

Feb. 1, 1927.

J. B. HARLOW

1,616,186

CONTROL AND SUPERVISORY SYSTEM

Filed June 30, 1921

2 Sheets-Sheet 1

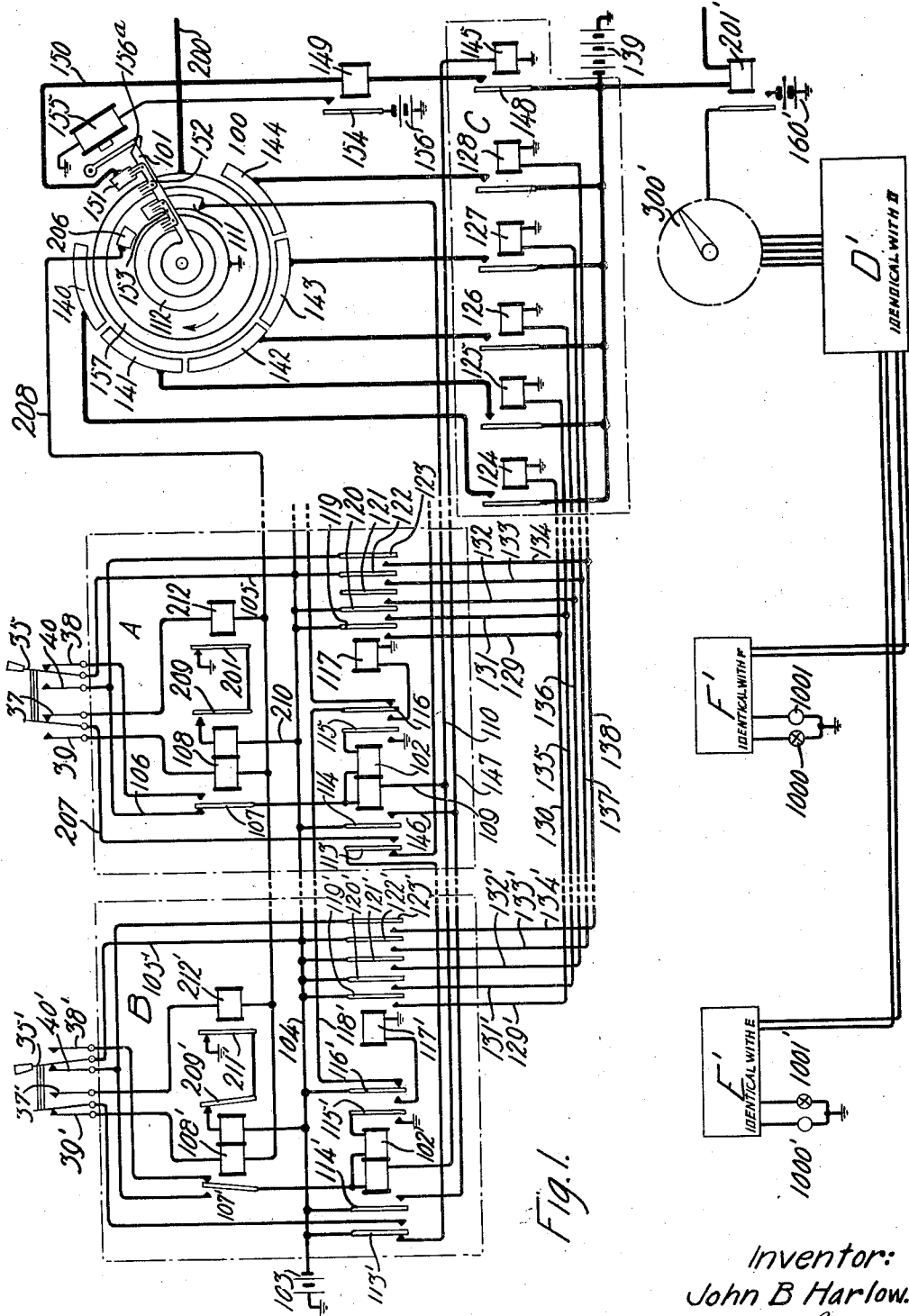


Fig. 1.

Inventor:
John B Harlow.
by Joel C. Palmer, Att'y

Feb. 1, 1927.

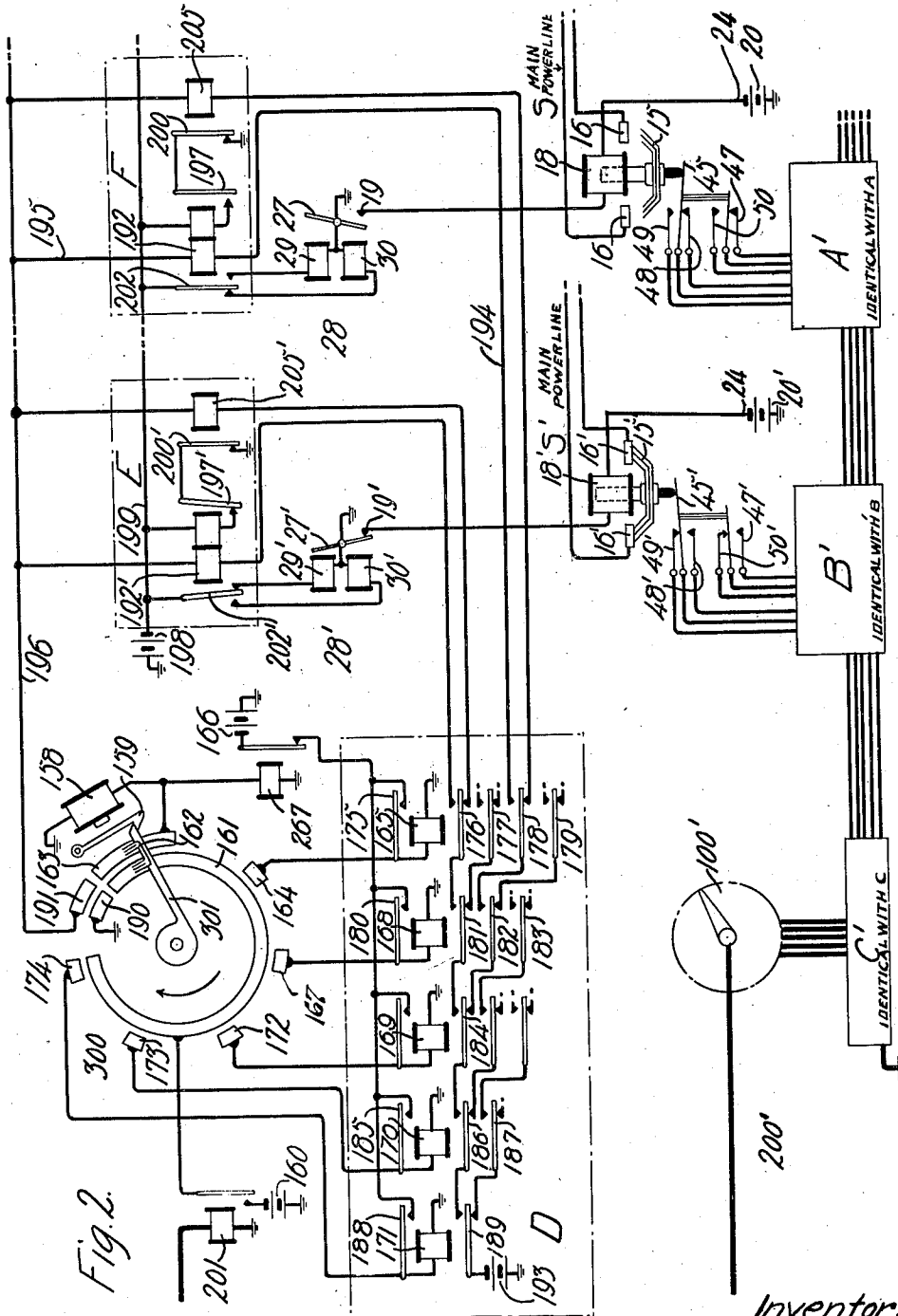
J. B. HARLOW

1,616,186

CONTROL AND SUPERVISORY SYSTEM

Filed June 30, 1921

2 Sheets-Sheet 2



Inventor:
John B. Harlow.
by Joel C. Paeney Att'y.

Patented Feb. 1, 1927.

1,616,186

UNITED STATES PATENT OFFICE.

JOHN B. HARLOW, OF UPPER MONTCLAIR, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

CONTROL AND SUPERVISORY SYSTEM.

Application filed June 30, 1921. Serial No. 481,532.

This invention relates to control and supervisory systems and particularly to such systems in which switches or other objects may be remotely controlled and supervised. The invention is particularly adapted for use in connection with automatic switches or circuit breakers employed with power lines.

There are now in use power generating and distribution systems in which a plurality of substations are located at points along a power line, each station being provided with a plurality of switches, and such switches are frequently adapted to be operated automatically under predetermined conditions. The present invention is well adapted to systems of this general type and includes means for selectively causing the opening and closing of any of the switches located at a substation from a central station located at a distance from the substation, together with means for indicating at the central station when the selected switches are opened or closed, and also to indicate at the central station when any of the said switches are opened or closed automatically, i. e., by means not set in operation at the central station.

In carrying out the present invention, control means is provided at the central station individual to each power switch which causes a pair of distributors, operating in synchronism and common to the control means and power switches, to selectively operate said power switches. A second pair of distributors are also provided common to all of said power switches and controllable by each of them to selectively operate indicating devices at the central station individual to each power switch. In practice it may be desired to actuate a plurality of the control means located at the central station one after the other, or simultaneously, and therefore "interlocking means" is provided whereby the distributors are only under the control of one of said control means at a time. Interlocking means is also provided for the pair of distributors that are controlled by the power switches which insures that an indication will be given at the central station when each switch is opened or closed, irrespective of whether these switches are actuated simultaneously or in any definite order. In case, for instance, a

large number of the switches are opened substantially simultaneously, from a heavy surge of current due to lightning or other cause, the interlocking mechanism insures that an indication will be given at the central station showing the position of each power switch operated.

One of the primary objects of the present invention is to produce such a system which includes a minimum number of operating elements, is reliable, and is rapid in operation; indicating at the central station the position of a switch a very few seconds after the switch has operated.

Other objects and features of the invention will be set forth in detail in the following specification and particularly pointed out in the appended claims.

In the accompanying drawings, which illustrate one embodiment of the invention, Fig. 1 illustrates schematically the mechanism and circuits located at the central station, while Fig. 2 illustrates schematically the apparatus and circuits located at a substation.

Referring now to the drawings in detail, the reference letters S and S' indicate two of a plurality of power switches located at the substation.

The switch S comprises a movable contact member 15 which cooperates with stationary contacts 16 connected in a line which may be a main power line or an auxiliary feeder for a main power line. The movable contact member 15 is carried by the core 17 which is reciprocally mounted within a helix 18, one end of which is connected to a contact 19, and its other end to a grounded battery 20. The contact 19 cooperates with a grounded armature 27 of a relay 28 having windings 29 and 30. The switch S' has the same associated elements as the switch S, similar elements bearing the same reference numerals with primes affixed thereto. The armature 27 and contact 19, associated with the switch S, are shown separated so that the helix 18 is deenergized and the switch is open. However, when winding 30 of relay 28 is deenergized and winding 29 energized, the armature 27 will be brought into engagement with contact 19, closing an energizing circuit for the helix 18 which may be traced from grounded battery 20, helix 18, contact 19, and

armature 27 to ground. The energization of helix 18 lifts the core 17 and holds the movable contact member 15 in engagement with the stationary contacts 16, closing switch S. When the winding 30 of the relay 28 is energized, and the winding 29 thereof deenergized, the armature 27 will be moved to open the circuit for the helix 18 at the contact 19 and permit the core 17 to drop carrying the movable contact member 15 out of engagement with the stationary contacts 16 opening the switch as is readily understood. Since the operation of switch S' is similar to switch S, a description of its operation is not thought to be necessary. The windings 29, 29', and 30 and 30' are selectively operated from the central station, shown in Fig. 1, by means hereinafter to be described, so that the switches S and S' may be opened or closed from the said central station.

In order to selectively energize the windings 29, 29', and 30, 30' of the relays 28 and 28' associated with the switches S and S', double-throw double-pole hand switches 35 and 35' are provided at the central station illustrated in Fig. 1. When switch 35 occupies the position shown, in which its contacting arms are in engagement with contacts 37 and 38 the winding 30 of relay 28 associated with switch S will be energized and when moved into engagement with contacts 39 and 40, the winding 29 of said relay 28 will be energized and winding 30 deenergized, opening the switch S in one instance and closing it in the other. In like manner when switch 35' occupies the position shown in which its contacting arms are in engagement with contacts 39' and 40', the winding 29' of relay 28', associated with switch S' will be energized and when moved into engagement with contacts 37' and 38' the winding 30' of the said relay 28' will be energized and the winding 29' deenergized. The mechanism and circuit arrangements for effecting the energization and deenergization of the windings 29, 29' and 30, 30' of the relays 28, 28' upon the actuation of the hand switches 35 and 35' will hereinafter be described in detail.

The switches S and S' in opening and closing each actuate a double-pole double-throw switch 45 and 45' respectively. When the switch 45 occupies the position shown in which its contacting arms are in engagement with contacts 47 and 48 (through mechanism and circuit arrangements, identical with those employed for causing the energization and deenergization of windings 29, 29' and 30, 30' of relays 28, 28' upon the actuation of switches 35 or 35') a lamp 1000 located at the central station will be lighted indicating that the switch S is open; and when the switch 45 is permitted, by the closing of switch S, to engage its con-

tacting arms with contacts 49 and 50, the lamp 1000 will be extinguished and a lamp 1001 lighted, indicating that the switch S is closed. In like manner the switch 45' upon the closing of the switch S' occupies the position shown in which its contacting arms are in engagement with contacts 49' and 50' causing a lamp 1001' located at the central station to be lighted, indicating that the switch S' is closed, and when the said switch in opening moves the switch 45' to engage its contacting arms with contacts 47' and 48' the lamp 1001' will be extinguished and a lamp 1000' lighted indicating that the switch S' is open.

Briefly, the means for selectively causing the energization and deenergization of the windings 29, 29' and 30, 30' of relays 28 and 28' by the actuation of switches 35 and 35' comprises distributors 100 and 300 located at the central station and substation, respectively. Each distributor comprises a plurality of insulated segments with which a rotating brush carrying arm 101 and 301 cooperates, the driving mechanism for each of the brush arms operating at a constant speed and in synchronism. It is to be understood that there is a pair of such distributors for each substation, one being located at the substation and the other at the central station. Associated with the switches 35 and 35' are groups of relays enclosed in dotted line rectangles and indicated generally by reference letters A and B. These relays when controlled through their associated switch 35 or 35' close circuits for operating different relays of a group associated with the segments of distributor 100. These relays indicated generally by the reference letter C, when energized serve to connect battery with their associated segments so that when the distributor arm 101 is rotated, pulses are sent over the line 200 connecting the central station and substation which intermittently energize a line relay 201 located at the substation. The distributor arm 301 being rotated in synchronism with the arm 101, each time the line relay 201 is energized, its brush carrying arm 301 closes circuits for energizing certain relays of a group associated with the segments of the distributor 300, this group being enclosed in a dotted line rectangle and designated generally by the reference letter D. The energization of the relays in group D complete circuits for controlling pairs of relays designated generally by reference letters E and F which control the energization and deenergization of windings 29', 30' and 29, 30 of relays 28' and 28, respectively. As will be hereinafter explained, different relays in groups C and D are actuated, dependent upon whether switch 35 or 35' is operated and also dependent upon the direction in which

the said switches are moved. The relays in this group determine which pairs of relays E or F will be operated to energize or de-energize the windings of relays 28 and 28'.

5 The switch 35 is shown in the position in which the power switch S at the substation is open. To close the power switch S the switch 35 is moved to engage its conducting arms with contacts 39 and 40, the engagement of contact 40 closing an energizing circuit for relay 102 which may be traced from grounded battery 103, conductors 104, 105, conducting arm of switch 35, contact 40, conductor 106, back contact 15 and armature 107 of relay 108, winding of relay 102, conductors 109, 110, segment 111 of distributor 100 through a brush 153 carried by the brush arm 101, to collector ring 112 which is grounded. Relay 102 in energizing attracts its armatures 113, 114, 115 and 116. Armature 115 in engaging its front contact completes a locking circuit for relay 102 which may be traced from grounded battery 103, conductors 104, 105, conducting arm of switch 35, contact 40, back contact and armature 107 of relay 108, winding of relay 102, armature 115 and front contact of said relay to ground. The attraction of armature 116 moves it out of engagement with its associated back contact and into engagement with its front contact completing an energizing circuit for relay 117 which may be traced from grounded battery 103, conductor 104, armature 116' and front contact of relay 102', conductor 118', armature 116 and front contact of relay 102, winding of relay 117 to ground. Relay 117 in energizing attracts its armatures 119, 120, 121, 122, 123 which complete energizing circuits for relays 124, 125, 127 and 128. The attraction of armature 121 does not complete an energizing circuit for relay 126 since this armature is not connected to any source of energy, the reason for which will be hereinafter explained. The energizing circuit for relay 128 may be traced from grounded battery 103, conductors 104 and 105, conducting arm and contact 40 of switch 35, armature 123 and front contact of relay 117, conductors 134 and 138, winding of relay 128 to ground. The energizing circuit for relay 127 may be traced from grounded battery 103, conductor 104, armature 122, and front contact of relay 117, conductors 133 and 137, winding of relay 127 to ground. The energizing circuits for relays 125 and 124 are similar to the energizing circuit for relay 127 except that the contacts associated with armatures 120 and 119 are connected to the windings of said relays by means of conductors 135—131 and 130—129, respectively. Attention is called to the fact that relay 128 is the only one whose energizing circuit depends upon the position of switch 35 the reason for which will be hereinafter described. Relays 124, 125, 127 and 128 in energizing attract their armatures connecting grounded battery 139 to their associated segments 140, 141, 143, 144, respectively, of the distributor 100. Relay 102 in energizing moves its armature 114 into engagement with its associated front contact completing an energizing circuit for relay 145 which may be traced from grounded battery 103, conductor 104, armature 114 and front contact of relay 102, conductors 146 and 147, winding of relay 145 to ground. Relay 145 in attracting its armature 148 completes an energizing circuit for relay 149 which may be traced from grounded battery 139, armature 148, front contact of relay 145, winding of relay 149, conductor 150, segment 151 of distributor 100 through a brush 152 carried by the brush carrying arm 101, segment 157, line wire 200, winding of relay 201 to ground. Relay 149 in energizing attracts its armature 154 completing an energizing circuit for release magnet 155 associated with the distributor arm 101. This circuit may be traced from grounded battery 156, armature 154 and front contact of relay 149, winding of magnet 155 to ground.

Armature 156^a of relay 155 is in the form of a latch holding the brush carrying arm 101 of the distributor 100 stationary in the position illustrated. When released magnet 155 is energized, as previously described, armature 156^a is attracted, releasing the brush carrying arm 101 and permitting it to be rotated, sweeping the brushes 152 and 153 carried thereby over the segments of the distributor in a clockwise direction. Line relay 201 in energizing attracts its armature and completes an energizing circuit for release magnet 158 associated with distributor 300 located at the substation. Release magnet 158 is provided with an armature 159 which is in the form of a latch retaining the brush carrying arm 301 of the distributor 300 in a stationary position, as is illustrated in Fig. 2, and when energized this relay attracts its armature releasing the brush carrying arm 301. The circuit for release magnet 158 may be traced from grounded battery 160, armature and front contact of line relay 201, segment 161 of distributor 300, brush 162, carried by distributor arm 301, segment 163, winding of release magnet 158 to ground.

From the above it will be apparent that when relay 145 is energized through the energization of relay 102, release magnets 155 and 158 associated with distributors 100 and 300, respectively, are simultaneously energized, releasing their associated distributor arms 101 and 301 so that these arms may be rotated synchronously in a clockwise direction, as is indicated by the arrows, sweeping their brushes over the

segments associated therewith. As soon as brush 153 which bridges segment 111 and collector ring 112 passes off segment 111, the energizing circuit for relay 102 is broken, but this relay remains energized over the locking circuit passing through its armature 115 and front contact so that relay 117 and relays 124, 125, 127 and 128 remain energized. However, the movement of brush 152 off of segment 151 breaks the energizing circuits for relay 149 and line relay 201, causing them to release their armatures. Relay 149 in deenergizing opens the energizing circuit for release magnet 155, while line relay 201 in deenergizing breaks the energizing circuit for release magnet 158. However, when release magnets 155 and 158 are deenergized releasing their latching armatures, the brush carrying arms 101 and 301 have rotated out of latching position and are free to make a complete revolution when they are again arrested by latching armatures 156^a and 159.

As soon as distributor arm 101 has rotated a distance sufficient to bridge collector ring 157 and segment 144 with brush 152, line relay 201 is again energized over a circuit which may be traced from grounded battery 139, armature and front contact of relay 128, segment 144, brush 152, collector ring 157, main line wire 200, line relay 201 to ground. At this time distributor arm 301 has moved synchronously with distributor arm 101 a distance sufficient to bridge segment 161 and a segment 164 with brush 162 so that when line relay 201 is energized, an energizing circuit is completed for relay 165, which circuit may be traced from grounded battery 160, armature and front contact of line relay 201, segment 161, brush 162, segment 164, winding of relay 165 to ground. Relay 165 in energizing attracts its armature 175 closing a locking circuit for itself which may be traced from grounded battery 166, armature and back contact of relay 267, armature 175 and front contact of relay 165, winding of said relay to ground. As the distributor arm 101 continues to rotate, it electrically connects segments 143, 141 and 140 with collector ring 157, in each instance energizing line relay 201. At the time line relay 201 is energized from battery connected to segment 143, distributor arm 301 will electrically connect segment 161 and segment 167, energizing relay 168 which completes a locking circuit for itself in parallel with the locking circuit for relay 165. In like manner relays 170 and 171 will be energized and close locking circuits for themselves when the distributor arm 301 electrically connects segments 173 and 174 with segment 161. Relay 169 which is associated with segment 172 will not be energized, for at the time that distributor arm 301 bridges this seg-

ment and segment 161, line relay 201 will not be energized, so that battery 160 will not be connected to segment 161. Line relay 201 is not energized at this time for the reason that relay 126 is not energized, and does not connect battery 139 to segment 142; relay 126 being deenergized due to the fact that armature 121 of relay 117 is not connected with battery 103, the reasons for which will be hereinafter described. Relay 165 in energizing attracts its armatures 175, 176, 177, 178 and 179, the first mentioned included in the locking circuit of the said relay. Relay 168 in energizing attracts its armatures 180, 181, 182 and 183, the first mentioned included in the locking circuit of the said relay. Relay 170 in energizing attracts its armatures 185, 186 and 187, the first mentioned included in the locking circuit of the said relay. Relay 171 in energizing attracts its armatures 188 and 189, the former included in the locking circuit of the said relay.

When distributor arm 301 has rotated a distance sufficient to bridge segments 190 and 191 of distributor 300, an energizing circuit is completed for relay 192 which may be traced from grounded battery 193, armature 189, front contact of relay 171, armature 186 and front contact of relay 170, armature 184 and back contact of relay 169, armature 182 and front contact of relay 168, armature 178 and front contact of relay 165, conductor 194, winding of relay 192, conductors 195, 196, segment 191, brush 162 of distributor arm 301, segment 190 to ground. Relay 192 in energizing attracts its armatures 197 and 202, the former completing a locking circuit for the relay which may be traced from grounded battery 198, conductor 199, winding of relay 192, armature 197 and front contact of relay 192, armature 200 and front contact of relay 205 to ground. The attraction of armature 202 by the energization of relay 192 completes an energizing circuit for winding 29 of relay 28, which may be traced from grounded battery 198, conductor 199, armature 202 and back contact of relay 192, winding 29 of relay 28 to ground.

As previously explained the energization of winding 29 of relay 28 completes an energizing circuit for the helix 18 of power switch S causing the said switch to close.

Returning to the apparatus at the central station, at the time the distributor arm 301 bridged segments 190 and 191 causing the energization of the relay 192 and winding 29 of relay 28, brush 153, carried by distributor arm 101 associated with distributor 100, bridged collector ring 112 and a segment 206 which completed an energizing circuit for relay 103 which may be traced from grounded battery 103, conductor 104, armature 113' and back contact of relay 102',

armature 113 and front contact of relay 102 (it will be recalled that this relay was energized and locked up through its armature 115) conductor 207, contacting arm of switch 35, contact 39, winding of relay 108, conductor 208, segment 206, brush 153, collector ring 112 to ground. Relay 108 in energizing, attracts its armatures 107 and 209. The attraction of armature 209 closes a locking circuit for the said relay which may be traced from grounded battery 103, conductors 104, 210, winding of relay 108, armature 209 and front contact of said relay, armature 201 and back contact of relay 212 to ground. Relay 108 in attracting its armature 107 opens the locking circuit for relay 102 permitting the said relay to deenergize. The deenergization of this relay opens the energizing circuit for relay 117 which releases its armatures 119 to 123 inclusive, opening the energizing circuits for relays 124, 125, 127 and 128 permitting the said relays to release their armatures and disconnecting the ground battery 139 from segments 144, 143, 141 and 140 of distributor 100.

Distributor arms 101 and 301 continue their clockwise rotation until arrested and latched by armatures 156^a and 159 of magnets 155 and 158, respectively, in the stationary positions illustrated in the drawings. Relay 108 remains energized as long as switch 35 is held in the position in which its conducting arms engage contacts 39 and 40, and relay 192 remains energized as long as its locking circuit remains unbroken at armature 200 and back contact of relay 205. In order to now visualize the position of the mechanism associated with power switch S and switch 35, attention is directed to the mechanism associated with power switch S' and switch 35', since switch 35' is in the position in which power switch S' is closed. It is thought that it may be easier to follow the operation of the system in opening one of the power switches by referring to the mechanism and circuits associated with power switch S', since this switch is shown closed.

To open power switch S' the switch 35' is moved from the position shown to one in which its conducting arms engage contacts 37' and 38'. The closing of contact 38' completes an energizing circuit for relay 102' which may be traced from grounded battery 103, conductors 104, 105' and conducting arm and contact 38' of switch 35', front contact and armature 107' of relay 108', winding of relay 102', conductor 110, segment 111, brush 153 of distributor arm 101, collector ring 112 to ground. Relay 102' in energizing attracts its armatures 113', 114', 115' and 116'. Armature 115' in engaging its front contact completes a locking circuit for relay 102' which may be traced from grounded battery 103, conductors 104, 105', conducting arm and contact 38' of switch 35', armature 107' and front contact of relay 108', winding of relay 102', armature 115' and front contact of said relay to ground. The attraction of armature 116' moves it out of engagement with its associated back contact and into engagement with its front contact, completing an energizing circuit for relay 117' which may be traced from grounded battery 103, conductor 104, armature 116' and front contact of relay 102', winding of relay 117' to ground. Relay 117' in energizing attracts its armatures 119', 120', 121', 122' and 123' which complete energizing circuits for relays 124, 125, 126, and 127. The energizing circuit for relay 124 may be traced from grounded battery 103, conductor 104, armature 119' and front contact of relay 117', conductors 129' and 130, winding of relay 124 to ground. The energizing circuits for relays 125, 126 and 127 are similar to the energizing circuit for relay 124, except that the contacts associated with armatures 120', 121' and 122' are connected to the windings of the said relays by means of conductors 135-131', 136-132', 137-133'. Relay 128 is not energized although armature 123' engages its cooperating front contact because the energizing circuit for this relay passes through conducting arm of switch 35' and contact 40' which is open. Relays 124, 125, 126 and 127 in energizing attract their armatures connecting grounded battery 139 to their associated segments 140, 141, 142 and 143, respectively, of distributor 100. Relay 102' in energizing moves its armature 114' into engagement with its associated front contact completing an energizing circuit for relay 145 which may be traced from grounded battery 103, conductor 104, armature 114' and front contact of relay 102, conductor 147, winding of relay 145 to ground. Relay 145 in attracting its armature 148 completes an energizing circuit for relay 149 which in attracting its armature 154 completes an energizing circuit for release magnet 155 associated with the distributor arm 101. Relay 145 in addition to causing the energization of release magnet 155 through the medium of relay 149, also closes an energizing circuit for line relay 201, located at the substation. Line relay 201 in energizing attracts its armature and completes an energizing circuit for release magnet 158, associated with distributor 300 located at the substation, and also closes an energizing circuit for relay 267 which may be traced from grounded battery 160, segment 161, brush 162, segment 163, winding of relay 267 to ground. Relay 267 in attracting its armature disconnects battery 166 from those relays of group D which were previously energized and locked up in controlling power switch S and causes them

to release their armatures, restoring them for subsequent operation.

Distributor arms 101 and 301 upon being released rotate synchronously in a clockwise direction sweeping their brushes over the segments associated therewith. Brush 101 in sweeping over segments 143, 142, 141 and 140 causes the intermittent energization of line relay 201, which in attracting its armature completes energizing circuits for relays 168, 169, 170 and 171 through the medium of distributor arm 301 and segments 167, 172, 173 and 174 associated with distributor 300. The energizing circuits for the various relays, above mentioned, which have not been described in detail were traced in connection with switch 35, and a reiteration of these circuits is not thought to be necessary.

When distributor arm 301 has rotated a distance sufficient to bridge segments 190 and 191 of distributor 300, an energizing circuit is completed for relay 205' which may be traced from grounded battery 193, armature 189 and front contact of relay 171, armature 186 and front contact of relay 170, armature 184 and front contact of relay 169, armature 181 and front contact of relay 168, armature 176 and back contact of relay 165, winding of relay 205', conductor 196, segment 191, brush 162 of distributor arm 301, segment 190 to ground. Relay 205' in energizing attracts its armature 200', opening the locking circuit for relay 192', permitting it to release its armatures. Armature 202' in engaging its back contact, causes an energization of winding 30' of relay 28' which may be traced from grounded battery 198, armature 202' and back contact of relay 192', winding 30' of relay 28' to ground.

As previously explained, the energization of winding 30' of relay 28' opens the energizing circuit for helix 18' of power switch S', permitting the core 17' associated with the said helix to fall and open the switch.

Returning to the apparatus at the central station, at the time distributor arm 301 bridged segments 190 and 191, causing the energization of relay 205' and winding 30', brush 153 carried by distributor arm 101 associated with distributor 100 bridged collector ring 112 and segment 206 which completed an energizing circuit for relay 212' which may be traced from grounded battery 103, armature 113', front contact of relay 102' conducting arm and contact 37' of switch 35', winding of relay 212', conductor 208, segment 206, brush 153, collector ring 112 to ground. Relay 212' in energizing attracts its armature 211', opening the locking circuit for relay 108' and permitting it to release its armatures. Armature 107' in moving out of engagement with its associated front contact opens the locking circuit for relay 102', permitting it to deen-

energize. The deenergization of relay 102' opens the energizing circuit for relay 117' which includes the armature 116' and associated back contact, and also opens the energizing circuit for relay 212' which includes armature 113' and associated front contact of relay 102'. Briefly stated, relay 212' in energizing releases relays 108', 117' and 102', which last mentioned relay opens the circuit for relay 212', returning all the mechanism associated with switch 35' to the same positions that the mechanism associated with switch 35 is shown to occupy as illustrated in the drawing.

The selective energization and deenergization of windings 29 and 30 of relay 28, and windings 29' and 30' of relay 28' depends upon what relays of group D, which includes relays 171, 170, 169, 168 and 165 are energized. These relays in turn are selectively energized, depending upon which relays of group C are energized, which group includes relays 124, 125, 126, 127 and 128. The relays of this group are energized dependent upon whether relays 117 and 117' in attracting their armatures complete energizing circuits therefor.

By referring to Fig. 1 it will be seen that with switch 35' in the position shown when relay 117' is energized its armatures 119', 120', 121', 122' and 123' close circuits to energize relays 124, 125, 126, 127 and 128, these relays through the medium of distributors 100 and 300 causing the energization of all of the relays of group D, which in attracting their armatures, close an energizing circuit for relay 192' which causes switch S' to close, as is readily understood. To cause the opening of switch S', switch 35' is actuated to move its conducting arms out of engagement with contacts 39' and 40' and into engagement with contacts 37' and 38'. With the switch in this position, the relay 117' when energized, in attracting its armatures will close energizing circuits for relays 124, 125, 126 and 127, but relay 128 will not be energized for the reason that the energizing circuit for this relay, which passes through the front contact and armature 123' of relay 117' will be open at contact 40', of switch 35'. As a consequence, all of the relays of group D except relay 165 will be energized completing an energizing circuit for relay 205' which, as previously described, causes the release of relay 192' and the opening of power switch S'. From this it will be understood that to close switch S' all of the relays of groups C and D are energized, whereas to open switch S', all of the relays but one of these groups are energized. To close switch S all of the relays of group C and group D are energized with the exception of relay 126 in group C, and relay 169 in group D, these relays not being energized as previously described, due to the fact that

armature 121 of relay 117 is not connected to battery 103. To open switch S only relays 124, 125 and 127 of group C, and relays 171, 170 and 168 of group D are energized, relay 126 of group C and relay 169 of group D not being energized for the reason just stated, while relay 128 of group C and relay 165 of group D are not energized due to the fact that to open switch S, switch 35 is moved to the position shown in Fig. 1, in which its conducting arm is out of engagement with contact 40, which contact is included in the energizing circuit of relay 128. As will be readily understood, the relays in groups C and D and the distributors 100 and 300 may serve to control a relatively large number of different power switches by providing a switch like 35 or 35' and associated relay groups like A and B for each power switch to be controlled, the relays of these groups corresponding to relay 117 or 117' having their various armatures connected to or disconnected from the conductor 104 leading to the battery 103 to cause the energization of various combinations of relays in groups C and D.

Should switches 35 and 35' be operated simultaneously in either direction or moved simultaneously in opposite directions or actuated one closely following the other, no confusion will result and the power switches S and S' will be actuated one after the other commensurate with the movement of the switches 35 and 35', due to an interlocking of the circuits for relay groups A and B. Assume that the switches 35 and 35' should be simultaneously moved from the positions illustrated in the drawings to opposite positions for causing the closing of power switch S and the opening of power switch S', respectively. This movement of switches 35 and 35' would cause a simultaneous energization of relays 102 and 102', the latter in attracting its armature 116' will complete an energizing circuit for relay 117', which in attracting its armatures energizes various relays in groups C and D through the medium of distributors 100 and 300 to control power switch S'. Although relay 102 was energized simultaneously with relay 102' and attracted its armature 116, relay 117 would not be energized for the reason that its energizing circuit though passing through armature 116 and front contact of relay 102 also includes armature 116' and back contact of relay 102', which armature and contact would be separated due to the energization of relay 102'. As a consequence, when relays 102, and 102' are simultaneously energized, the latter locks out the former and the relays in group B have exclusive use of the relays in groups C and D until relay 102' is subsequently deenergized, which in releasing completes the energizing circuit for relay 117 which in attracting its armature energizes

various relays in groups C and D through the medium of the distributors 100 and 300. Irrespective of how many relay groups like A and B are provided associated with switches like 35 and 35', and irrespective of whether these switches are operated simultaneously, the relays in groups C and D will be under the exclusive control of the relay groups like A and B in the order of their proximity to the battery 103. If, however, sufficient time elapses between the movement of a switch 35 and the movement of a switch 35', which is nearer battery 103 than switch 35, to allow the contacts on the distributor arm 101 to move away from segment 111, relay 102' cannot be operated as its operating circuits will be open. The switch more remote from the battery will therefore control until its cycle is completed, whereupon the less remote switch will set in operation the relays associated with it and operate its corresponding switch.

Power switches S and S' in opening and closing actuate double-pole double-throw switches 45 and 45', respectively. These switches are exactly like switches 35 and 35' and operate groups of relays A' and B', respectively, which are identical with groups A and B, and as a consequence relay groups A' and B' have not been shown on the drawings in detail but have been merely indicated by rectangles. The relays in groups A' and B' control a group of relays identical with group C which are indicated by the rectangle designated C'. These relays serve to connect ground to associated segments of a distributor 100' corresponding to distributor 100. As the brush carrying arm of distributor 100' sweeps over its segments, line relay 201' (corresponding to line relay 201) is intermittently energized to connect grounded battery 160', (corresponding to battery 160), to the segments of distributor 300' which corresponds with distributor 300. The circuit for line relay 201' may be traced from grounded segments of distributor 100', line 200', winding of line relay 201' to grounded battery 139. As the brush carrying arm of distributor 300' passes over segments of the distributor to which battery 160' has been connected, energizing circuits are completed for various relays of a group which corresponds to group D, and is designated by the rectangle marked D'. These relays complete circuits for pairs of relays corresponding to E and F which are designated by rectangles E' and F' to illuminate lamps 1000 or 1001, and lamps 1000' or 1001', these lamps corresponding with the windings 29, 30 and 29', 30' of relays 28 and 28', respectively.

From the foregoing it will be understood that through the medium of switches 35 and 35', switches S or S' may be opened or closed, which in operating actuate

switches 45 and 45' controlling lamps 1000, 1001, 1000' and 1001', located at the central station, indicating which of the power switches are operated and whether these switches are opened or closed. As previously described, switches S and S' may be opened under the control of underload or overload relays 25 and 25' and 26, 26', respectively, and when actuated thereby also indicate through the medium of the lamps at the central station whenever the power switches are opened or closed. The circuits for relay groups A' and B' are interlocked similarly to relay groups A and B, and as a consequence, although power switches S and S' may be actuated either from the central station or through the medium of the overload and underload relays, no confusion will result and the lamps at the central station will be lighted and extinguished one after the other commensurate with the movement of switches 45 and 45' to indicate the position of the power switches S and S'. This interlocking feature is of special importance in cases where a large number of switches are opened substantially simultaneously from a heavy surge of current on the power line due to lightning or other cause, the interlocking mechanism insuring that an indication will be given at the central station showing the position of each power switch operated.

What is claimed is:

1. A system of the character described comprising a plurality of power switches, means including a pair of distributors operated in synchronism, a manual switch for each power switch having alternate positions, means including circuits closed in one position of each manual switch to control the means including the distributors to open the corresponding power switch and means including circuits closed in the other position of each manual switch to control the means including said distributors to close the corresponding power switch, and means actuated by the simultaneous operation of two manual switches in either position for placing the control of the means including said distributors under the exclusive control of only one of said manual switches.

2. A system of the character described, comprising a transmitting distributor and a receiving distributor, control switches, having alternate positions, an electromagnet controlled by each switch, a plurality of relays variably operated jointly by any electromagnet and the corresponding switch, the number operated depending upon the position of the switch, and devices corresponding to said switches controlled by said relays through the medium of said distributors.

3. A system of the character described, comprising a transmitting distributor and

a receiving distributor operated in synchronism, a control switch movable to a plurality of positions, an electromagnet controlled by said switch, a plurality of relays selectively operated by said electromagnet depending upon the position of said switch, and a translating device controlled by said relays through the medium of said distributors.

4. A system of the character described, comprising a transmitting distributor and a receiving distributor operated in synchronism, a control switch movable to a plurality of positions, an electromagnet controlled by said switch, a plurality of relays selectively operated by said electromagnet depending upon the position of said switch, a relay controlled by the operation of each of said relays through the medium of said rotary distributors, and a translating device controlled jointly by said last mentioned relays.

5. A system of the character described, comprising a central station and a sub-station joined by a single line conductor, synchronously operated rotary distributors associated with said line conductor at said stations, a control switch having alternate positions at said central station, an electromagnet controlled by said switch, a plurality of relays selectively controlled by said electromagnet depending upon the position of said switch, a relay at said sub-station allotted to each of said relays and controlled thereby through the medium of said rotary distributors, and a translating device at said sub-station controlled jointly by said last-mentioned relays.

6. A system of the character described, comprising a central station and a sub-station joined by a single line conductor, synchronously operated rotary distributors associated with said line conductor at both of said stations, a translating device at said sub-station, a switch having alternate positions at said central station, an electromagnet controlled by said switch, a plurality of relays at the central station selectively operated by said electromagnet depending upon the position of said switch, and a plurality of relays at said sub-station selectively controlled by said first-mentioned relays through the medium of said rotary distributors for controlling said translating device.

7. A system of the character described, comprising a central station and a sub-station connected by a single line conductor, synchronously operated rotary distributors associated with said line conductor at both of said stations, a translating device at said sub-station, a control switch at said central station movable to a plurality of positions, an electromagnet controlled by said switch, a plurality of relays at said central station selectively operated by said electromagnet depending upon the position of said switch, a plurality of relays at said sub-station selec-

tively controlled by said first-mentioned relays through the medium of said rotary distributor, and means controlled jointly and selectively by said relays for operating said translating device.

8. A system of the character described, comprising a central station and a sub-station joined by a single line conductor, a rotary distributor associated with said line conductor at each of said stations, said distributors being operated in synchronism, a translating device at said sub-station, a control switch at said central station movable to a plurality of positions, an electromagnet controlled by said switch, a plurality of relays at said central station selectively operated by said electromagnet depending upon the position of said switch, a plurality of relays at said sub-station selectively controlled by said first mentioned relays through the medium of said rotary distributors, a relay having two windings adapted when energized to open and close said translating device, respectively, and means controlled jointly and selectively by said sub-station relays to selectively energize the windings of said last-mentioned relay.

9. A system of the character described, comprising a central station and a sub-station joined by a single line conductor, synchronously operated rotary distributors associated with said line conductor at said stations, a plurality of control switches having alternate positions at said central station, an electromagnet controlled by each of said switches, a plurality of relays selectively operable by said electromagnets depending upon the position of said switches, a relay at said sub-station allotted to each of said relays and controlled thereby through the medium of said rotary distributors, and a plurality of translating devices at said sub-

station selectively controlled by said last-mentioned relays.

10. A system of the character described, comprising a central station and a sub-station joined by a single line conductor, synchronously operated rotary distributors associated with said line conductor at said stations, a plurality of translating devices at said sub-station, a plurality of switches having alternate positions at said central station, an electromagnet allotted to each of said switches and controlled thereby, a plurality of relays at said central station selectively operated by said electromagnets depending upon the position of the switches associated therewith, and means at said sub-station controlled by said relays through the medium of said rotary distributors for controlling said translating devices.

11. A system of the character described comprising a central station and a sub-station joined by a single line conductor, synchronously operated rotary distributors associated with said line conductor at said stations, a plurality of translating devices at said sub-station, a plurality of control switches at said central station movable to a plurality of positions, an electromagnet allotted to each of said switches and controlled thereby, a plurality of relays at said central station selectively operated by each of said electromagnets depending upon the position of the respective control switches, a plurality of relays at said sub-station selectively controlled by said first-mentioned relays through the medium of said rotary distributors, and means controlled jointly and selectively by said relays for operating said translating devices.

In witness whereof, I hereunto subscribe my name this 24th day of June A. D., 1921.

JOHN B. HARLOW.