed until it has been made conducting by a succeeding impulse, or the control circuit is restored to normal by the release of relay 114 and the consequent removal of battery 132 from the anodes of the tubes.

If the brush set 115 stays on the terminal set, the above described circuit operations would complete the hunting. The brush set, however, may have been traveling at such speed that the quantity of kinetic energy stored in the brush, tape, pulleys and motor rotor will cause the test brush to overrun and break with the terminal, on its upper edge as shown by the broken line indication of brush 171 in Fig. 2.

Should brush 171 break with the upper edge of the terminal on this or any other account, a break pulse will be transmitted into the control circuit 110 by virtue of the fact that the circuit previously established through the transformer by the brush 171 is now broken. This break pulse will be of opposite polarity to the make pulse and so will operate tube 103 which was previously primed, which, in turn, allows tubes 108 and 109 to become conducting, the effect of which will be to reverse the rotation of motor 112 to drive brush 115 back towards the grounded terminal, operate magnet 105 to release brake 163, prime tube 104 and quench tube 102. When the brush again engages this terminal, a make pulse will cause the next tube 104 to operate which, in turn, causes the priming of tube 101 and the quenching of tube 103. Should brush 171, on its downward travel, break with the bottom edge of the terminal, another pulse will be produced which will operate tube 101, prime tube 102 and extinguish tube 104, causing thereby a reversal of motor operation and an upward travel of the brush, the operations continuing, the brush being driven towards the marked terminal after each break pulse, the motor being stopped and the brake being set until the brush comes to rest on the marked terminal.

When the tip and ring brushes (not shown) of the brush set 115 have engaged the corresponding tip and ring terminals of the line in the bank, the cut-off relay 165 is operated in the well-known manner, thereby releasing line relay 166 and the bank relay 114. The release of relay 114 removes battery supply 132 from the anodes of the control thyratrons 101, 102, 103 and 104 the effect of which is to quench the arc in the thyratron which was last operating and again make negative the grid of the rectifying thyratron which was then functioning.

While the invention has been illustrated with reference to a high speed selector switch, it is obvious that its principles may be applied to other indexing or positioning controls. For example, the transformer 160 might be operated in a photocell circuit to permit light beam control of the brush position, and this control might be used with elevators to secure leveling at floors.

What is claimed is:

1. The combination with a rectifying device of en electrical network to control said device comprising a plurality of thermionic elements arranged to be primed for operation in sequence prior to their operation by a succession of impulses and to be disabled by the operation of a succeeding one of said thermionic elements, each alternate one of said thermionic elements being adapted when operated to control said rectifying device.

2. The combination with an electrical network which includes a plurality of thermionic devices adapted to operate in sequence by a succession of impulses, of a full wave rectifier comprising a plurality of other thermionic devices, means for rendering said other thermionic devices conducting when alternate ones of said plurality of thermionic devices operate, a source of alternating current connected to said other thermionic devices, and an electromagnet responsive to the rectified current produced by said plurality of said other thermionic devices.

3. The combination with a motor and a source of operating current therefor, of a first element to control the flow of current in one direction through said motor, a second element to control the flow of current in the opposite direction through said motor, signaling impulse means, a plurality of ionic devices serially disposed for progressive operation subsequent to the priming thereof by a succession of impulses from said impulse means whereby one operated device disables a previously operated device, and means controlled by alternate ones of said devices when operated in response to a succession of impulses for rendering effective said first and second control elements in alternation to control the flow of current from said source to said motor in the direction determined by the operated control element.

4. The combination with a selector switch having a bank of terminals, a test brush cooperating with said terminals, a motor for advancing said brush in a hunting movement over said termi-

nals, a source of operating current for said motor and means for applying a marking potential to any one of said terminals, of an electrical network for controlling the connection of said source of current to said motor comprising a plurality of thermionic devices arranged to be primed for operation and caused to operate in rotation by a succession of impulses of alternate polarity produced by said brush engaging and disengaging a marked terminal to cause reversals of current flowing from said source to said motor, each device upon operating priming the next succeeding device for operation and disabling the next preceding device.

5. In a telephone system, a selector switch having a bank of terminal sets, each set including a test terminal, a brush set including a test brush cooperating therewith, and means for advancing said brush set in a hunting movement over said bank of terminals, means for applying a marking potential to any one of said test terminals, a first thermionic device for controlling said brush set advancing means, a second thermionic device responsive to the engagement of said test brush with a marked terminal for disabling said first thermionic device to arrest the hunting movement of said brush set, and a third thermionic device responsive to the disengagement of said test brush from said marked terminal in the event said brush set overruns said marked terminal for reversing said advancing means to return said brush set to said marked terminal.

6. In a telephone system, a selector switch having two banks of terminal sets, each set including a test terminal, a brush set including a test brush cooperating therewith, normally positioned midway between said banks, and means for advancing said brush set in a hunting movement over either one of said banks, means for applying a marking potential to any one of said test terminals, a first thermionic device for controlling said brush set advancing means, a second thermionic device responsive to the engagement of said test brush with a marked terminal for disabling said first thermionic device to arrest the hunting movement of said brush set and a third thermionic device responsive to the disengagement of said test brush from said marked terminal in the event said brush set overruns the marked terminal for reversing said advancing means to return said brush set to said marked terminal.

7. In a telephone system, a selector switch having a bank of terminal sets, each set including a test terminal, a brush set including a test brush cooperating therewith, and means for advancing said brush set in a hunting movement over said bank of terminals, means for applying a marking potential to any one of said test terminals, a first thermionic device for controlling said brush set advancing means, a second thermionic device controlled by said first thermionic device and responsive to the engagement of said test brush with a marked terminal for disabling said first thermionic device to arrest the hunting movement of said brush set, a third thermionic device controlled by said second thermionic device and responsive to the disengagement of said test brush from said marked terminal in the event that said brush set overruns said marked terminal for reversing said advancing means to return said brush set to said marked terminal, and a fourth thermionic device controlled by said third thermionic device and responsive to the reengagement of said test brush with said marked terminal for arresting the return movement of said brush set.

8. In a telephone system, a selector switch having two banks of terminal sets, each set including a test terminal, a brush set including a test brush cooperating therewith, normally positioned midway between said banks, and means for advancing said brush set in a hunting movement over either one of said banks, means for applying a marking potential to any one of said test terminals, a first thermionic device for controlling said advancing means to move said brush set in a hunting movement over one of said banks, a second thermionic device responsive to the engagement of said test brush with a marked terminal in said bank for disabling said first thermionic device to arrest the hunting movement of said brush set, a third thermionic device for controlling said advancing means to move said brush set in a hunting movement over the other of said banks, and a fourth thermionic device responsive to the engagement of said test brush with a marked terminal in said other bank for disabling said third thermionic device to arrest the hunting movement of said brush set.

9. In a telephone system, a selector switch having two banks of terminal sets, each set including a test terminal, a brush set including a test brush cooperating therewith, normally positioned midway between said banks, and means for advancing said brush set, means for applying a marking potential to any one of said test terminals, a first thermionic device for controlling said advancing means to move said brush set in an initial hunting movement over one of said banks or in a return movement over the other of said banks, a second thermionic device responsive to the engagement of said test brush with a marked terminal in said one bank for disabling said first thermionic device to arrest the hunting movement of said brush set, a third thermionic device for controlling said advancing means to move said brush set in an initial hunting movement over said other bank or in a return movement over said one bank and a fourth thermionic device responsive to the engagement of said test brush with a marked terminal in said other bank for disabling said third thermionic device to arrest the hunting movement of said brush set, said first and third thermionic devices being responsive to the disengagement of said test brush from said marked terminal in the event that said brush set overruns said marked terminal in its initial hunting movement for controlling said advancing means to return said brush set to the marked terminal.

10. In a telephone system, a selector switch having a panel bank of terminals and a brush set cooperating therewith, a belt for traversing said brush set across said bank, means for driving said belt in one direction to traverse said brush set in a hunting movement over said bank of terminals or in the reverse direction to return said brush set towards its normal position, means for applying a marking potential to any one of said terminals, thermionic testing means for arresting the hunting movement of said brush set when it engages a marked terminal of said bank, and other thermionic means operated by said thermionic testing means for controlling said driving means to reverse the direction of movement of said belt to return said brush set to said marked terminal in the event said brush set overruns said terminal in its hunting movement.

11. In a telephone system, a selector switch having a panel bank of terminals and a brush set cooperating therewith, a belt for traversing said brush set across said bank, a pair of pulleys over which said belt runs, means for driving one of said pulleys to traverse said belt in one direction in a hunting movement, means for applying a marking potential to any one of said terminals, a thermionic circuit for testing a marked terminal on said bank when said brush set is engaged therewith and for controlling said driving means, said thermionic circuit comprising a pair of thermionic devices for controlling said driving means and for testing the lower and upper edges of said marked terminal in the upward movement of said switch in the event said brush overruns said terminal, and another pair of thermionic devices for controlling said driving means in the reverse direction and for testing the upper and lower edges of said marked terminal in the downward movement of said switch.

12. In a telephone system, a selector switch having a panel bank of terminals and a brush set cooperating therewith, a belt for traversing said brush set across said bank, a pair of pulleys over which said belt runs, means for driving one of said pulleys to drive said belt, a magnetic clutch operative to free said belt to move said brush set in a hunting movement over said terminals, means for applying a marking potential to any one of said terminals, thermionic testing means for arresting the movement of said brush set when it engages a marked terminal of said bank, and other thermionic means operated by said thermionic testing means when said brush connects with said marked terminal for disabling said magnetic clutch to engage said belt.

13. In a telephone system, a selector switch having two panel banks of terminals and a brush set cooperating therewith normally positioned midway between said banks, a belt for traversing said brush set across said banks, means for driving said belt, a first thermionic control means for causing said belt to be driven in one direction to move said brush set in a hunting movement over one of said banks, a second thermionic control means for causing said belt to be driven in the opposite direction to move said brush set in a hunting movement over the other of said banks, means for establishing an electrical marking condition on a terminal of either bank, means operative in accordance with the bank in which a marked terminal is located for determining which one of said thermionic control means shall be effective, and means for rendering effective said other thermionic control means for response to the electrical marking condition on said marked terminal.

14. In a telephone system, a selector switch having a panel bank of terminals and a brush set cooperating therewith, a belt for traversing said brush set across said bank, means for driving said belt in one direction to traverse said brush set in a hunting movement over said bank of terminals, a thermionic device operable when said brush set engages a marked terminal during its hunting movement, an electromagnetically controlled brake engageable with said belt and operable upon the operation of said thermionic device to stop the movement of said belt and said brush set, and another thermionic device operable following the operation of said first thermionic device for reversing the direction of movement of said belt to return said brush set to said marked terminal in the event said brush set overruns said terminal in its hunting movement.

15. In a telephone system, a selector switch having two panel banks of terminals and a brush set cooperating therewith normally positioned midway between said banks, a belt for traversing said brush set across either bank, means for driving said belt, means for applying a marking potential to any one of said terminals, a first thermionic control means for causing said belt to be driven in one direction to move said brush set in a hunting movement over one of said banks, a second thermionic control means for causing said brush to be driven in the opposite direction to move said brush set in a hunting movement over the other of said banks, and means operative in accordance with the bank in which a marked terminal is located for determining which one of said thermionic control means shall be effective.

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