June 19, 1923. 1,459,186

L. POLINKOWSKY

TELEPHONE EXCHANGE SYSTEM

Filed April 30, 1920 3 Sheets-Sheet 1

Fig. 1.

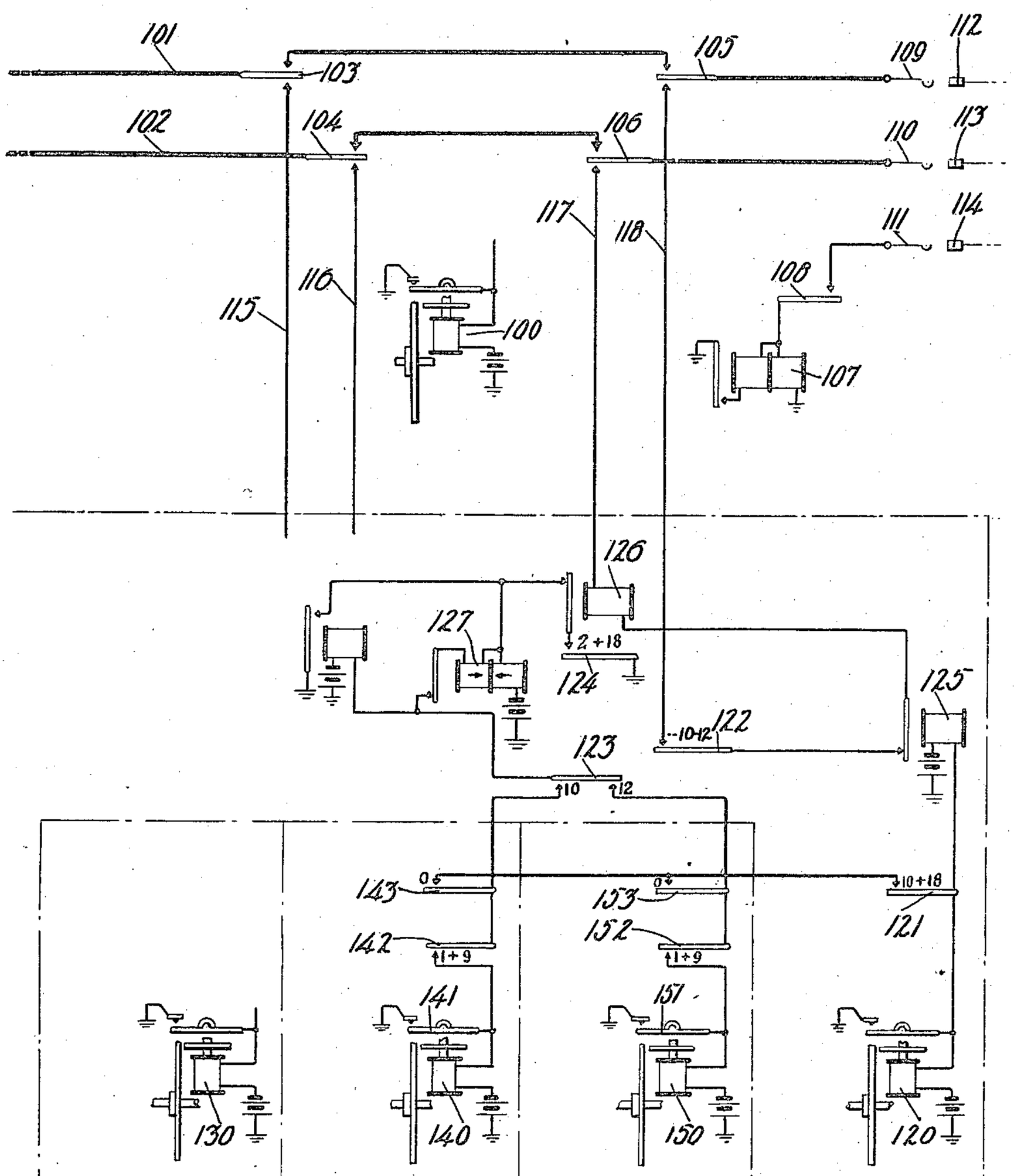


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Fig. 2.

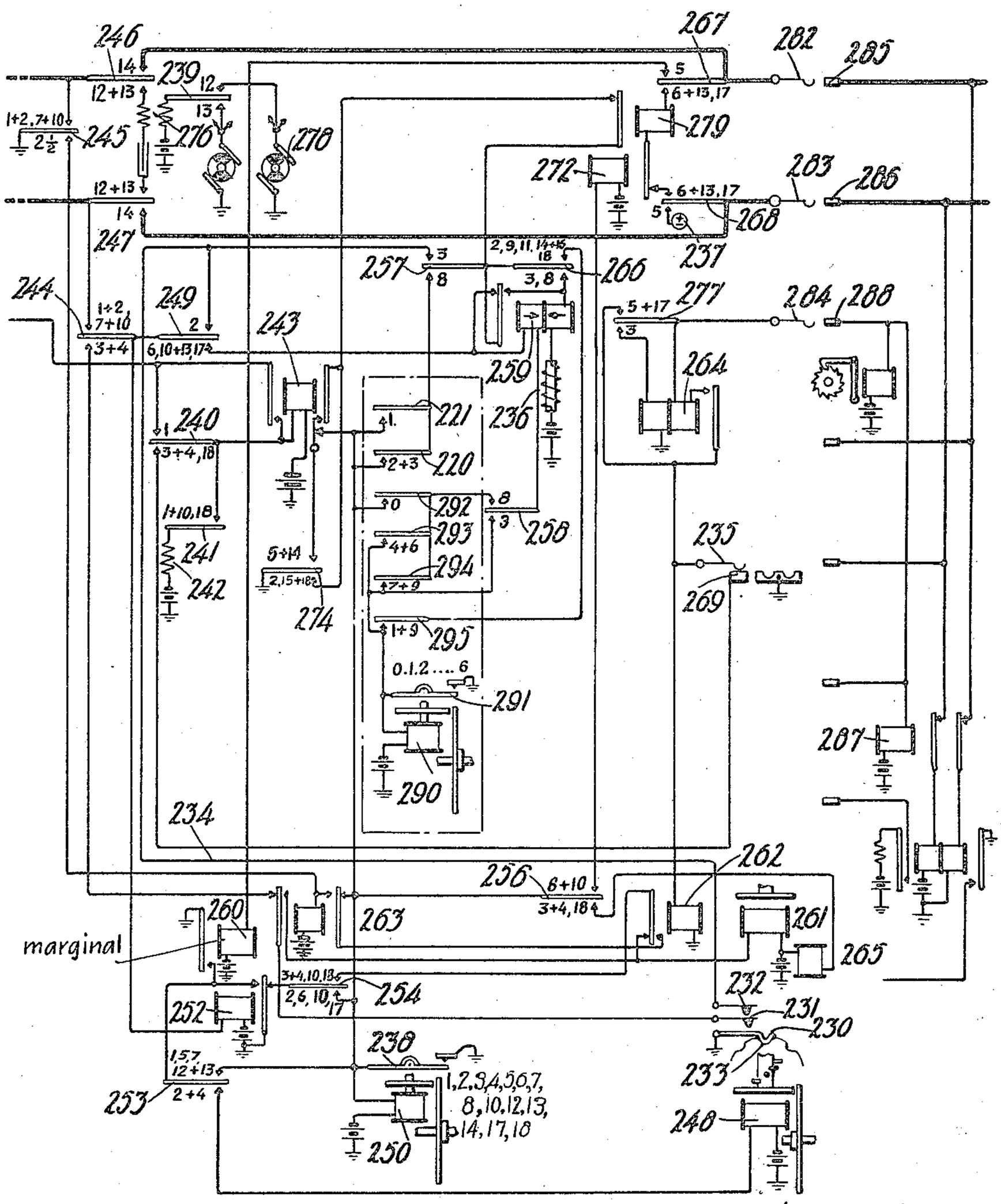


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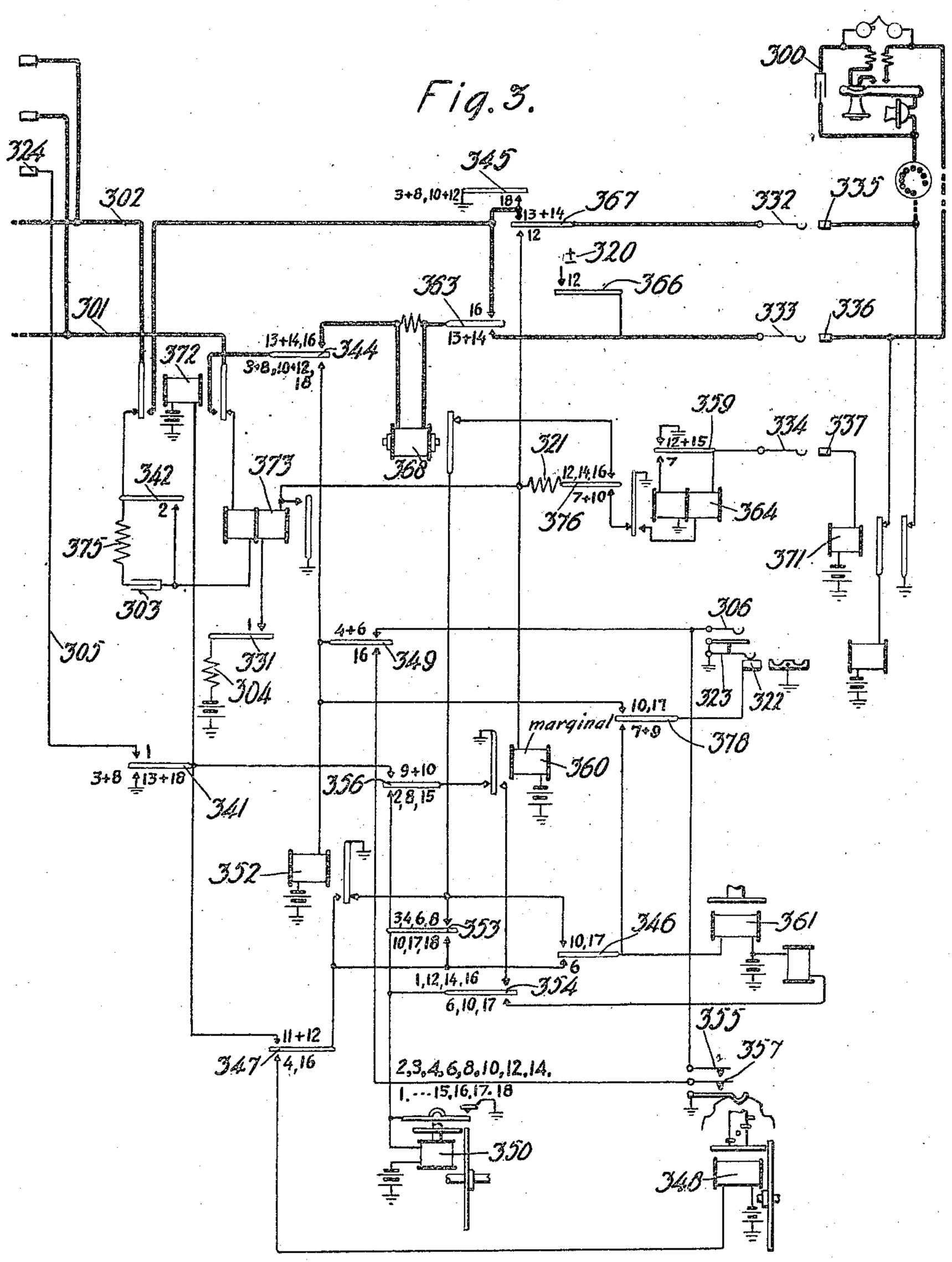
Fig. 3.

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Patented June 19, 1923. 1,459,186

# UNITED STATES PATENT OFFICE.

LIPA POLINKOWSKY, OF ANTWERP, BELGIUM, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## TELEPHONE-EXCHANGE SYSTEM.

Application filed April 30, 1920. Serial No. 377,980.

*To all whom it may concern:*

Be it known that I, LIPA POLINKOWSKY, a citizen of Russia, residing at Antwerp, Belgium, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone systems and particularly to systems in which machine switching apparatus is used for establishing connections between subscribers' lines.

The object of this invention is the provision of means, in a system where the selective switches are operated under the control of register controlling devices, whereby a single registration is effective to control a plurality of selective movements of the switches in the extension of a connection.

A feature of the invention relates to the provision of means operable in accordance with the selective movement of a switch to produce a registration corresponding to such movement, and which means is thereupon effective to control the selective movement of a succeeding switch in the extension of a connection.

Another feature of the invention relates to the provision of means, operative on the release of the switches, for simultaneously rendering selectable both ends of the trunk lines extending between such switches.

Other features of the invention will become more apparent from a consideration of the following description and appended claims.

In the drawings, Figs. 1, 2 and 3, taken in order illustrate so much of a telephone system as is necessary to an understanding of the invention.

Fig. 1 illustrates diagrammatically a group selector switch and a register controlling mechanism. Fig. 2 shows a selective switch in the central office having access to trunk lines outgoing to a distant private branch exchange. Fig. 3 shows the incoming end of the central office trunks terminating in connecting switches in the private branch exchange.

In the system disclosed there is provided a central office equipped with group selector switches such as the one illustrated diagrammatically in Fig. 1, and a register controlling mechanism for controlling the selective operation of these switches and also succeeding switches in the establishment of connections. There is also provided in the central office special selective switches, such as the one shown in Fig. 2, for extending connections to trunk lines leading to distant private branch exchanges. When a subscriber in the central office desires to obtain a connection with another subscriber local to the same office, he causes the positioning of the registers in accordance with the number of the desired line. These registers are then effective to control the selective operations of the switches in the central office to complete the establishment of the connection. When however, a connection is desired with a subscriber's line belonging to a distant private branch exchange, the record set up on the controlling registers causes the group selecting switches shown in Fig. 1 to select a trunk leading to one of the special switches in the central office. This switch is then operated under the control of the tens register to select a level of trunks outgoing to the desired private branch exchange. The movement of the special switch, in the selection of the desired level of the trunks, determines the setting of a register associated with such switch in accordance with the registration which controls the switch in its selection of the level of outgoing trunks. By this means the tens registration, which determines the selection of the proper level of trunks outgoing to the private branch exchange, is reproduced on the register individual to the switch. The switch, after having chosen the proper level of trunks, operates automatically to select an idle trunk in the level leading to the final connecting switch in the private branch exchange. This final connecting switch is then operated under the control of the individual register to select a level of subscribers' lines. After having selected the proper level of lines, the final switch in the private branch exchange is then operated under the control of the units register of the register controlling mechanism in the central office to complete the connection to the called line.

The selective switches used in this system and the register controlling mechanism for controlling said switches may be of the type

shown and described in the patent to Polinkowsky No. 1,365,269, granted January 11, 1921.

In the following detailed description of the operation of the system it is assumed that a subscriber whose line terminates in the central office, desires to hold a conversation with a subscriber whose line belongs to a distant private branch exchange, as for example, the subscriber at substation 300. In any well-known manner the calling subscriber's line is extended by way of conductors 101 and 102 to a first group selector switch whose brushes are shown at 109, 110 and 111. In the manner described in the above application of Polinkowsky, a controlling circuit switch 100 for the first group selector switch advances its contacts 103 and 104 into position to extend the calling line by way of conductors 115 and 116 to an idle register controlling mechanism. The calling subscriber then operates his impulse transmitter to position the registers 130, 140 and 150, in accordance with the called line designation.

Since the call is one intended for a subscriber's line in the distant private branch exchange, the brushes of the first group selector 109, 110 and 111 are operated under the control of register 130 to select the terminals 112, 113 and 114 of a trunk leading to the special switch in the central office. When the test brush 111 encounters the test terminal 114, a circuit is completed from battery, winding of relay 243, contact 240 (1) of sequence switch 250, terminal 114, brush 111, contact 108 of sequence switch 100, right-hand high resistance winding of test relay 107 to ground. In parallel to this circuit a circuit is also completed from battery through resistance 242, contact 241, contact 240 (1), to ground through the winding of relay 107. Relay 107 energizes and closes a low resistance path to ground through its left-hand low resistance winding and contact and armature. Relay 243 becomes energized and closes a locking circuit for itself over its left-hand armature and contact, independent of sequence switch contact 240. At the same time the brushes 109 and 110, by making engagement with terminals 112 and 113 respectively, close the fundamental circuit for controlling the brush tripping operation of the switch. This circuit may be traced from battery through the winding of relay 252, contact 244 (1 to 2), terminal 113, brush 110, contact 106, conductor 117, winding of stepping relay 126, armature and contact of relay 125, contact 122 of sequence switch 120, closed in position 10, conductor 118, contact 105, brush 109, terminal 112, contact 245 (1 to 2) to ground. Relay 252 becomes energized and closes a circuit from ground through its armature and front contact, contact 253 (1), winding of sequence switch 250 to battery and ground. Sequence switch 250 advances from position 1 into position 2. In position 2 of sequence switch 250 a circuit is closed from battery through the winding of trip spindle power magnet 248, contact 253 (2 to 4), front contact and armature of relay 252 to ground. The power magnet 248 causes the rotation of the trip spindle to select the proper set of brushes.

When the trip spindle is in its home position the interrupter brush 230 engages the comparatively deep notch 233. The notch 233 is so formed with respect to the remaining notches on the trip spindle element that brush 230 and contact spring 231 remain in engagement with each other at all times while the trip spindle is away from its normal position. The contact springs 231 and 232 are so disposed that they engage each other only during the time that the interrupter brush 230 is passing from one to another of the comparatively shallow notches in the trip spindle element. These shallow notches, of which there are ten, correspond to the brush tripping positions of the switch.

At the time the sequence switch 120 of the register controlling mechanism reached position 10 prior to the closure of the fundamental circuit, a cuircuit was established from ground through contact 124, armature and contact of relay 126, left-hand winding of relay 127, armature and contact of relay 127, contact 123 (10), contact 142 of the tens register 140 through the winding of said register to battery and ground. A circuit was also completed from battery through the right-hand winding of relay 127 to ground at contact 124. Relay 127, being differential, is not operated when both its windings are energized simultaneously. The register 140, however, becomes energized and moves from the position to which it was adjusted by the calling subscriber's transmitter to the next succeeding position. When the master contact 141 of register 140 closes between positions, the left-hand winding of relay 127 is shunted out, permitting this relay to energize over its right-hand winding. When the fundamental circuit is closed, as above described, the stepping relay 126 becomes energized and opens the circuit of the right-hand winding of differential relay 127. Relay 127 thereupon deenergizes. As the brush tripping spindle leaves its normal position, a circuit is closed from battery through the winding of relay 252, contact 249 (2), conductor 234, contacts 232 and 231, and brush 230 to ground. This circuit maintains the energization of relay 252 and causes the shunting of stepping relay 126. Relay 126, by releasing its armature, closes the above-

traced circuit for advancing the tens register 140 to its next succeeding position. This operation continues, the register 140 advancing one position for each deenergization of stepping relay 126 until said register reaches its normal position 0. In position 0 of register 140 a circuit is closed from battery through the winding of sequence switch 120, contact 121 (10), contact 143 (0), contact 123 (10), contact and armature and left-hand winding of relay 127, contact and armature of relay 126, contact 124 to ground. In parallel to this circuit, a circuit is also completed for the relay 125. Relay 125 operates to open the fundamental circuit and sequence switch 120 passes from position 10 into position 12. As soon, after the fundamental circuit is opened at the register controlling mechanism, as contacts 231 and 232 are opened, relay 252 becomes deenergized. The retraction of the armature of relay 252 opens the circuit of power magnet 248 and also closes a circuit including contact 254 (2) for driving sequence switch 250 out of position 2 and into position 3. The tripping spindle has thus been rotated to a position for tripping the set of brushes having access to the desired level of trunks as determined by the setting of the tens register 140. The principle by which the registers 130, 140 and 150 of controlling mechanisms of this type are set in positions corresponding to the complements of the digits, is fully explained in the British patent issued to Western Electric Company, Limited, No. 146,517, accepted October 5, 1921.

When sequence switch 250 reaches position 3, a circuit is completed from battery through resistance 242, contact 241, contact 240 (3 to 4), contact 269, brush 235, winding of relay 262 to ground. Relay 262 energizes in this circuit. While sequence switch 250 is passing through position $2\frac{1}{2}$ a circuit is closed from battery through the winding of relay 263, contact 245 ($2\frac{1}{2}$) to ground. The contact 245 does not open when passing out of position $2\frac{1}{2}$ until after contact 240 has closed in position 3 to permit the energization of relay 262, hence with relays 262 and 263 simultaneously energized, a locking circuit is completed as follows, for the latter of these relays: battery, through the winding of relay 263, front contact and right-hand armature of said relay, front contact and armature of relay 262, contact 254 (3 to 4), back contact and armature of relay 252 to ground. A circuit is now established from battery through the winding of brush carriage power magnet 261, front contact and left-hand armature of relay 263, contact 231, interrupter brush 230 to ground. Magnet 261 energizes and moves the brush carriage away from its normal position whereupon the brush 235 disengages the home contact 269 to open the above-traced circuit for relay 262. The brush carriage, in moving away from its normal position, causes the tripping of the selected set of brushes 282, 283 and 284. Relay 262, by deenergizing, opens the locking circuit of relay 263. Relay 263 releases its armatures and opens the circuit of power magnet 261 causes the brush carriage to stop. Relay 263 also completes a circuit from battery through the winding of relay 252, contact 244 (3 to 4), back contact and left-hand armature of relay 263, contact 231, interrupter brush 230 to ground. Relay 252 becomes energized and completes a circuit from battery through the winding of the trip spindle power magnet 248, contact 253 (2 to 4), front contact and armature of relay 252 to ground. The trip spindle power magnet 248 energizes in this circuit and rotates forward to its normal position. It will be noted that since the trip spindle is provided with ten tripping positions, it will pass through a number of positions in its restoration to normal, which is the complement of the tens digit that serves to determine the selection of the proper set of brushes 282, 283, and 284 of the selective switch. For example, if the tens digit is 6, the trip spindle in rotating from this position to position zero covers four positions, the complement of 6. As will now be described, the trip spindle in passing through these complementary positions, serves to cause the setting of the individual register 290 in a position where it is later effective to determine the brush-selecting operation of the final switch in the private branch exchange, in accordance with the tens digit. When the contacts 231 and 232 are first closed in the restoration of the tripping spindle, a circuit is completed from battery through the winding of register 290, contact 258 (3), left-hand winding and back contact and armature of relay 259, contact 257 (3), conductor 234, contacts 232 and 231, to ground. In parallel to this circuit, a circuit is also completed from battery through the winding of coil 236, right-hand winding of relay 259, contact 266 (3), and thence to ground at contacts 231 and 230. The relay 259 being differential, does not operate when both of its windings are energized simultaneously. Register 290, however, becomes energized and advances from position 0 into position 1. In passing from position 0 to position 1, the master contact 291 closes and short-circuits the left-hand winding of relay 259. Relay 259 thereupon operates by means of current flowing through its right-hand winding. When contacts 232 and 231 again open as the brush 230 drops into the next shallow notch,

a circuit for the right-hand winding of relay 259 is opened to permit the release of this relay. The next closure of contacts 232 and 231 completes the above-traced circuit for register 290, which advances from position 1 into position 2. This operation continues until the trip spindle reaches its normal position at which time the interrupter brush 230 engages the comparatively deep notch 233. This causes the separation of contact 231 and brush 230, and the consequent opening of the circuit of relay 252. Relay 252, by releasing its armature opens the circuit of trip spindle power magnet 248.

Relay 252 by deenergizing also completes a circuit from battery through the winding of brush carriage power magnet 261, back contact and armature of relay 262, contact 254 (3 to 4), back contact and armature of relay 252 to ground. Power magnet 261 energizes and causes the rotation of brushes 282, 283 and 284, over the selected level of trunks in search of an idle one thereof. The engagement of test brush 284 with test terminal 288 of an idle trunk, which is identified by the presence of a full battery potential, closes a circuit from battery through the winding of cut-off relay 287, terminal 288 brush 284, contact 277 (3), left-hand high resistance winding of test relay 264, to ground. Relay 264 becomes energized and completes a substitute low resistance circuit through its right-hand winding, contact and armature and the winding of relay 262 to ground. This low resistance path serves to reduce the potential on the multiples of terminal 288 to render the selected trunk busy to other switches. Relay 262 energizes and opens the circuit of the power magnet 261 to stop the brush carriage. Relay 262 also completes a circuit from battery through the winding of sequence switch 250, back contact and right-hand armature of relay 263, front contact and armature of relay 262, contact 254 (3 to 4), back contact and armature of relay 252 to ground. Sequence switch 250 passes through position 4 and into position 5.

Since it may be desirable to use the trunk lines interconnecting the central office and the private branch exchange, as two-way trunks, it is necessary to render the distant end of the trunk line busy as soon as possible. To accomplish this the sequence switch 250 in position 5, completes a circuit from the source of alternating current 237, contact 268 (5), brush 283, terminal 286, conductor 301 right-hand armature and back contact of relay 372, left-hand winding of relay 373, condenser 303, resistance 375, back contact and left-hand armature of relay 372, conductor 302, terminal 285, brush 282, contact 267 (5), winding of relay 260, to battery and ground. Relay 260 is marginal and does not operate in series with resistance 375 and condenser 303. Relay 373 in the private branch exchange, however, attracts its armature and closes a locking circuit for itself from battery through resistance 304, contact 331 (1), right-hand winding and contact and armature of relay 373, to ground. Relay 373 establishes a circuit from ground through its armature and contact, winding of relay 360, to battery and ground. Relay 360 energizes and completes a circuit from battery through the winding of sequence switch 350, contact 354 (1), front contact and armature of relay 360, to ground, for moving this sequence switch into position 2. Sequence switch 350, in leaving position 1, opens the test conductor 305 at contact 341, to render the trunk non-selectable by switches in the private branch exchange. In position 2 of sequence switch 350, condenser 303 and resistance 375 are shunted at contact 342. Relay 260 now becomes energized and completes a circuit from battery through the winding of sequence switch 250, contact 253 (5), front contact and armature of relay 260 to ground. Sequence switch 250 advances from position 5 into position 6. In position 6 of sequence switch 250, relay 252 is energized in a circuit from battery through the winding of said relay, contact 249 (6), back contact and armature of relay 259, armature and contact of relay 279, right-hand armature and contact of relay 243, contact 274 (5 to 14) to ground. The source of alternating current 237 is disconnected at contacts 267 and 268 to permit the deenergization of relay 373. Relay 373 opens the circuit of relay 360 which in turn deenergizes and closes a circuit from battery through the winding of sequence switch 350, contact 356 (2), back contact and armature of relay 360 to ground. Sequence switch 350 moves from position 2 into position 3. In position 3 of sequence switch 350, relay 372 is energized by means of a circuit closed at contact 341 (3 to 8). Relay 372 attracts its armatures and completes a circuit from battery through the winding of relay 352, contact 344 (3 to 8) front contact and right-hand armature of relay 372, conductor 301, terminal 286, brush 283, contact 268 (6 to 13), contact and armature of relay 272, winding of relay 279, contact 267 (6 to 13), brush 282, terminal 285, conductor 302, left-hand armature and front contact of relay 372, contact 345 (3 to 8) to ground. Relay 279 energizes in this circuit and opens the holding circuit of relay 252. Relay 252 releases its armature and completes a circuit including contact 254 (6) for driving sequence switch 250 out of position 6 and into position 7.

With sequence switch 250 in position 7 and the register controlling sequence switch 120 in position 12, the units controlling position, the fundamental circuit is closed as hereinbefore described. Relay 252 attracts its armature and complete a circuit including contact 253 (7), for driving sequence switch 250 out of position 7 and into position 8. Between positions 7 and 8 of sequence switch 250, a circuit is momentarily closed from battery through the winding of relay 272, contact 256 (8 to 10), master contact 238 of sequence switch 250 to ground. Relay 272 remains energized until the sequence switch 250 reaches position 8. The energization of relay 272 opens the above-traced circuit for relays 352 and 279, permitting these relays to release their armatures. In position 8 of sequence switch 250 and after the release of the armature of relay 279, a circuit is closed from battery through the winding of coil 236, right-hand winding of relay 259, contact 266 (8), armature and contact of relay 279, right-hand armature and contact of relay 243, contact 274 (5 to 14) to ground. This circuit is closed slightly before the contact 258 closes in position 8. The differential relay 259, therefore operates and remains energized to prevent the disturbance of register 290 until relay 279 again energizes to open the circuit through the right-hand winding of relay 259.

When relay 352 deenergizes in response to the energization of relay 272 in the central office, a circuit is completed from battery through the winding of sequence switch 350, contact 353 (3), back contact and armature of relay 352 to ground. Sequence switch 350 moves from position 3 into position 4. With sequence switch 250 in position 8 and relay 272 deenergized, the above-traced circuit is closed for the energization of relays 352 and 379. Relay 352 completes a circuit from ground through its armature and front contact, contact 347 (4), through the winding of trip spindle power magnet 348, to battery and ground. The trip spindle power magnet energizes and causes the rotation of the trip spindle in the well-known manner. When relay 279 energizes, with sequence switch 250 in position 8, the circuit through the right-hand winding of relay 259 is opened causing this relay to deenergize. As the brush-tripping spindle of the final connecting switch in the private branch exchange approaches its first brush-tripping position, contacts 355 and 357 are closed to complete a circuit including contact 349 (4 to 6), for shunting out relay 279. Relay 279 by retracting its armature completes a circuit from battery through the winding of register 290, one of the two contacts 293 or 294 of register 290 dependent upon the position in which said register is standing, contact 258 (8), left-hand winding and back contact and armature of relay 259, armature and contact of relay 279, right-hand armature and contact of relay 243, contact 274 (5 to 14), to ground. In parallel to this circuit, a circuit is also completed from battery through the winding of coil 236, right-hand winding of relay 259, contact 266 (8), and thence to ground at contact 274. The differential relay 259 remains inoperative whereas register 290 energizes and advances one position. In passing between positions the master contact 291 short-circuits the left-hand winding of relay 259 to permit said relay to energize. This operation continues until the register 290 has been restored to its normal position 0, at which time the trip spindle of the final switch will have advanced to a position for tripping the set of brushes having access to the desired group of subscribers' lines. As soon, after the register 290 reaches position 0, as relay 279 releases its armature, a circuit is established from battery through the winding of sequence switch 250, contact 292 (0) of register 290, contact 258 (8), left-hand winding and back contact and armature of relay 259, armature and contact of relay 279, right-hand armature and contact of relay 243, contact 274 (5 to 14), to ground. A parallel circuit is also completed from battery through the winding of relay 272, contact 256 (8 to 10), and thence to ground at contact 274. Relay 272 operates to open the circuit of relay 352 and sequence switch 250 energizes and moves from position 8 into position 10. The next opening of contacts 355 and 357 after the energization of relay 272, causes the release of relay 352, which completes a circuit from ground through its armature and back contact, contact 353 (4), winding of sequence switch 350 to battery and ground. Sequence switch 350 advances from position 4 into position 6.

When sequence switch 250 leaves position 8, contact 258 is opened to permit the deenergization of relay 272. The above traced circuit including relays 352 and 279 is then closed. Relay 352 attracts its armature and completes a circuit from battery through the winding of the brush carriage power magnet 361, contact 346 (6), front contact and armature of relay 352 to ground. The magnet 361 causes the rotation of the brush carriage to advance the selected set of brushes 332, 333 and 334 into engagement with the terminals of the called line 300. For each set of line terminals passed over by the brushes, a circuit is closed from battery through the winding of relay 352, contact 349 (4 to 6), interrupter brush 306, to ground. This circuit maintains the energization of relay 352 but causes the shunting of relay 279 in the central office. Upon the first deenergization of relay 279, a circuit is completed from battery through the winding of relay 252,

contact 249 (10 to 13), back contact and armature of relay 259, armature and contact of relay 279, right-hand armature and contact of relay 243, contact 274 (5 to 14), to ground. This circuit maintains the energization of relay 252 but causes the shunting of the stepping relay 126 in the fundamental circuit. Relay 126 by retracting its armature closes a circuit for the advance of the units register 150 in the manner described in connection with the tens register 140. This circuit may be traced from battery through the winding of register 150, contact 152, contact 123 (12) of sequence switch 120, contact and armature and left-hand winding of relay 127, contact and armature of relay 126, to ground at contact 124. For each succeeding closure of the interrupter brush 306, relay 279 deenergizes to in turn cause the energization of the stepping relay 126 to cause the advance from position to position of the units register 150. When register 150 reaches its 0 position, which determines that the brushes 332, 333 and 334 have reached the terminals 335, 336 and 337 of the called line, a circuit is completed from battery through the winding of sequence switch 120, contact 121, contact 153 (0), contact 123 (12), contact and armature and left-hand winding of relay 127, contact and armature of relay 126, contact 124, to ground. The sequence switch 120 advances to its next position while relay 125 is energized as above described to open the fundamental circuit. As soon, after the energization of relay 125, as relay 279 becomes energized, relay 252 releases its armature and completes a circuit from battery through the winding of sequence switch 250, contact 254 (10), back contact and armature of relay 252 to ground. A circuit is also completed from battery through the winding of relay 272, contact 256 (8 to 10), contact 254 (10), back contact and armature of relay 252 to ground. Relay 272 opens the circuit of relay 352 while sequence switch 250 energizes and moves into position 12. As soon, after the energization of relay 272, as the interrupter brush 306 is opened, relay 352 deenergizes and completes a circuit from battery through the winding of sequence switch 350, contact 353 (6), back contact and armature of relay 352 to ground. Sequence switch 350 passes from position 6 into position 8. With the sequence switch contact 256 open in position 12, relay 272 is permitted to deenergize and again complete a circuit for the energization of relays 352 and 279.

While the sequence switch 350 is passing through position 7, a test is made to determine the busy or idle condition of a called line. Assuming the line to be idle, full potential is found on terminal 337 and a circuit is closed from battery through the winding of relay 371, terminal 337, brush 334, contact 359 (7), left-hand high resistance winding of relay 364 to ground. Relay 364 energizes and closes a substitute circuit through its low resistance right-hand winding and front contact and armature to ground. This low resistance path decreases the potential on terminal 337 to render the called line busy. In position 8 of sequence switch 350 a circuit is completed from ground through the armature and back contact of relay 360, contact 356 (8), winding of sequence switch 350 to battery and ground for driving sequence switch 350 into position 10. In leaving position 8, sequence switch 350 opens at its contact 341, the holding circuit of relay 372. This relay, however, is energized in a circuit including contact 356 (9 to 10) and the back contact and armature of relay 360. In passing from position 8 to 10, sequence switch 350 opens its contacts 344 and 345 to cause the momentary deenergization of relays 352 and 279. Relay 279 by retracting its armature completes a circuit from battery through the winding of relay 252, contact 249 (10 to 13), back contact and armature of relay 259, armature and contact of relay 279, right-hand armature and contact of relay 243, contact 274 (5 to 14), to ground. Relay 252 becomes energized and completes a circuit from ground through its armature and front contact, contact 253 (12 to 13), winding of sequence switch 250, to battery and ground. Sequence switch 250 leaves position 12. Before sequence switch 250 reaches position 13, however, relay 279 becomes energized in series with relay 352 and opens the circuit of relay 252. Relay 252, therefore, deenergizes and sequence switch 250 stops at position 13.

With sequence switch 350 in position 10 and relay 352 energized, a circuit is completed from ground through the armature and front contact of relay 352, contact 353 (10), winding of sequence switch 350 to battery and ground for moving said sequence switch into position 12. In position 12 ringing current is applied to the called line by means of a circuit traceable from the ringing source 320, contact 366 (12), brush 333, terminal 336, over the loop of the called line, and returning by way of terminal 335, brush 332, contact 367 (12), winding of relay 360 to battery and ground. When the called subscriber responds by removing his receiver from the switchhook, the marginal relay 360 is energized in the usual manner and closes a circuit from battery through the winding of sequence switch 350, contact 354 (12), to ground at the front contact and armature of relay 360. Sequence switch 350 is moved from position 12 into position 14. Sequence switch 350, in leaving position 12, opens the circuit of relay 360 which thereupon deenergizes. In positions 13 to 18 of sequence switch 350, relay 372 is maintained ener-

gized in a circuit including sequence switch contact 341. When sequence switch 350 leaves position 12, contacts 344 and 345 are opened to cause the deenergization of relays 279 and 352. Relay 279 releases its armature and completes the above-traced circuit for relay 252. Relay 252 completes a circuit from ground through its armature and front contact, contact 253 (13), winding of sequence switch 250 to battery and ground. Sequence switch 250 advances into position 14 which is the talking position. With sequence switch contacts 246 and 247 closed in position 14, and sequence switch contacts 367 and 363 closed in position 14, a through circuit is established from the first group selector, shown in Fig. 1, to the called subscriber's line. Talking battery is supplied in the usual manner from the central office and the supervisory relay 368 is energized in series therewith.

After the conversation has been completed, the calling subscriber, by replacing his receiver on the switchhook, causes the release of the first group selector switch in the well-known manner. The test brush 111 by disengaging test terminal 114, opens the holding circuit of relay 243. Relay 243 releases its armatures and completes a circuit from battery through the winding of sequence switch 250, make-before-break contact of relay 243, contact 274 (5 to 14) to ground. Sequence switch 250 thereupon moves from position 14 into position 17. In position 17 of sequence switch 250, relay 252 becomes energized in a circuit from battery through the winding of said relay, contact 249 (17), back contact and armature of relay 259, armature and contact of relay 279, contact 274 (15 to 18) to ground. The reason for energizing relay 252 is, as will be presently seen, to hold the sequence switch 250 from passing out of position 17 to render the outgoing end of the trunk idle until the switch at the distant end of the trunk has reached the necessary point in its restoration for rendering the distant end of said trunk idle.

The opening of the line circuit causes the release of relay 368 in the private branch exchange. A circuit is then closed from battery, through the winding of relay 360, resistance 321, contact 376 (14), contact and armature of relay 368, back contact and armature of relay 352 to ground. Relay 360 becomes energized and closes a circuit from battery through the winding of sequence switch 350, contact 354 (14), front contact and armature of relay 360, to ground. Sequence switch 350 advances from position 14 into position 15. Relay 360 releases its armature and completes a circuit including contact 356 (15), for driving sequence switch 350 out of position 15 and into position 16. In position 16, the above-traced circuit for relay 360 is again closed through contact 376, and the contacts and armatures of relays 368 and 352. Relay 360 becomes energized and completes a circuit including contact 354 (16) for moving sequence switch 350 into position 17. A circuit is now closed from battery through the winding of brush carriage power magnet 361, contact 346 (17), back contact and armature of relay 352 to ground. The brush carriage commences to rotate and on reaching its normal position, a circuit is completed from battery, through the winding of relay 352, contact 378 (17), contact 322, brush 323 to ground. Relay 352 opens the circuit of power magnet 361 and also completes a circuit from battery, through the winding of sequence switch 350, contact 353 (17), front contact and armature of relay 352 to ground. Sequence switch 350 moves into position 18. In position 18 of sequence switch 350, a circuit is established from battery, through the winding of relay 352, contact 344 (18), thence over the trunk conductor as hereinbefore traced, through the winding of relay 279, and returning to ground at contact 345 (18). Relays 352 and 279 become energized. Relay 352 by attracting its armature, closes a circuit including sequence switch contact 353 for driving sequence switch 350 out of position 18 and into position 1. The relay 279 by attracting its armature, opens the circuit of relay 252. Relay 252 releases its armature and completes a circuit including contact 254 (17) for moving sequence switch 250 into position 18.

It will be observed that sequence switch 350 and sequence switch 250 are advanced simultaneously from their respective positions, 18 and 17. Sequence switch 350, by moving from position 18 into position 1, opens the circuit of relay 372 and closes the contact 341 to render the test terminal 324 of the trunk line selectable by switches of the private branch exchange. The sequence switch 250, in passing out of position 17 opens its contact 277 to render the test terminal 288 of the trunk line selectable to other switches in the central office. By this arrangement both ends of the two-way trunk are simultaneously released.

With sequence switch 250 in position 18 a circuit is closed from battery through the winding of brush carriage power magnet 261, back contact and armature of relay 262, contact 254 (18), back contact and armature of relay 252 to ground. The brush carriage commences to rotate and on reaching its normal position, a circuit is closed from battery through resistance 242, contact 241 (18), contact 240 (18), contact 269, brush 235, winding of relay 262 to ground. Relay 262 becomes energized and opens the circuit of magnet 261 to stop the brush carriage. Relay 262 also establishes a circuit from bat-

tery through the winding of sequence switch 250, back contact and armature of relay 263, front contact and armature of relay 262, contact 254 (18), back contact and armature of relay 252 to ground. Sequence switch 250 thereupon advances into its normal position 1.

It will now be assumed that the called line 300 is busy at the time its terminals are tested by the final selector switch. This being the case, a reduced potential exists on test terminal 337 and relay 364 does not receive sufficient current to attract its armature when sequence switch 350 passes through position 7. Since relay 364 remains deenergized a circuit is closed from battery through the winding of relay 360, resistance 321, contact 376 (7 to 10), back contact and armature of relay 364 to ground. Relay 360 attracts its armature and opens the circuit which would otherwise drive sequence switch 350 out of position 8. Sequence switch 350, therefore, comes to rest in position 8 and contacts 344 and 345 remain closed to prevent the momentary deenergization of relay 279. The relay 252 is therefore not energized in the manner above described and sequence switch 250 which has just advanced into position 12, remains in this position. A circuit is thereupon closed from ground through the interrupter 278, contact 239 (12), primary winding of the tone coil 276, to battery and ground. The interrupter 278 causes the impression of a characteristic tone on the calling line which notifies the calling subscriber that the called line is busy. The calling subscriber, replacing his receiver on the switchhook, causes the release of the first group selector and the consequent deenergization of relay 243. Relay 243 closes the circuit hereinbefore traced for advancing sequence switch 250 out of position 12 and into position 17. The opening of contacts 267 and 268 as sequence switch 250 leaves position 13, causes the deenergization of relay 352. Relay 352 completes a circuit from ground through its armature and back contact, and contact 353 (8) for driving sequence switch 350 into position 10. In position 10 of sequence switch 350, relay 360 is energized by means of a circuit closed through contact 367 and the back contact and armature of relay 364. Relay 360, at its armature and back contact, opens the holding circuit of relay 372. Relay 372 releases its armatures to prevent the closure of the energizing circuit of relay 352 when sequence switch 250 reaches position 17. Relay 352, therefore, remains deenergized and a circuit is completed from battery through the winding of brush carriage power magnet 361, contact 346 (10), back contact and armature of relay 352 to ground. The brush carriage rotates and on reaching its home position, a circuit is closed from battery through the winding of relay 352, contact 378 (10), contact 322, brush 323 to ground. Relay 352 operates and opens the circuit of the power magnet 361 and also closes a circuit including contact 353 (10) for moving sequence switch 350 into position 12. In position 12 of sequence switch 350, relay 372 remains deenergized to prevent the energization of relay 352 in series with relay 279. The relay 368 being deenergized, however, a circuit is closed as above described, for the energization of relay 360, including contact 376, contact and armature of relay 368 and the back contact and armature of relay 352. Relay 360 completes a circuit including contact 354 (12) for moving sequence switch 350 into position 14. In position 14, relay 372 is again energized by means of a circuit closed at contact 341 (13 to 18). Contacts 344 and 345, being open in this position however, relay 352 is still unable to energize in series with relay 279. Relay 360 is again energized in the circuit traced and closes the circuit including contact 354 (14), for driving sequence switch 350 into position 15. In position 15 relay 360 deenergizes and completes a circuit including contact 356 for driving sequence switch 350 into position 16. Relay 360 again energizes and prepares a circuit as explained for moving sequence switch 350 into position 17. In position 17 relay 352 is again energized in a circuit over contact 378, contact 322, brush 323. Relay 352 completes a circuit including contact 353 (17), for moving sequence switch 350 into position 18. In position 18 of sequence switch 350, relay 352 becomes energized in series with relay 279 and from this point on the remainder of the disconnection takes place as hereinbefore described.

The private branch exchange disclosed in this system is assumed to have a capacity sufficiently large to utilize several levels of trunks in the switch at the central office. Accordingly positions 4 and 9 of the individual register 290 are assigned to the establishment of connections to this particular private branch exchange. The remaining positions from 0 to 3 of register 290, in which positions contacts 220 and 221 are closed, may be assigned to the establishment of connections to a smaller private branch exchange requiring a comparatively few levels of trunks in the switch.

What is claimed is:

1. In a telephone exchange system, a telephone line, a selective switch, a second selective switch, a plurality of switch-controlling registers, means controlled in accordance with the setting of one of said controlling registers for operating said first switch to extend the telephone line to said second switch, and means operated in ac-

cordance with the extent of operation of said first switch for controlling the operation of said second switch to further extend the telephone line.

2. In a telephone exchange system, a telephone line, a selective switch, a second selective switch, a plurality of switch-controlling registers, means controlled in accordance with the setting of one of said registers for operating said first switch to extend the telephone line to said second switch, means operated in accordance with the extent of operation of said first switch for controlling the selective operation of said second switch, and means controlled in accordance with the setting of another of said controlling registers for further selectively operating said second switch to extend the telephone line.

3. In a telephone exchange system, a telephone line, a selective switch, a second selective switch, a plurality of switch-controlling registers, means controlled in accordance with the setting of one of said registers for operating said first switch to extend the telephone line to said second switch, an additional register, means for setting said additional register in accordance with the extent of operation of said first switch, and means controlled in accordance with the setting of said additional register for selectively operating said second switch to further extend the telephone line.

4. In a telephone exchange system, a telephone line, a selective switch, a second selective switch, a plurality of switch-controlling registers, means controlled in accordance with the setting of one of said registers for operating said first switch to extend the telephone line to said second switch, an additional register individual to said first switch, means for setting said additional register in accordance with the extent of operation of said first switch, and means controlled in accordance with the setting of said additional register for selectively operating said second switch to further extend the telephone line.

5. In a telephone exchange system, a telephone line, a selective switch, a second selective switch, a plurality of switch-controlling registers, means controlled in accordance with the setting of one of said registers for operating said first switch to extend the telephone line to said second switch, an additional register individual to said first switch, means for setting said additional register in accordance with the extent of operation of said first switch, and means controlled in accordance with the setting of said additional register for selectively operating said second switch, said last means being also controlled in accordance with the setting of another of said controlling registers for further selectively operating said second switch to extend the telephone line.

6. In a telephone exchange system, a telephone line, a selective switch having brushes and a brush-selecting element, a second selective switch, a plurality of switch-controlling registers, means controlled in accordance with the setting of one of said registers for operating said brush-selecting element to select a set of brushes, means for operating the selected brushes of said first switch to extend the telephone line to said second switch, and means operated in accordance with the extent of operation of said brush-selecting element for controlling the selective operation of said second switch to further extend the telephone line.

7. In a telephone exchange system, a telephone line, a selective switch having brushes and a brush-selecting element, a second selective switch, a plurality of switch-controlling registers, means controlled in accordance with the setting of one of said registers for operating said brush-selecting element to select a set of brushes, means for operating the selected brushes of said first switch to extend the telephone line to said second switch, means for restoring said brush-selecting element to its normal position, and means operated in response to the restoration of said brush-selecting element for controlling the selective operation of said second switch to further extend the telephone line.

8. In a telephone exchange system, a selective switch, a trunk line, a second selective switch, means for operating said first switch to extend a connection over said trunk to said second switch, means for operating said second switch to further extend said connection, means for rendering said trunk busy at said first switch, means for rendering said trunk busy at said second switch, means for releasing said switches, and means operated during the release of said switches for removing the busy condition of said trunk at both switches simultaneously.

9. In a telephone exchange system, a telephone line, a selective switch having brushes and a brush selecting device, a second selective switch, means for operating said brush selecting device to select a set of brushes, means for operating the selected brushes of the first switch to extend the telephone line to said second switch, and means operated in accordance with the extent of operation of said brush selecting device for controlling the selective operation of said second switch to further extend the telephone line.

10. In a telephone exchange system, a telephone line, a selective switch having brushes and a brush selecting device, a sec-

ond selective switch, means for operating said brush selecting device to select a set of brushes of said first switch, means for operating the selected set of brushes to extend the telephone line to said second switch, means for restoring the brush selective device to its normal condition, and means operated in response to the restoration of said brush selecting device for controlling the selective operation of said second switch to further extend the telephone line.

In witness, whereof, I hereunto subscribe my name this 2nd day of April A D., 1820.

LIPA POLINKOWSKY.