Aug. 12, 1924. 1,504,228

J. W. GOODERHAM

TELEPHONE EXCHANGE SYSTEM

Filed Nov. 30, 1920 6 Sheets-Sheet 1

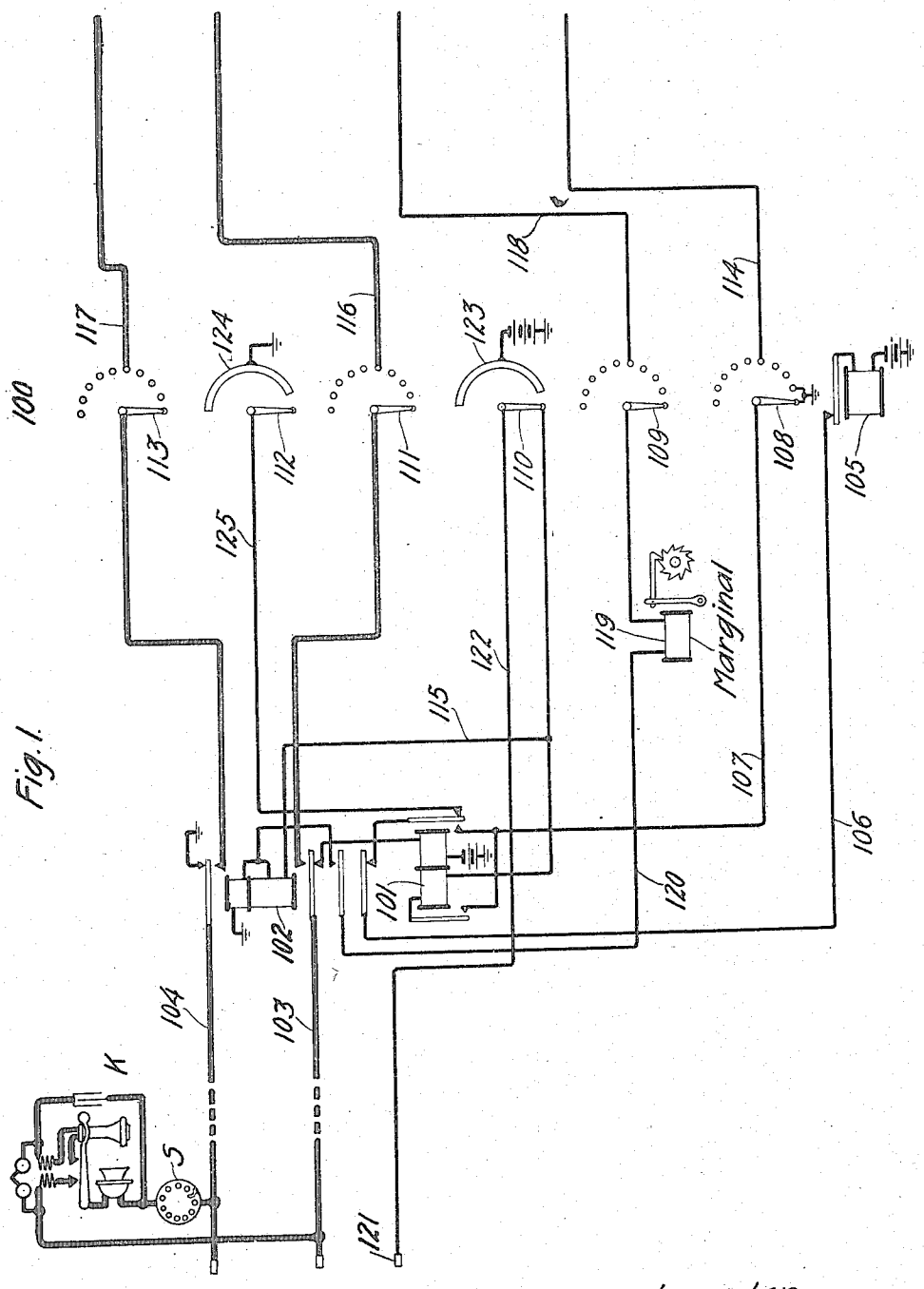

Fig. 1.

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TELEPHONE EXCHANGE SYSTEM

Filed Nov. 30, 1920 6 Sheets-Sheet 2

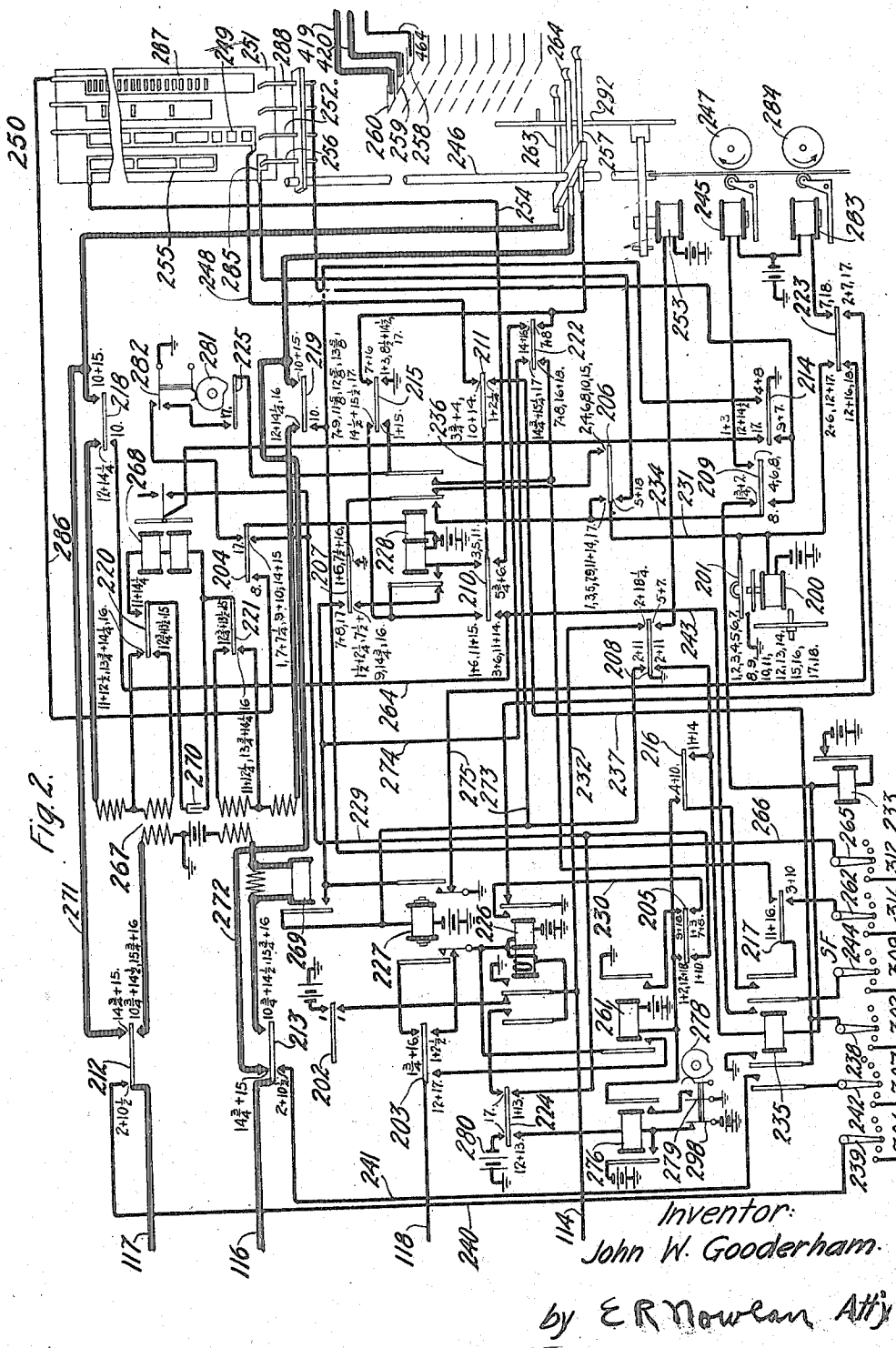

Fig. 2.

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TELEPHONE EXCHANGE SYSTEM

Filed Nov. 30, 1920 6 Sheets-Sheet 3

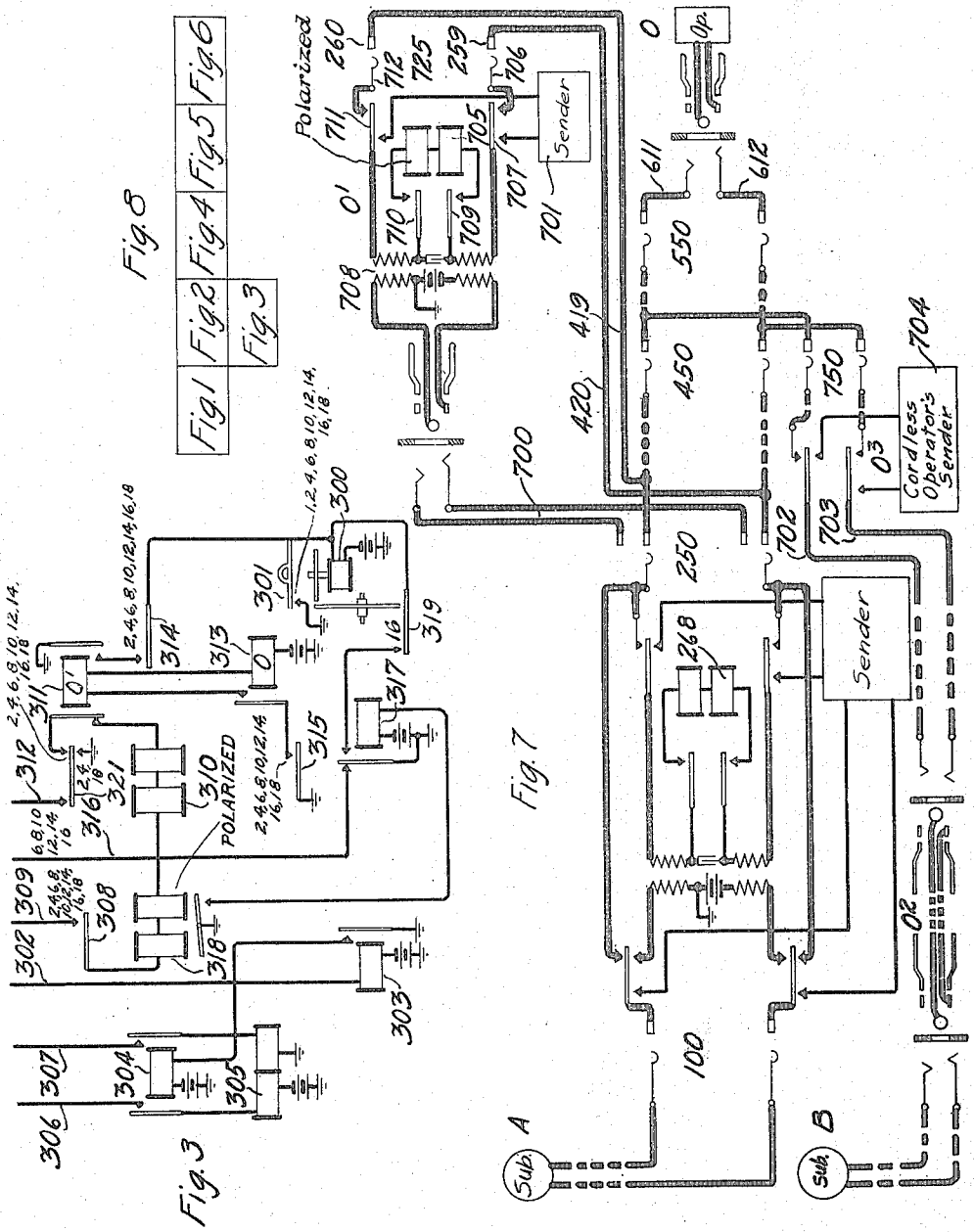

Fig. 7

Fig. 3

Fig. 8

Fig. 1	Fig. 2	Fig. 3
	Fig. 4	Fig. 5
		Fig. 6

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TELEPHONE EXCHANGE SYSTEM

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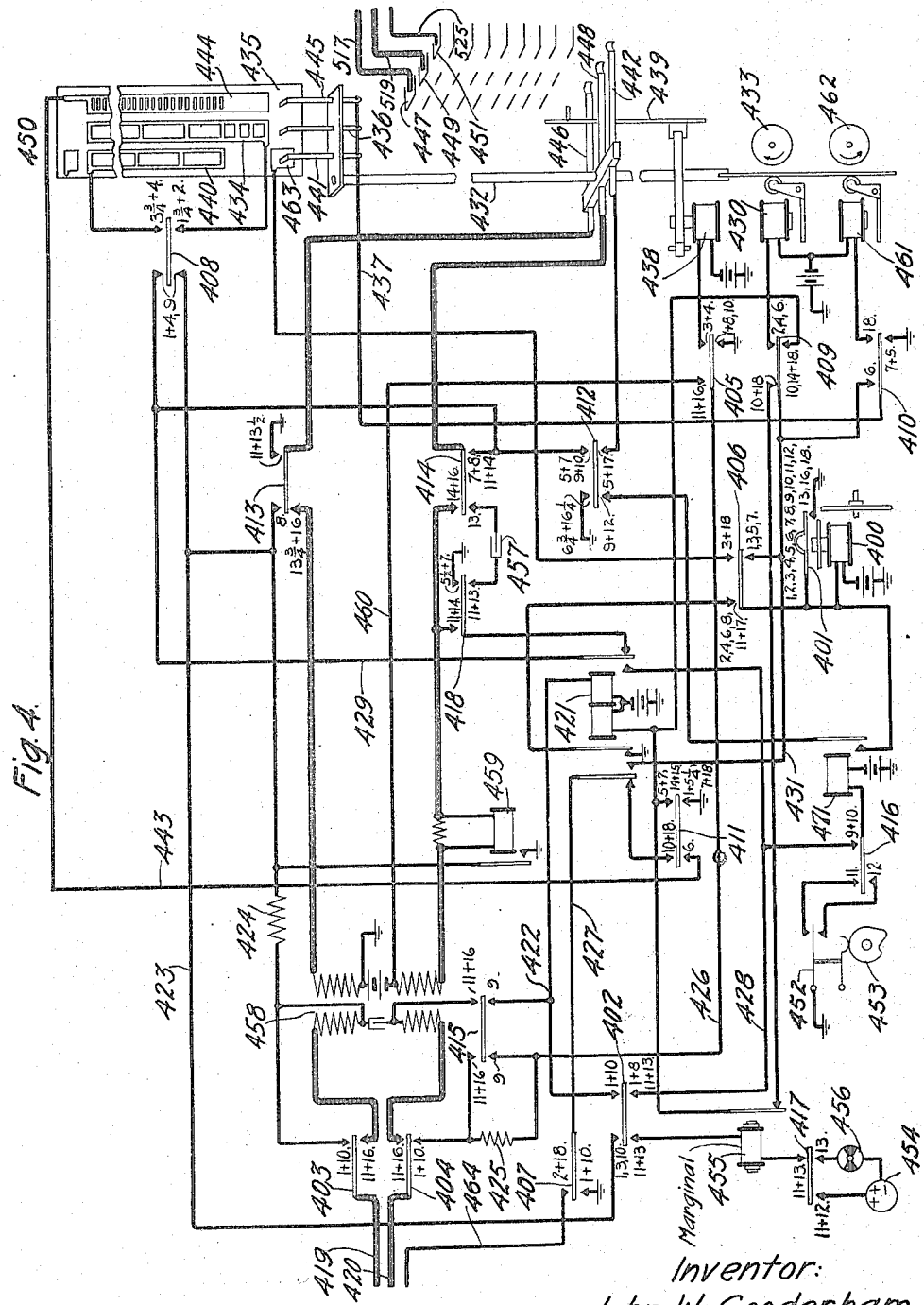

Fig. 4.

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TELEPHONE EXCHANGE SYSTEM

Filed Nov. 30, 1920 6 Sheets-Sheet 5

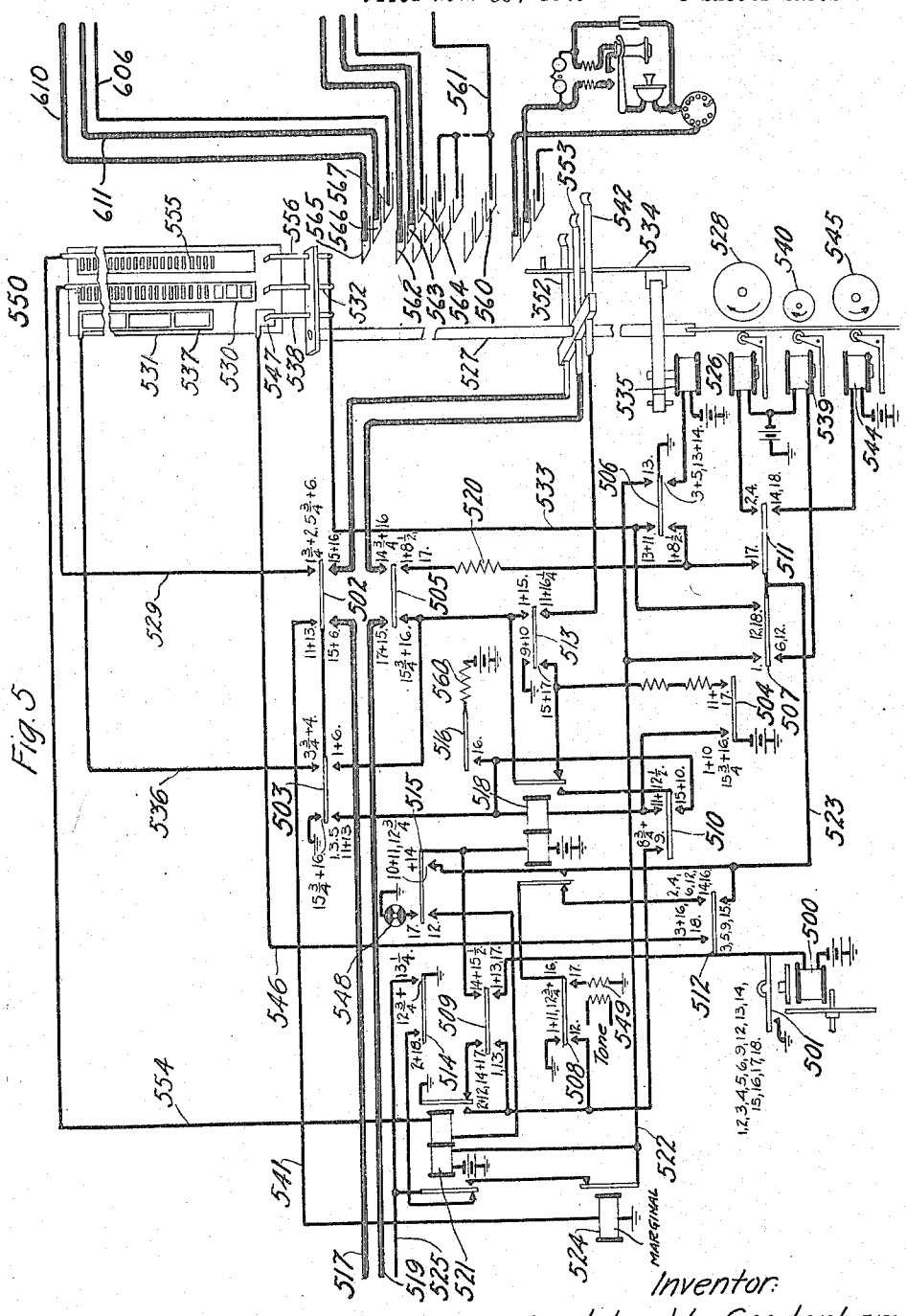

Fig. 5

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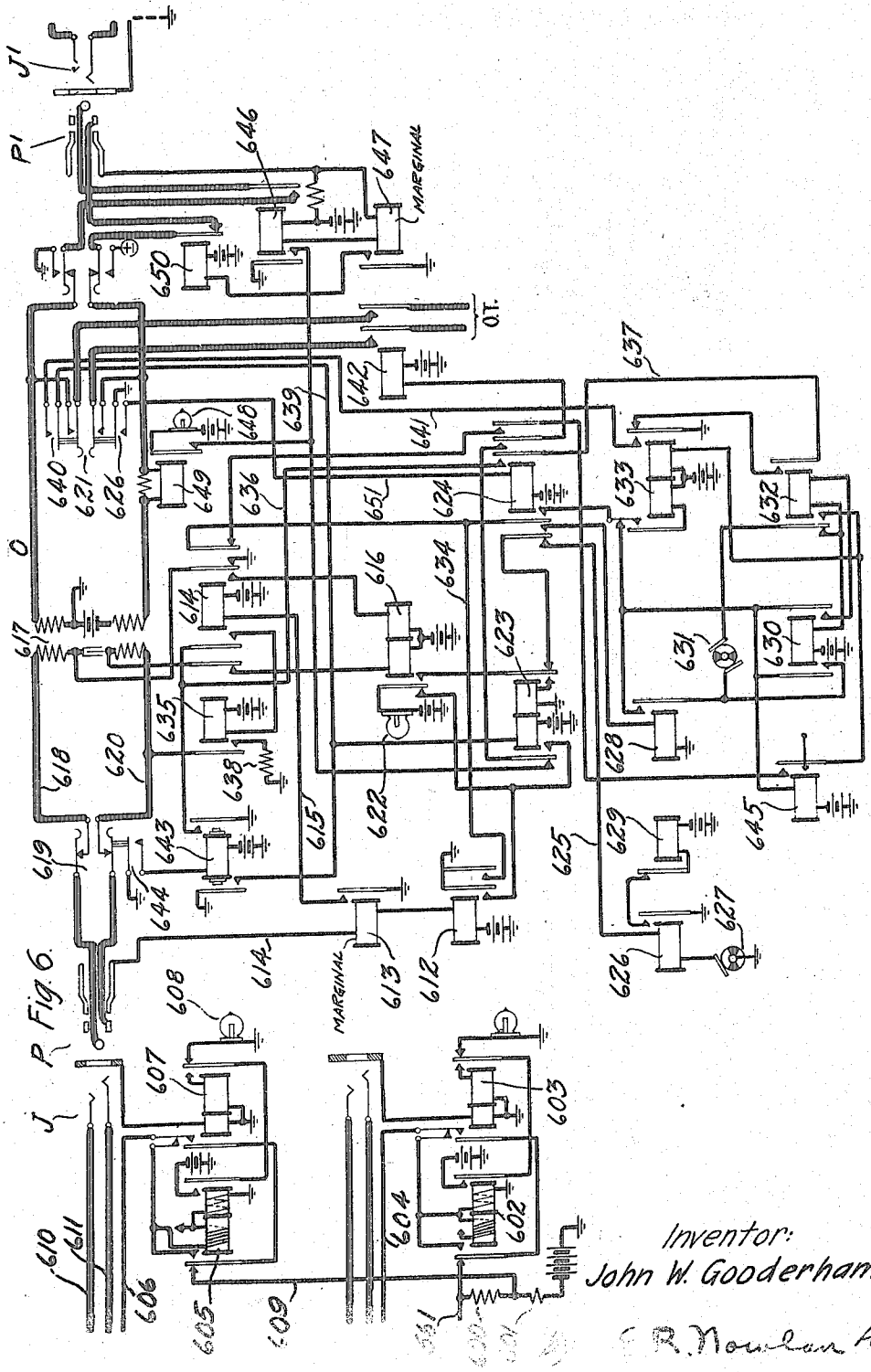
TELEPHONE EXCHANGE SYSTEM

Filed Nov. 30, 1920 6 Sheets-Sheet 6



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Patented Aug. 12, 1924. 1,504,228

UNITED STATES PATENT OFFICE.

JOHN W. GOODERHAM, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed November 30, 1920. Serial No. 427,445.

To all whom it may concern:

Be it known that I, JOHN W. GOODERHAM, a citizen of the United States, residing at New York, in the county of New York, State of New York, 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 a telephone system and more particularly to a system in which connections between subscribers' lines are established by means of mechanical switching devices.

In the installation of telephone exchanges in which mechanical switching mechanism is employed for extending connections between subscribers' lines it is the usual practice to divide the entire exchange into a plurality of offices and to make provision in each office for ultimately giving service to 10,000 subscribers' lines. The number of offices in the exchange is so selected that at the outset no office is required to function to its ultimate capacity and therefore only such switching units are initially installed in each office as are necessary to care for the immediate expansion of the system. As the demand for service in any particular office increases, additional switching units are added until the ultimate capacity is reached when a new office is established.

Obviously during the period in which the demand for service is increasing, there must always be switching units which are not employed to their full capacity. This is especially true of incoming selector switches which have access to small groups or divisions of trunk lines and to final selector switches which have access to the individual subscribers' lines. Thus there will be a number of terminal sets in the banks of incoming selector switches which are blank or not connected to working trunk lines extending to final selector switches, and terminal sets in the banks of final selector switches which are blank or not connected to subscribers' lines.

If the exchange operates upon a full mechanical basis, that is calling subscribers set up connections by dialing the numbers of desired lines to position the selector switches, or if the connections are established semi-mechanically, that is an operator causes the setting of the selector switches in accordance with instructions received from calling subscribers, it may be, as often occurs, that a selector switch will be set to extend a connection into a division of an office which has not yet been installed or a final selector switch will be set upon a blank bank terminal to which no subscriber's line has been connected or upon the terminal of a line from which former service has been discontinued. In such a case it is desirable to route such connections to a special operator's position, sometimes called an intercepting operator's position, so that the subscriber or operator may be informed that they have inadvertently established the connection to such a blank terminal.

It is therefore an object of the invention to provide means for extending a connection automatically to an operator's position when a selector switch is inadvertently positioned upon a blank set of bank terminals.

A further object of the invention is to provide a group of trunk circuits less in number than the number of blank terminals in the bank of a selector switch for extending a connection to an operator's position when the selector switch is erroneously positioned upon one of such blank terminals.

The principal feature of the invention resides in providing a group of trunk lines extending from the banks of selector switches in which there are blank terminals to such intercepting operators' positions. The number of trunks in the group is made adequate to care for the maximum density of such traffic to the operator's position and is less than the total number of blank terminals to be served. Thus a selector switch upon being set upon a set of blank terminals will automatically move its brushes to the terminals of the first trunk of the group extending to the intercepting operator's position. If this trunk is busy, the switch will continue to move its brushes over the other trunks of the group until an idle trunk is found.

Further features of the invention will be apparent from the following description considered in connection with the accompanying drawings in which Fig. 1 shows one of a group of lines terminating in a full mechanical office of the exchange and a rotary line switch individual to such line by means of which the subscriber's line may be connected to an idle district selector switch; Fig. 2 shows a district selector and

sender finder switch together with the circuits and controlling mechanism associated therewith; Fig. 3 shows diagrammatically a portion of a register sender which may be associated with the district selector of Fig. 2 for controlling the setting of the selector switches; Fig. 4 shows an incoming selector switch provided with mechanism for applying ringing current to the terminals of called lines together with the circuits and mechanism for controlling such switch; Fig. 5 shows the mechanism and circuits of a final selector switch; Fig. 6 shows the first and last trunk lines of a group of trunk lines extending from blank terminals of the final selector switch of Fig. 5 to an intercepting operator's position and a cord circuit at the operator's position; Fig. 7 shows a diagram of circuits over which connections may be extended to an intercepting operator's position; and Fig. 8 illustrates the manner in which the several figures should be arranged to show as much of a complete organization of circuits as is necessary to properly illustrate the invention. In Fig. 6, relays 602 and 605 are shown with optional wiring according to whether the trunk line is one of a group at which time it will be wired in accordance with relay 602, or an individual line using the wiring of relay 605.

The calling subscriber's line K is of the usual type provided with a transmitter, receiver and call-bell and, since it terminates in a full mechanical exchange, it is also equipped with the impulse sending dial S of the usual type.

The subscriber's line terminates in an individual trunk finding switch 100 of the well-known step-by-step type which, through a plurality of wipers, has access to a group of trunk lines terminating in district selector switches. The switch is provided with a stepping magnet for advancing the wipers over the terminals of trunk lines in search of an idle trunk line and for advancing the wipers forwardly to normal position upon the release of the established connection.

The district selector switch 250, the incoming selector switch 450 and the final selector switch 550 disclosed in Figures 2, 4 and 5 are of the type shown and described in the patent to Craft and Reynolds 1,123,696 issued January 5, 1915. Each of these switches is provided with a vertically disposed switch shaft having five sets of brushes each brush set having access to a bank of 100 terminals. For driving the switch shaft upwardly an up-drive magnet is provided which when energized presses the switch shaft against a constantly driven power drum, and for restoring the switch to normal position a second down-drive magnet is provided which when energized presses the switch shaft against a second constantly driven power drum. For determining the particular set of brushes on the switch shaft to be employed, a tripping spindle is provided as described in the patent hereinbefore referred to. The final selector switch 550 differs from the other selector switches in being provided with additional means comprising a second up-drive magnet and driving drum for driving the switch shaft upwardly, whereby the shaft is driven upwardly by the two up-drive drums at different speeds, rapidly during brush selection and group selection, and more slowly during the terminal selection movement of the switch shaft.

The sender finder switch SF shown in Fig. 2 is of the well known step-by-step type, the wipers being advanced by the stepping magnet to hunt for an idle sender such as diagrammatically shown in Fig. 3. This switch has no normal position, the wipers resting in contact with the bank terminals last employed, when the switch is not in use. Only so much of the register sender is shown in Fig. 3 as is necessary for an understanding of the invention. This sender may be of the type disclosed in Patent 1,395,977 issued to F. A. Stearn and F. J. Scudder, November 1, 1921, and functions in the manner set forth therein to control the selector switches 250, 450 and 550.

For controlling the circuits associated with the several selector switches and the circuits of the office sender, auxiliary switches are provided. These switches may be of the type described in the patent to Reynolds et al, No. 1,127,808 issued February 9, 1915, and known in the art as sequence switches. Each sequence switch comprises a rotatable shaft driven from a constantly operated source of power through a magnetic clutch member and carries a plurality of circuit closing cams which, at different radial positions of the shaft cause the closure of a plurality of contacts. The cam contacts associated with each sequence switch are closed only in the positions indicated by the numerals associated with each contact with the exception of the master contacts 201, 301, 401 and 501 associated respectively with sequence switches 200, 300, 400 and 500, these latter contacts being opened in the positions indicated by the numerals appearing adjacent to such contacts and closed in all other positions.

The different pieces of apparatus employed in the system having now been fully described, it is thought that a clearer understanding of the invention may be had from a description of the method of establishing a connection. It will be assumed that the calling subscriber at the substation K desiring a connection with a subscriber in his own office whose directory No. is PENnsylvania 8432, through inadvertence dials the number corresponding to PENnsylvania 8632

and that this latter number has not been assigned to any subscriber, but appears as a blank terminal in the banks of all final selector switches which have access to the group of lines containing lines 8500 to 8999 inclusive.

The calling subscriber to initiate a call removes his receiver from its switch hook thereby closing a circuit for the line relay 101 of the trunk hunting switch 100, which circuit may be traced from grounded battery through the right hand winding of relay 101, the innermost lower armature and back contact of cut-off relay 102, over line conductor 103, through the substation of subscriber's line K and then back over line conductor 104 to ground at the upper armature and back contact of cut-off relay 102. The line relay energizes in this circuit and closes a circuit for the stepping magnet 105 of the switch 100, which circuit may be traced from grounded battery through the winding, armature and contacts of magnet 105, conductor 106, the lowermost armature and back contact of relay 102, the right hand armature and front contact of relay 101, conductor 107 and thence to ground through the wiper 108 and the normal contact of the bank to which this wiper has access. The magnet 105 upon energizing in this circuit opens its energizing circuit at its armature contacts and thereupon deenergizes, advancing the wipers 108, 109, 110, 111, 112 and 113 of switch 100 to the second position contacts of the respective banks to which they have access. As the second contact which wiper 108 engages is permanently connected to ground, the magnet 105 is reenergized and steps the wipers to the third set of contacts which are individual to the first trunk of the group of trunks to which switch 100 has access.

If the first trunk of the group is busy there will be a ground potential on the test terminal thereof appearing in the lowermost bank of the switch and the switch will therefore continue stepping until an idle trunk is found, upon the test terminal of which battery potential appears. When such an idle trunk is found a circuit is closed from battery through the contacts of sequence switch cam 202 (1) of the district selector 250 to which the first idle trunk extends, through the inner left hand armature and back contact of sleeve relay 226, over test conductor 114, wiper 108, conductor 107, left hand armature and front contact and left hand winding of relay 101, conductor 115 to ground through both windings of cut-off relay 102. Relay 102 is energized in this circuit and opens, at its lowermost armature and back contact and at its upper armature and back contact, the circuit previously traced through the winding of stepping magnet 105 and at its upper armature and front contact and at its uppermost lower armature and front contact extends the conductors 103 and 104 of the subscriber's line to the wipers 111 and 113 of the switch 100 and from thence to the trunk conductors 116 and 117 leading to the selected district selector. Relay 102 also at its intermediate lower armature and front contact closes a circuit extending through the right hand winding of sleeve relay 226 of the district selector switch, the break contacts of the left hand armature of slow releasing relay 227, the lower right hand contact of sequence switch cam 203 (1 to 2½) sleeve conductor 118, wiper 109, winding of marginal message register magnet 119, conductor 120, the intermediate lower armature and front contact of relay 102 and thence to ground through the upper winding of relay 102. The sleeve relay 226 of the district selector switch energizes in this circuit but owing to its marginal nature the message register magnet 119 does not energize at this time.

For making the calling subscriber's line K busy to all calls incoming thereto, battery potential is connected to the multiples of test terminal 121 of the calling line appearing in the banks of all final selectors having access to this line, over conductor 122 through wiper 110, segment 123 and grounded battery. Wiper 112 through the grounded segment 124 prepares a circuit extending over conductor 125 to the back contact of the right hand armature of line relay 101 preparatory to restoring finder switch 100 to normal when the cut-off relay 102 becomes deenergized upon the termination of the connection.

Upon the energization of sleeve relay 226, a circuit is established for the line relay 228 of the district selector switch 250 which circuit extends from grounded battery through the right hand winding of this relay, the lower right hand contact of sequence switch cam 204, conductor 229, the lower contacts of sequence switch cam 205, conductor 230 and thence to ground through the front contact and right hand armature of relay 226. At its inner left hand armature and back contact relay 226 opens the initial energizing circuit previously traced extending through the windings of relays 101 and 102 and at its left hand armature and front contact connects ground potential to the test conductor 114 of the selected trunk to mark the trunk busy to other line switches.

Relay 228 upon energizing closes a circuit for driving the sequence switch 200 of the district selector switch out of its normal position 1 and into position 2, this circuit extending from grounded battery through the winding of the driving magnet of switch 200, conductor 231, the upper left hand contact of sequence switch cam 206 (1), the

inner right hand armature and front contact of relay 228, and thence to ground at the lower right hand contact of sequence switch cam 207 (1 to 6). The sequence switch magnet energizes in this circuit and under the control of master cam 201 drives the sequence switch into position 2 in which position the circuit previously traced over cam 202 is opened and a circuit is closed from grounded battery through the winding of relay 227, the upper left hand contact of sequence switch cam 208 (2 to 11) and thence to ground.

Relay 227 upon energizing closes a locking circuit for the sleeve relay 226 extending through the right hand winding of relay 226, the make contacts of the left hand armature of relay 227 and thence to the sleeve conductor 118 over the upper contacts of sequence switch cam 203 (1¾ to 16), this circuit being maintained through position 16 of the sequence switch or until relay 227 becomes deenergized. Upon reaching position 2 the sequence switch connects a new holding ground to the test conductor 114 extending from conductor 114 over conductor 232 and through the upper right hand contact of sequence switch cam 208, which holding ground is maintained through position 18¼ of the sequence switch.

When the sequence switch reaches position 1¾, a circuit is closed for the stepping magnet 233 of the sender finder SF, extending from grounded battery through the interrupter contacts and winding of magnet 233, the upper left hand contact of sequence switch cam 209 (1¾ to 2), conductor 234 and thence to ground through the inner right hand armature and front contact of relay 228 and the lower right hand contact of sequence switch cam 207 (1 to 6). A circuit is also closed at this time through the winding of stepping magnet 233, the winding of cut-in relay 235 and thence to ground at the lower left hand contact of sequence switch cam 208 (2 to 11). Relay 235 does not energize at this time, however, since its winding is shunted by ground connected through the armature of line relay 228.

As soon as sequence switch 200 leaves position 1, the initial energizing circuit of line relay 228 is opened at the lower right hand contact of sequence switch cam 204, but this relay remains locked up over a circuit extending from grounded battery, its left hand winding, its left hand armature and front contact, the upper left hand contact of sequence switch cam 210 (1 to 6), conductor 236, the lower right hand contact of sequence switch cam 211 (1 to 2¼) conductor 237 test wiper 238 of the sender finder switch SF and to ground on the contact with which the wiper 238 is in engagement, if the office sender which is then associated with the district selector through the wipers of switch SF is at the time busy. The stepping magnet 233 energizes in the circuit previously traced opening its own circuit at its armature contacts thereby causing its own deenergization to advance the wipers of the switch SF one step. If the test wiper 238 then engages a contact corresponding to another busy sender, line relay 228 remains locked up and the circuit for stepping magnet 233 is again established. In this manner the magnet 233 advances the wipers of the finder switch until an idle office sender is found when the wiper 238 will find no ground on the terminals corresponding to such idle sender and the line relay 228 will thereupon deenergize. Relay 228 upon deenergizing, opens at its inner right hand armature and front contact, the circuit extending through the stepping magnet 233 thereby arresting the stepping movement of the switch SF, and closes at its inner right hand armature and back contact a circuit for driving sequence switch 200 out of position 2 and into position 3. This circuit may be traced from grounded battery through the winding of the magnet of sequence switch 200, conductor 231, the upper right hand contact of sequence switch cam 206 (2), the inner right hand armature and back contact of relay 228 and thence to ground at the lower right hand contact of sequence switch cam 207. As soon as line relay 228 deenergizes, the shunt around the winding of relay 235 is removed at the inner right hand armature and front contact of relay 228 and relay 235 thereupon energizes in series with stepping magnet 233, the current flowing through its circuit not being sufficient to cause the energization of the stepping magnet because of the high resistance of the winding of relay 235. Relay 235 upon energizing closes a circuit extending from ground through its inner left hand armature and front contact, over wiper 238 and the teminal upon which it is resting, conductor 302 and thence to grounded battery through the winding of relay 303. Relay 303 energizes in this circuit and at its armature and contact establishes a circuit for relay 304 which latter relay at its armatures and contacts closes an impulse circuit extending through the windings of the impulse relay 305 and over the calling subscriber's line loop. This circuit may be traced from grounded battery through the left hand winding of relay 305, the left hand armature and contact of relay 304, conductor 306, wiper 239, conductor 240, the upper left hand contact of sequence switch cam 212 (2 to 10½) conductor 117, wiper 113, the upper armature and front contact of relay 102, conductor 104, thence over the subscriber's line loop and returning over

conductor 103, the innermost lower armature of relay 102, wiper 111, conductor 116, the lower contact of sequence switch cam 213 (2 to 10½), conductor 241, the outer left hand armature and front contact of relay 235, wiper 242, conductor 307, the right hand armature and contact of relay 304 and thence to ground through the right hand winding of impulse relay 305. Ground potential connected to the wiper 238 through the inner left hand armature and front contact of relay 235 also establishes a busy potential upon multiples of test conductor 302 to prevent other sender finders from selecting the sender which has now been taken for use by the calling subscriber.

The calling subscriber now proceeds to dial the number of the desired line. Under the assumption that the subscriber desires a connection with the subscriber's line which is listed in the directory as PENnsylvania 8432 and that this line is reached through a district selector switch 250, an incoming selector 450 and a final selector 550, the subscriber proceeds to dial three letters corresponding to the office designation of the office in which the desired line is located and then dials four digits representing the number of the line in such office. In the case assumed the calling subscriber will dial the letters PEN and then should dial the numerals 8432, but through inadvertence dials the numerals 8632. The three letters which represent the office code causes the setting of the code registers in the office sender in the manner fully set forth in the aforesaid patent to F. A. Stearn and F. J. Scudder which, through the mechanism associated with the sender, controls the setting of the district selector switch 250 for extending the connection through the desired office of exchange, in this case to an incoming selector in the subscriber's own office.

The dialing of the numerals 8632 causes the setting of the numerical registers of the sender in the manner set forth in the aforesaid patent for controlling the setting of the incoming selector switch 450 and the final selector switch 550. Following the setting of the code registers of the sender, the sender sequence switch 300 is moved from its normal position into position 2 in the manner set forth in the aforesaid patent, and the fundamental switch controlling circuit which extends from the sender to the selector switch 250 is closed at sequence switch cams 308 and 321. This circuit may be traced from grounded battery through the left hand winding of relay 228 of the district selector switch, the upper right hand and lower left hand contacts of sequence switch cam 210, conductor 243, the inner right hand armature and front contact of relay 235, the wiper 244 of the sender finder switch SF and the contact of the bank with which this wiper is associated, conductor 309, contact of sequence switch cam 308 (2), windings of overflow relay 318, windings of sender stepping relay 310, the armature and back contact of the No. 0′ counting relay 311, and thence to ground at the right hand contacts of sequence switch cam 321. The line relay 228 of the district selector switch and stepping relay 310 of the office sender both energize in this circuit.

Relay 228 upon energizing closes a circuit for driving sequence switch 200 out of position 3 and into position 4. This circuit extends from grounded battery through the magnet winding of the sequence switch 200, the upper left hand contact of sequence switch cam 206 (3), the inner right hand armature and front contact of relay 228 and thence to ground at the lower right hand contact of sequence switch cam 207 (1 to 6). With the district sequence switch 200 in position 4, a circuit is now closed for the updrive magnet 245 of the district selector, which circuit extends from grounded battery through the winding of magnet 245, the upper right hand contact of sequence switch cam 209 (4), conductor 234, and thence to ground through the inner right hand armature and front contact of relay 228 and the lower right hand contact of sequence switch cam 207. Magnet 245 upon energizing presses the depending portion of the switch shaft 246 against the constantly rotating updrive drum 247 thereby causing the upward movement of the switch shaft. Upon the movement of the sequence switch 200 out of position 3, the initial energizing circuit of relay 228, which extends through its left hand winding and the upper right hand and lower left hand contacts of sequence switch cam 210 is opened at the upper right hand contact of this sequence switch cam, but a locking circuit for relay 228 is closed through its left hand winding, its left hand armature and front contact, the left hand contacts of sequence switch cam 210, and thence over the fundamental circuit as traced.

As the switch shaft of the district selector switch approaches its first brush tripping position, brush 252 engages the metallic portion of segment 249 of the commutator 251 and a circuit is closed in shunt of the winding of sender stepping relay 310, which may be traced from a point in the fundamental circuit between the winding of relay 228 and the windings of relay 310, through the upper contact of sequence switch 211 (3¾ to 4) conductor 248, brush selection segment 249 of the commutator 251, brush 252 carried upon the upper end of the switch shaft 246 and thence to ground at the lower left hand contact of sequence switch cam 214 (9 to 7). Upon the application of this shunt around the windings of stepping relay 310,

relay 310 deenergizes, relay 228, however, remaining energized over the shunt circuit just traced.

As the brush shaft 246 continues to move upwardly, the stepping relay 310 will again become energized as soon as the brush 252 engages the first insulating portion of segment 249. The stepping relay 310 will then continue to be intermittently energized and deenergized as the switch shaft of the district selector moves upwardly until the sender has been satisfied with respect to the district brush selection condition which has been established at the sender by the particular code which the calling subscriber has registered. When the sender is satisfied, the No. 0′ counting relay 311 becomes energized and locked up through the winding of the No. 0 counting relay 313 over a circuit extending from grounded battery through the winding of relay 313, the winding of relay 311, the armature and front contact of relay 313, and thence to ground at sequence switch contact 315 in the manner well known in the art and set forth in detail in the patent hereinbefore referred to. Relay 311 upon energizing closes a circuit for driving sequence switch 300 out of position 2 and into position 4 which may be traced from grounded battery through the winding of the magnet of sequence switch 300, sequence switch contact 314 (2), and thence to ground at the right hand armature and front contact of relay 311. At its left hand armature and back contact, relay 311 opens the fundamental circuit previously traced through the windings of relays 310 and 228. When sequence switch 300 leaves position 2, the locking circuits of all counting relays which have been energized are opened at sequence switch cam 315 and these relays deenergize.

As soon following the opening of the fundamental circuit by the No. 0′ counting relay 311 as the brush 252 engages the next insulating portion of segment 249, relay 228 becomes deenergized, closing a circuit for driving the district selector sequence switch 200 out of position 4 and into position 5. This circuit extends from grounded battery through the winding of the magnet of sequence switch 200, the upper right hand contact of sequence switch cam 206 (4), the inner right hand armature and back contact of relay 228 and thence to ground at the lower right hand contact of sequence switch cam 207. As soon as relay 228 deenergizes, the circuit previously traced through the updrive magnet 245 is opened at the inner right hand armature and back contact of relay 228. With sequence switch 200 of the district selector in position 5 and the sender sequence switch 200 in position 4, the fundamental circuit previously traced is again established and relay 228 of the district selector and stepping relay 310 of the sender again energize. Relay 228 upon energizing causes the movement of the district selector sequence switch 200 from position 5 into position 6, the sequence switch magnet 200 being energized over a circuit extending over conductor 231, the upper left hand contact of sequence switch 206 (5), the inner right hand armature and front contact of relay 228, and thence to ground at the lower right hand contact of sequence switch cam 207. As soon as sequence switch 200 leaves position 5, the initial energizing circuit of relay 228, which is closed over the fundamental circuit through the upper right-hand contact of sequence switch cam 210 (5), and the lower left hand contact of cam 210 (3 to 6) is opened, but relay 228 remains locked up through its left hand winding, its left hand armature and front contact and the left hand contacts of sequence switch cam 210.

Upon reaching position 6, the circuit previously traced for the updrive magnet 245 is again established through the upper right hand contact of sequence switch 209 (6) and the inner right hand armature and front contact of relay 228, and in the manner previously described, the switch shaft 246 is again driven upwardly. Since at this time the tripping spindle 292 has been rotated by the trip magnet 253, which was energized in position 5 of sequence switch 200 over a circuit extending from grounded battery through the winding of magnet 253 and to ground through the lower right hand contact of sequence switch 208 (5 to 7), the first set of brushes is now tripped upon the initial upward movement of switch shaft 246 and during the continued upward movement of the switch shaft, the tripped set of brushes travels over the contacts of the bank with which they are associated. The remaining four sets of brushes not being tripped are functionless at this time. During the continued upward movement of the switch shaft and as the tripped set of brushes approaches the first group of contacts in the bank, brush 256 engages the metallic portion of the group selection segment 255 of the commutator and a circuit in shunt of the windings of sender stepping relay 310 is established, extending from grounded battery through the left hand winding, the left hand armature and front contact of relay 228, the upper left hand and lower right hand contacts of sequence switch cam 210, conductor 254, segment 255, brush 256 and thence to ground at the lower contact of sequence switch cam 214 (9 to 7). Further upward movement of the switch shaft advances the brush 256 into engagement with an insulating portion of segment 255 thereby removing the shunt from around the windings of stepping relay 310. The intermittent connection of this shunt around the windings of stepping relay 310 causes the intermittent energization and deenergi-

zation of stepping relay 310 which, in the well-known manner, causes the successive energization of counting relays associated with the sender.

When the sender has been satisfied with respect to the district group selection condition which has been established therein through the setting of the code registers by the calling subscriber, the No. 0 counting relay 313 becomes energized closing the circuit of the No. 0′ counting relay 311 which locks up in series with relay 313 through the contact of sequence switch cam 315 (4). Upon the energization of relay 311, the circuit previously traced through the magnet winding of sequence switch 300 is again established and the sequence switch 300 is driven out of position 4 and into position 6. At its left hand armature and back contact relay 311 opens the fundamental circuit thereby causing the deenergization of relays 310 and 228. As soon as sequence switch 300 leaves position 4, the locking circuits of the energized counting relays are opened at the sequence switch cam 315 and these relays deenergize. As soon following the opening of the fundamental circuit as the brush 256 engages the next insulating portion of commutator segment 255, relay 228 deenergizes opening at its inner right hand armature and front contact the circuit previously traced extending through the winding of the updrive magnet 245 thereby arresting the upward movement of the switch shaft for positioning the tripped set of brushes in engagement with the first set of terminals of the selected group. At its inner right hand armature and back contact relay 228 closes a circuit extending through the upper right hand contact of sequence switch cam 206 for driving sequence switch 200 out of position 6 and into position 7. In position 7 relay 228 energizes over a circuit extending from grounded battery through its right hand winding, the lower right hand contact of sequence cam 204 (7 to 7½), conductor 229, the lower contacts of sequence switch cam 205 and to ground at the right hand armature and front contact of sleeve relay 226. Relay 228, upon energizing, closes a circuit for driving sequence switch 200 out of position 7 and into position 8. This circuit may be traced from grounded battery through the magnet winding of the sequence switch, conductor 231, the upper left hand contact of sequence switch cam 206 (7), the inner right hand armature and front contact of relay 228, the upper left hand contact of sequence switch cam 207 (7 to 8) and thence to ground through the make contacts of the right hand armature of relay 227.

As soon as sequence switch 200 leaves position 7, the initial energizing circuit of relay 228 is opened at sequence switch cam 204, but relay 228 locks up over a circuit extending from grounded battery through its left hand winding, its left hand armature and front contact, the upper contacts of sequence switch 215 to the test brush 257, and if the first trunk of the selected group is busy to ground at the test terminal of this trunk. Upon reaching position 8 with relay 228 energized, a circuit is established for the updrive magnet 245 which may be traced from grounded battery through the magnet 245, the upper right hand contact of sequence switch cam 209 (8), the inner right hand armature and front contact of relay 228 and to ground at the lower right hand contact of sequence switch cam 207. The updrive magnet 245 upon energizing again drives the switch shaft upwardly in search of an idle trunk in the selected group. So long as the test brush 257 encounters the terminals of busy trunks, relay 228 remains locked up. When, however, an idle trunk is encountered which it will be assumed is the trunk terminating in terminals 258, 259 and 260, the locking circuit of relay 228 is opened and relay 228 deenergizes as soon as the brushes 257, 263 and 264 have been properly centered upon bank terminals 258, 259, and 260. Until the brushes are so centered relay 228 remains locked up over a circuit extending through its right hand winding, the lower left hand contact of sequence switch cam 204 (8), conductor 286, centering segment 287, brush 288, the lower left hand contact of cam 209 (8), conductor 234, the inner right hand armature and front contact of relay 228 to ground at the lower right hand contact of sequence switch cam 207 (7½ to 16).

Relay 228 upon deenergizing opens the circuit previously traced through the winding of the updrive magnet 245 thereby arresting the upward movement of the switch shaft 246 and closes a circuit extending through its inner right hand armature and back contact over sequence switch cam 206 (8) for driving sequence switch 200 out of position 8 and into position 9. Upon reaching position 8½ busy ground potential is connected to the multiple test terminals of the selected trunk over brush 257 and the right hand contacts of cam 215. Relay 228 again energizes when sequence switch 200 reaches position 9 over a circuit extending through its right hand winding, the lower right hand contact of sequence switch cam 204 (9 to 10), conductor 229, the lower left hand and upper right hand contact of sequence switch 205 and to ground at the right hand armature and front contact of relay 261. Relay 261 is at this time energized over a circuit extending from grounded battery through its winding, the upper left hand contact of sequence switch cam 216, (4 to 10), the outer right hand armature and

front contact of relay 235, the lower right hand contact of sequence switch cam 217 (3 to 10), wiper 262 of the sender finder switch SF, conductor 316, the armature and back contact of advance relay 317 and thence to ground.

Relay 228 upon energizing in the circuit previously traced closes a circuit through its inner right hand armature and front contact for driving sequence switch 200 out of position 9 and into position 10, in which position the fundamental circuit is extended through contacts of sequence switch cams 218 and 219 over brushes 263 and 264 of the district selector switch to the line relay 421 of the incoming selector switch 450. This circuit may be traced from grounded battery through the right hand winding of relay 421, conductor 422, the upper contacts of sequence switch cam 402, conductor 423, resistance element 424, the upper contact of sequence switch cam 403 (1 to 10) trunk conductor 419, bank terminal 260 and brush 263 of the district selector switch 250, the upper right hand and lower left-hand contacts of sequence switch spring 218, conductor 264, conductor 243, the inner right hand armature and front contact of relay 235, wiper 244, conductor 309, the contact of sequence switch cam 308 (6), the windings of overflow relay 318 and sender stepping relay 310, the armature and back contact of counting relay 311, the upper contacts of sequence switch cam 321, conductor 312, wiper 265, conductor 266, the lower left hand and upper right hand contacts of sequence switch cam 219, brush 264 and bank terminal 259 of district selector switch 250, trunk conductor 420, the lower contact of sequence switch cam 404 (1 to 10), resistance element 425, conductor 426, and thence to ground through the lower contact of sequence switch cam 405 (1 to 8). Relay 421 energizes in this circuit and at its outer left hand armature and front contact closes a circuit for driving sequence switch 400 out of its normal position 1 and into position 2, this circuit extending from grounded battery through the winding of the driving magnet of sequence switch 400, the lower right hand contact of sequence switch cam 406 (1), the outer left hand armature and front contact of relay 421, conductor 427 and thence to ground at the lower contact of sequence switch cam 407 (1 to 10). As soon as sequence switch 400 leaves position 1, the initial energizing circuit of relay 421 is opened at the upper left hand contact of sequence switch cam 402, but relay 421 remains energized over the fundamental circuit through a locking branch of the fundamental circuit which may be traced from grounded battery through the right hand winding of relay 421, the right hand contacts of sequence switch cam 402, conductor 428, the right hand armature and front contact of relay 421, conductor 429, the left hand contacts of sequence switch cam 408 (1 to 4) and thence over the fundamental circuit as previously traced.

In position 2 of sequence switch 400, a circuit is closed for the updrive magnet 430 which may be traced from grounded battery through the winding of this magnet, the upper right hand contact of sequence switch cam 409 (2), conductor 431, the outer left hand armature and front contact of relay 421 and thence to ground at the lower contact of sequence switch cam 407. Magnet 430 upon energizing presses the depending portion of the switch shaft 432 against the constantly rotating updrive drum 433 causing thereby the upward movement of the switch shaft. As the shaft of the switch approaches its first brush tripping position, brush 436 engages a metallic portion of the brush selection segment 434 of the commutator 435 and a circuit is closed in shunt of the stepping relay 310 of the office sender, which may be traced from grounded battery through the right hand winding of relay 421, conductor 422, the right hand contacts of sequence switch cam 402, conductor 428, the right hand armature and front contact of relay 421, conductor 429, the upper left hand contact of sequence switch cam 408 (1 to 4), the lower right hand contact of sequence switch cam 408 ($1\frac{3}{4}$ to 2) segment 434, brush 436, conductor 437 and thence to ground at the lower contact of sequence switch cam 410 (7 to 5). Upon the establishment of this shunt, relay 421 is maintained energized over the shunt and stepping relay 310 deenergizes. As the switch shaft 432 continues in its upward movement, the brush 436 engages an insulating portion of the segment 434 and the previously traced shunt is opened, whereupon stepping relay 310 again energizes. In this manner as the switch shaft 432 moves upwardly the stepping relay 310 of the office sender is intermittently energized and deenergized to successively energize and lock up counting relays associated with the sender, all in the well known manner.

It has been assumed that the calling subscriber has dialed No. 8632 and that, therefore the numerical registers of the sender have been set to register this number. The No. 4 counting relay was therefore energized upon the initial energization of stepping relay 310 when the fundamental circuit was first extended through the winding of line relay 421 of the incoming selector switch. Therefore when the switch shaft 432 of the incoming selector switch has moved upwardly to such an extent as to position the fifth set of brushes thereon in such a relation to the tripping spindle 439 as to later cause the tripping of this partic-

ular set of brushes, the counting relays succeeding the No. 4 counting relay will have become energized and locked up and the No. 0′ counting relay 311 will open the fundamental circuit at its left hand armature and back contact. At its right hand armature and front contact, relay 311 establishes the previously traced circuit for driving sequence switch 300 out of position 6 and into position 8. When the sequence switch leaves position 6, the locking circuits of the energized counting relays are opened at sequence switch cam 315 and the counting relays deenergize.

As soon following the opening of the fundamental circuit by the No. 0′ counting relay 311 as the brush 436 engages the next insulating portion of commutator segment 434, line relay 421 becomes deenergized, opening at its outer left hand armature and front contact the circuit of the updrive magnet 430 thereby arresting the upward movement of the switch shaft 432, and at its inner left hand armature and back contact closing a circuit for driving sequence switch 400 out of position 2 and into position 3. This circuit may be traced from grounded battery through the magnet winding of sequence switch 400, the upper left hand contact of sequence switch cam 406 (2) and thence to ground at the inner left hand armature and back contact of relay 421. Upon reaching position 3 sequence switch 400 closes a circuit for the tripping magnet 438 extending from grounded battery through the magnet winding 438 and thence to ground through the right hand contacts of sequence switch cam 405. Magnet 438 upon energizing rotates the tripping spindle 439 into such a position as will trip the selected set of brushes, which in the case assumed is the fifth set of brushes, upon the subsequent upward movement of the switch shaft 432.

Upon reaching position 3 the fundamental circuit extending through the winding of relay 421 and the windings of stepping relay 310 and overflow relay 318 is again established over the circuit previously traced. Relay 421 upon energizing in this circuit again closes the circuit previously traced for driving sequence switch 400 out of position 3 into position 4 and at its right hand armature and front contact closes the locking circuit previously traced for maintaining itself energized over the fundamental circuit after the sequence switch 400 leaves position 3. With sequence switch 400 in position 4 and relay 421 energized, the circuit previously traced through the updrive magnet 430 is again closed and the switch shaft 432 is again driven upwardly. During the initial upward movement of the switch shaft the fifth set of brushes is tripped by the tripping spindle 439 and during the subsequent upward movement of the switch shaft the tripped set of brushes travels in engagement with the terminals of the bank with which they are associated, and as the brush shaft of the selector switch moves the tripped set of brushes into engagement with the lowermost group of terminals in the bank, brush 441 engages the metallic portion of the group selection segment 440 of the commutator 435 and a circuit is closed in shunt of the windings of sender stepping relay 310 which may be traced from grounded battery through the right hand winding of relay 421, conductor 422, the right hand contacts of sequence switch cam 402, conductor 428, the right hand armature and front contact of relay 421, conductor 429, the upper contacts of sequence switch cam 408, commutator segment 440 brush 441, conductor 437 and thence to ground at the lower contact of the sequence switch cam 410 (7 to 5). Relay 421 is maintained energized over this shunt circuit, but stepping relay 310 deenergizes. As the switch shaft 432 continues in its upward movement, the brush 441 engages an insulating portion of segment 440 and the shunt circuit is opened and stepping relay 310 again energizes. In this manner as the switch shaft 432 continues its upward movement, the stepping relay 310 of the sender is intermittently energized and deenergized.

At this time the thousands and hundreds numerical registers of the sender are so set as to provide a circuit for the No. 1 counting relay, which circuit is completed upon the first energization of stepping relay 310 at the time relay 310 energizes in series with relay 421 at the beginning of the group selection movement of the incoming selector switch. Therefore when the switch shaft of the incoming selector switch is moved upwardly to such an extent as to position the tripped set of brushes upon the first contact of the second group of the bank, the No. 0 counting relay 313 will become energized establishing a locking circuit for itself through the winding of No. 0′ relay 311. The No. 0′ relay 311 upon energizing opens the fundamental circuit at its left hand armature and back contact and at its right hand armature and front contact closes the circuit previously traced for driving sequence switch 300 out of position 8 and into position 10. When the sequence switch leaves position 8, the locking circuits of the energized counting relays are opened at the contact of sequence switch cam 315 and these relays deenergize.

As soon following the opening of the fundamental circuit by the No. 0′ counting relay 311 as the brush 441 engages the next insulating portion of the commutator segment 440, relay 421 of the incoming selector switch deenergizes and opens the circuit previously traced through the updrive mag-

net 430 thereby arresting the upward movement of the switch shaft. At its inner left hand armature and back contact relay 421 closes a circuit extending through the winding of the driving magnet of sequence switch 400 and the upper left hand contact of sequence switch cam 406 (4) for driving the sequence switch out of position 4 and into position 5. In position 5 relay 421 is again energized by a circuit extending from grounded battery through its left hand winding and thence to ground through the right hand contacts of sequence switch cam 411. Relay 421 now closes a circuit extending from ground at sequence switch cam 407 and through the outer left hand armature and front contact of relay 421 for driving sequence switch 400 out of position 5 and into position 6. Upon leaving position 5¼ the initial energizing circuit extending through the winding of relay 421 is opened at sequence switch cam 411, but relay 421 remains energized over a locking circuit extending from grounded battery through its right hand winding, the right hand contacts of sequence switch cam 402, conductor 428, the right hand armature and front contact of relay 421, conductor 429, the right hand contacts of sequence switch cam 412 and thence to the test brush 442 and to ground at the test terminal of the first trunk of the group to which the tripped set of brushes has access, if the first trunk of the group is at the time busy.

With sequence switch 400 in position 6 and relay 421 locked up over the circuit traced through the test brush 442, a circuit is closed for the updrive magnet 430 as previously traced for driving the switch shaft upwardly in its trunk hunting movement. This movement will continue so long as the test brush 442 encounters ground potential on the test terminals of the trunks of the group over which this brush moves. When, however, an idle trunk is found which, it will be assumed is the trunk terminating in the bank terminals 447, 449, 451, the locking circuit of relay 421 will be opened and since the initial energizing circuit of relay 421 was opened as soon as the sequence switch moved out of position 5¼, relay 421 will deenergize thereby opening at its inner left hand armature and front contact the circuit of the updrive magnet 430. To insure, however, that the brushes shall be properly centered on the terminals of the selected idle trunk, relay 421 is maintained energized to maintain the circuit of the updrive magnet 430 until the brushes are so centered, by an additional locking circuit extending from grounded battery through the left hand winding of relay 421, the upper right hand and lower left hand contacts of sequence switch cam 411, conductor 443, centering commutator segment 444, brush 445, conductor 437, the upper left hand contact of sequence switch cam 410 (6), conductor 431, the outer left hand armature and front contact of relay 421 and thence to ground through the sequence switch cam 407 (1 to 10).

Upon the deenergization of relay 421 following the centering of the brushes upon the terminals of the selected idle trunk, the circuit previously traced is again closed for driving the sequence switch 400 out of position 6 and into position 7. In position 7 relay 421 again energizes in a circuit extending through its left hand winding and the right hand contacts of sequence switch cam 411 and closes a circuit for driving the sequence switch out of position 7 and into position 8, in which position the tip conductor of the fundamental circuit is extended through the resistance element 424, the upper left hand contact of sequence switch cam 413 (8), brush 446 and bank terminal 447 of the incoming selector switch 450, trunk conductor 517, the lower left hand contact of sequence switch cam 502 (15 to 6), the lower left hand contact of sequence switch cam 503 (1), the right hand winding of relay 518 and thence to grounded battery through the upper left hand contact of sequence switch cam 504 (1 to 10). The ring conductor of the fundamental circuit extends as previously described over conductor 426 to ground at the lower right hand contact of sequence switch cam 405 (1 to 8). Upon the extension of the connection to the final selector switch, relay 421 of the incoming selector switch which was energized in position 7 of sequence switch 400 is maintained energized in position 8 of the sequence switch 400, over a circuit extending from grounded battery through the right hand winding of relay 421, conductor 422, the right hand contacts of sequence switch cam 402, conductor 428, the right hand armature and front contact of relay 421, conductor 429, the lower right hand contact of sequence switch cam 414 (7 to 8), brush 448 and terminal 449 of the incoming selector switch, trunk conductor 519, the upper left hand and lower right hand contacts of sequence switch cam 505, resistance element 520 and thence to ground through the lower left hand contact of sequence switch cam 506 (1 to 8½). Busy ground potential is placed on the multiples of test terminal 451 of the selected trunk over test brush 442 and the lower right hand and upper left hand contacts of sequence switch cam 412.

Upon the extension of the fundamental circuit to the final selector switch 550, with the sender sequence switch 300 in position 10, relay 518 of the final selector and stepping relay 310 of the office sender energize. Relay 518 upon energizing closes a circuit for relay 521 which may be traced from

grounded battery through the left hand winding of this relay, conductor 522, the upper left hand contact of sequence switch cam 507 (1), conductor 523, the left hand armature and front contact of relay 518 and thence to ground through the upper contact of sequence switch cam 508 (1 to 11). Relay 521 energizes in this circuit and at its left hand armature and front contact closes a locking circuit for itself extending from grounded battery through its left hand winding through the armature and back contact of test relay 524, the left hand armature and front contact of relay 521, sleeve conductor 525 of the trunk circuit extending back to the incoming selector switch, bank terminal 451 and brush 442 of the incoming selector switch and thence to ground at sequence switch cam 412. Relay 521 upon energizing also closes a circuit for driving sequence switch 500 out of its normal position 1 into position 2, which circuit may be traced from grounded battery through the winding of the magnet of sequence switch 500, through the lower contacts of sequence switch cam 509 and to ground at the right hand armature and front contact of relay 521. When sequence switch 500 moves out of position 1, the initial energizing circuit of relay 518 is opened at the lower left hand contact of sequence switch cam 503, but relay 518 remains energized over the fundamental circuit by reason of a locking circuit extending from grounded battery through the left hand contact of sequence switch cam 504, the right hand winding of relay 518, the lower right hand contact of sequence switch cam 510 (15 to 10), the right hand armature and front contact of relay 518, the lower right hand contact of sequence switch cam 503 (1 to 6) and over the fundamental circuit as previously traced.

Relay 518 upon energizing, with sequence switch 500 in position 2, closes a circuit for the high speed updrive magnet 526 which may be traced from grounded battery through the upper right hand contact of sequence switch cam 511 (2), conductor 523, the left hand armature and front contact of relay 518 and thence to ground at the upper left hand contact of sequence switch cam 508. Magnet 526 upon energizing presses the depending portion of the switch shaft 527 against the constantly rotating high speed drum 528 thereby causing the switch shaft to be moved upwardly at a high speed in its brush selection movement. As the brush shaft approaches its first brush tripping position, brush 532 engages the metallic portion of the brush selection commutator segment 530 of the commutator 531 and a circuit is closed in shunt of the windings of the sender stepping relay 310, which may be traced from grounded battery through the left hand contact of sequence switch cam 504, the right hand winding of relay 518, the lower right hand contact of sequence switch cam 510 (15 to 10), the right hand armature and front contact of relay 518, the lower right hand contact of sequence switch cam 503 (1 to 6), the upper right hand contact of sequence switch cam 502 (1¾ to 2), conductor 529, commutator segment 530, brush 532, conductor 533 and thence to ground through the upper left hand contact of sequence switch cam 506 (13 to 11). Upon the establishment of this shunt circuit relay 518 at the final selector switch is maintained energized, but stepping relay 310 of the office sender deenergizes.

As the switch shaft 527 continues in its upward movement, the brush 532 advances into engagement with an insulating portion of the commutator segment 530 and the shunt circuit previously traced is opened, whereupon sender stepping relay 310 again energizes. In this manner as the switch shaft 527 continues its upward movement, stepping relay 310 of the office sender is intermittently energized and deenergized.

On the initial closure of the fundamental circuit through the winding of relay 518 and the windings of stepping relay 310, with the sender sequence switch 300 in position 10, and under the assumption that the calling subscriber has set the hundreds register of the sender in position six, a circuit is closed in the well known manner for the No. 1 counting relay. In response to the intermittent energization and deenergization of sender stepping relay 310, the counting relays energize and lock up in succession in the well known manner until the No. 0 counting relay 313 becomes energized, when an energizing circuit for the No. 0′ counting relay 311 is established, extending from grounded battery through the windings of relays 313 and 311, the armature and front contact of relay 313 and thence to ground through the contact of sequence switch cam 315 (10). Counting relay 311 upon energizing closes a circuit at its right hand armature and front contact, extending through the contact of sequence switch cam 314 (10) for driving sequence switch 300 out of position 10 and into position 12. When the sequence switch leaves position 10, the locking circuits of the energized counting relays are opened at sequence switch cam 315 and these relays deenergize. At its left hand armature and back contact relay 311 opens the fundamental circuit previously traced through the windings of stepping relay 310 and relay 518 of the final selector switch.

As soon following the opening of the fundamental circuit as the brush 532 engages the next insulating portion of the commutator segment 530, relay 518 becomes

deenergized and at its left hand armature and front contact opens the energizing circuit of the updrive magnet 526 to arrest the upward movement of the switch shaft. At its left hand armature and back contact relay 518 closes a circuit for driving sequence switch 500 out of position 2 and into position 3, this circuit extending from grounded battery through the winding of the sequence switch magnet 500, the upper right hand contact of sequence switch cam 512 (2), the left hand armature and back contact of relay 518 and thence to ground at the upper contact of sequence switch cam 508. The second set of brushes has now been positioned with relation to the tripping fingers of the tripping spindle 534 so that upon a subsequent upward movement of the switch shaft, this set of brushes will be tripped for engagement with the bank of one hundred terminals with which this brush set is associated. To cause the tripping of this set of brushes the tripping magnet 535 is energized as soon as sequence switch 500 reaches position 3, over a circuit extending from grounded battery through the tripping magnet 535 and thence to ground at the lower right hand contact of sequence switch 506 (3 to 5). When sequence switch 500 reaches position 3, the energizing circuit of relay 518 is again established over the fundamental circuit as previously described and relay 518 and stepping relay 310 of the office sender again energize. Relay 518 upon energizing closes the previously traced circuit for driving sequence switch 500 out of position 3 and into position 4. With sequence switch 500 in position 4, the previously traced circuit for the updrive magnet 526 is again established at the left hand armature and front contact of relay 518. Relay 518 also establishes the previously traced locking circuit for itself extending through its right hand armature and front contact for maintaining itself energized over the fundamental circuit after the sequence switch 500 leaves position 3 and the initial energizing circuit is opened at the lower left hand contact of sequence switch cam 503.

Upon the energization of updrive magnet 526 the switch shaft 527 is driven upwardly in its group selection movement, and during the initial portion of this movement the second set of brushes is tripped by a finger of the tripping spindle 534. During the remainder of the group selection movement, the tripped set of brushes then travels upwardly in contact with the terminals of the bank with which they are associated. As the tripped set of brushes approaches the lowermost set of contacts of the first group in the bank, brush 538 engages a metallic portion of the group selection commutator segment 537 of the commutator 531 and a circuit is closed in shunt of the windings of the sender stepping relay 310, which may be traced from grounded battery through the left hand contact of sequence switch cam 504 (1 to 10), the right hand winding of relay 518, the lower right hand contact of sequence switch cam 510 (15 to 10), the right hand armature and front contact of relay 518, the right hand contacts of sequence switch cam 503, conductor 536, commutator segment 537, brush 538, conductor 533 and thence to ground at the upper left hand contact of sequence switch cam 506 (13 to 11). Relay 518 at the final selector switch is maintained energized over this shunt circuit but the sender stepping relay 310 becomes deenergized so long as the shunt circuit is maintained.

As the switch shaft 527 continues in its upward movement the brush 538 engages an insulating portion of the commutator segment 537 and the previously traced shunt circuit is opened and stepping relay 310 of the sender again energizes. In this manner as the switch shaft continues its upward movement, the sender stepping relay 310 intermittently energizes and deenergizes.

Upon the initial energization of sender stepping relay 310 with the sender sequence switch 300 is position 12, it being assumed that the calling subscriber has set the tens register upon its third position contacts, a circuit was established for the No. 3 counting relay in the well known manner. In response to the intermittent operation of the sender stepping relay 310, the counting relays energize and lock up in succession until the No. 0 counting relay 313 becomes energized, when a locking circuit is established through its winding, the winding of No. 0′ counting relay 311, the armature and front contact of relay 313 and to ground at the contact of the sequence switch cam 315 (12). Relay 311 upon energizing closes a circuit extending through its right hand armature and contact, the contact of sequence switch cam 314 (12), and through the winding of the magnet of sequence switch 300 for driving sequence switch 300 into position 14. At its left hand armature and back contact counting relay 311 opens the fundamental circuit previously traced through the windings of sender stepping relay 310 and the winding of relay 518 at the final selector switch.

As soon following the opening of the fundamental circuit as brush 538 engages the next insulating portion of commutator segment 537, relay 518 becomes deenergized and opens the circuit previously traced through the winding of the updrive magnet 526, and closes the circuit previously traced for driving sequence switch 500 out of position 4 and into position 5. In position 5 the fundamental circuit extending through the wind-

ings of stepping relay 310 and the right hand winding of relay 518 is again established. Relay 518 upon energizing closes the previously traced locking circuit for itself and closes a circuit for driving sequence switch 500 out of position 5 and into position 6. Upon reaching position 6, a circuit is established for low speed updrive magnet 539 which circuit may be traced from grounded battery through the winding of magnet 539, the lower left hand contact of sequence switch cam 507 (6), conductor 523, the left hand armature and front contact of relay 518 and thence to ground at the upper left hand contact of sequence switch cam 508. The low speed updrive magnet 539 upon energizing presses the depending portion of the switch shaft 527 against the constantly rotating low speed drum 540 thereby causing the upward movement of the switch shaft in its units selection movement.

As the tripped set of brushes approaches the first set of terminals in the selected group the brush 532 engages a metallic portion of the units selection portion of commutator segment 530 and a circuit is closed in shunt of the windings of sender stepping relay 310, which may be traced from grounded battery through the left hand contact of sequence switch cam 504 (1 to 10), the right hand winding of relay 518, the lower right hand contact of sequence switch cam 510 (15 to 10), the right hand armature and front contact of relay 518, the lower right hand contact of sequence switch cam 503 (1 to 6), the upper right hand contact of sequence switch cam 502 (5¾ to 6), conductor 529, commutator segment 530, brush 532, conductor 533 and thence to ground at the upper left hand contact of sequence switch cam 506. Relay 518 is maintained energized over this shunt circuit but sender stepping relay 310 deenergizes.

As the switch shaft 527 continues its upward movement, brush 532 comes into engagement with an insulating portion of the commutator segment 530 and the previously traced shunt circuit is opened, whereupon the sender stepping relay 310 again energizes. In this manner during the continued upward movement of the switch shaft the sender stepping relay 310 intermittently energizes and deenergizes.

Upon the initial closure of the fundamental circuit for controlling the units selection movement of the final selector switch with the sender sequence switch 300 in position 14 and, under the assumption that the calling subscriber has set the units register upon its fifth position terminals, a circuit is established in the well known manner for the No. 2 counting relay. In response to the intermittent operation of relay 310, the counting relays energize and lock up in succession until the No. 0 counting relay 313 becomes energized, when a locking circuit is established for this relay as previously traced through the winding of the No. 0′ counting relay 311. Relay 311 upon energizing closes the previously traced circuit extending through the contact of sequence switch cam 314 for driving the sender sequence switch 300 out of position 14 and into position 16. At its left hand armature and back contact relay 311 opens the fundamental circuit previously traced through the windings of sender stepping relay 310 and the right hand winding of relay 518 at the final selector switch.

As soon following the opening of the fundamental circuit as the brush 532 engages the next insulating segment of commutator 530, relay 518 becomes deenergized and thereupon opens the circuit of the updrive magnet 539 to arrest the upward movement of the switch shaft and closes the previously traced circuit for driving sequence switch 500 out of position 6 and into position 9.

The brushes of the final selector switch 550 have now been positioned upon the bank terminals which are numbered 8632. With the sequence switch 500 in position 9, a circuit is now closed for reenergizing relay 518, which may be traced from grounded battery through the left hand contact of sequence switch cam 504 (1 to 10), the right hand winding of relay 518, the lower right hand and upper left hand contacts of sequence switch cam 510 and thence to ground at the right hand armature and front contact of relay 521. Relay 518 upon energizing closes a locking circuit for itself extending from grounded battery through its right hand winding, the lower right hand contact of sequence switch cam 510 (15 to 10), the right hand armature and front contact of relay 518 and thence to ground through the upper contacts of sequence switch cam 513 (9 to 10). This locking circuit will be maintained through position 10 of sequence switch 500. Relay 518 upon energizing also closes a circuit as previously traced for driving sequence switch 500 out of position 9, and the switch will continue to advance under the influence of its master cam 501 through intermediate positions into position 12. Upon reaching position 10 a new holding circuit is established for relay 518 extending from grounded battery through the left hand winding of relay 518, the lower right hand contact of sequence switch cam 515 (10 to 11), the left hand armature and front contact of relay 518 and thence to ground at the upper left hand contact of sequence switch cam 508. Upon reaching position 11 sequence switch 500 establishes a new holding circuit for relay 518 extending from ground through the winding of test relay 524, conductor 541, the upper left hand contact of sequence

switch cam 502 (11 to 13), the lower left hand contact of sequence switch cam 503 (11 to 13), the right hand winding of relay 518, the upper right hand contact of sequence switch cam 510 (11 to 12½), the right hand armature and front contact of relay 518, the right hand contacts of sequence switch cam 513, test brush 542 and thence to grounded battery on the test terminal 560 of the set of terminals upon which the tripped set of brushes of the final selector switch has been set. It is to be noted in this connection that all blank bank terminal sets will be grouped together and, with the exception of the last terminals of the group, which are connected to trunks extending to an intercepting operator's position, all test terminals will be permanently connected to grounded battery over conductor 561 and through resistance elements 600 and 601. The battery potential supplied to these test terminals will be reduced since it is applied through both resistance elements 600 and 601.

The current now flowing over the locking circuit of relay 518 and through the winding of relay 524 is not sufficient to energize relay 524 since this relay is marginally wound, but the current is sufficient to maintain the energization of relay 518. with sequence switch 500 in position 12, test relay 524 deenergized and relay 518 energized, a circuit is now established for the updrive magnet 539 which may be traced from grounded battery through the winding of magnet 539, the lower left hand contact of sequence switch cam 507 (12) conductor 523, the left hand armature and front contact of relay 518, the lower left hand contact of sequence switch cam 508 (12) and thence to ground at the right hand armature and front contact of relay 521. The energization of the updrive magnet 539 causes the switch shaft 527 to be moved upwardly in a hunting movement. When the test brush 542 encounters the next test terminal which test terminal corresponds to a second set of blank terminals and is therefore multipled to the conductor 561, the line relay 518 is maintained energized and sufficient current does not flow to energize relay 524 and therefore the switch shaft continues to move upwardly until the brushes of the switch encounter the set of terminals 562, 563 and 564. This set of terminals is shown connected to the first of a group of trunk lines extending to an intercepting operator's position. It will be assumed that this trunk line is in use on another intercepted call and that therefore busy battery potential is connected to the test terminal 564 of this trunk over a circuit which may be traced from grounded battery through the contacts of sequence switch cams of the other final selector switch which has been set upon multiple terminals of the trunk line, corresponding to cams 504 and 513, the test brush of such other selector and to the multiple of terminal 564. Since however the multiple of terminal 564 is at this time connected over sleeve conductor 604 of the first trunk of the group through the low resistance winding of relay 602 to ground, the greater portion of the current is diverted through the winding of relay 602, and when the test brush 542 engages test terminal 564, the locking circuit previously traced through the winding of relay 518 and the winding of relay 524 is maintained, but the current flowing over this circuit is still insufficient to energize the test relay 524. The switch shaft, therefore, will continue its hunting movement over the terminals of succeeding trunk lines of the group terminating in the intercepting operator's position.

When the test brush 542 encounters test terminal 567 which it will be assumed is the test terminal of the last and idle trunk line extending to the intercepting operator's position, ground potential will be encountered on this test terminal and the circuit previously traced through the winding of relay 518 and the winding of test relay 524 will be opened. Relay 518 will thereupon deenergize opening the circuit of the updrive magnet and closing a circuit for driving sequence switch 500 out of position 12 and into position 13, this circuit extending from grounded battery through the upper right hand contact of sequence switch cam 512 (12), the left hand armature and back contact of relay 518, the lower left hand contact of sequence switch cam 508 (12) and thence to ground at the right hand armature and front contact of relay 521.

To insure that relay 518 will not deenergize upon brush 542 finding the terminal of an idle trunk line to stop the upward movement of the switch shaft, before the brushes have been properly centered on the terminals of the idle trunk line, relay 518 is locked up over a circuit extending from grounded battery through the left hand winding of relay 518, the lower left hand contact of sequence switch cam 515 (12), the right hand winding of relay 521, conductor 554, centering segment 555 of commutator 531, brush 556, conductor 533, the upper right hand contact of sequence switch cam 507 (12), conductor 523, the left hand armature and front contact of relay 518, the lower left hand contact of sequence switch 508 (12) and thence to ground at the right hand armature and front contact of relay 521, this circuit being maintained until brush 556 engages an insulating segment of commutator 531 corresponding with the centered position of the brush set upon the terminals of the selected line.

Upon reaching position 13, a circuit is established over the lower contacts of sequence switch cam 509 and the right hand armature and front contact of relay 521, for driving sequence switch 500 out of position 13 and into position 14, and in position 14 a circuit is established as previously traced through the magnet winding of sequence switch 500, the upper right hand contact of cam 512 the left hand armature and back contact of relay 518 and thence to ground at the upper left hand contact of sequence switch cam 508 for driving the sequence switch into position 15 or the talking position, in which position the trunk conductors 517 and 519 are connected respectively with the brushes 552 and 553 over the lower contacts of sequence switch cam 502 and the upper contacts of sequence switch cam 505.

Upon the deenergization of relay 518, a circuit is established for placing busy battery potential upon the multiples of test terminal 567 and for causing the energization of sleeve relay 605 at the incoming end of the selected trunk line at the intercepting operator's position. This circuit may be traced from grounded battery through the right hand contact of sequence switch cam 504 (11 to 17), the right hand armature and back contact of relay 518, the right hand contacts of sequence switch cam 513, test brush 542, test terminal 567, conductor 606, the normally closed break contacts of the left hand armature of cut-off relay 607 thence to ground through the windings of relay 605. Relay 605 energizes in this circuit and at its right hand armature and front contact establishes a circuit for the trunk lamp 608, which circuit may be traced from grounded battery through the right hand armature and front contact of relay 605, the right hand armature and back contact of relay 607 and thence to ground through the trunk lamp 608. The attraction of the left hand armature 605 is without effect at this time.

If the final selector switch 550 finds all of the trunks leading to the intercepting operator's position busy, the test brush 542 will encounter full battery potential upon the test terminal 567 of the last trunk line of the group since in this case terminal 567 will be connected over sleeve conductor 606 through the high and low resistance windings of relay 605 to ground.

Relay 518 will therefore be maintained energized over the locking circuit previously traced through the test brush 542 and sufficient current will now flow over the circuit to energize test relay 524. When sequence switch 500 reaches position 12, the holding circuit of relay 521 previously traced through the armature and contact of relay 524 will be opened and relay 521 upon deenergizing will close a circuit extending from grounded battery through the magnet winding of sequence switch 500, the lower right hand and upper left hand contacts of sequence switch cam 509 and the right hand armature and back contact of relay 521, for driving sequence switch 500 out of position 12 and into position 13. When sequence switch 500 leaves position 12½, the previously traced holding circuit through windings of relays 524 and 518 is opened, but relay 518 remains locked up over a circuit extending through its left hand winding, the lower right hand contact of cam 515 (10 to 12¾), the left hand armature and front contact of relay 518 and to ground at the upper contact of cam 508 (12¾ to 16). This is possible, due to the method of cutting cams, for example, the upper right contact of cam 510 remains closed through position 12½+5° or actually through position 12¾ and the lower right contact of cam 515 closes 5° before position 12¾ or at position 12½ so that there is actually an overlap of ¼ of a position between the closing of cam 515 and the opening of cam 510 and relay 518 is, therefore, maintained energized. When sequence switch 500 reaches position 13, relay 521 is again energized over a circuit extending from grounded battery through its left hand winding, conductor 522 and thence to ground through the upper right hand contact of sequence switch cam 506 (13), and upon energizing locks itself to trunk conductor 525 through the back contact and armature of test relay 524, which deenergizes when sequence switch 500 leaves position 12½. Relay 521 also closes a circuit for driving sequence switch 500 out of position 13 and into position 14, this circuit extending from grounded battery through the magnet winding of sequence switch 500, the lower contacts of sequence switch cam 509 and thence to ground at the right hand armature and front contact of relay 521. When sequence switch 500 reaches position 14, a circuit is established for the down drive magnet 544 which may be traced from grounded battery through the winding of magnet 544, the lower right hand contact of sequence switch cam 511 (14), conductor 523, the left hand armature and front contact of relay 518 and thence to ground through the upper contact of sequence switch cam 508.

Upon the energization of the down drive magnet 544, the depending portion of switch shaft 527 is pressed against the constantly rotating down drive drum 545 thereby causing the downward movement of switch shaft 527 into normal position. When the switch shaft reaches normal position a circuit is established for driving sequence switch 500 out of position 14 and into position 17. This circuit may be traced from grounded battery through the winding of the magnet of sequence switch 500, the upper left hand

contact of sequence switch cam 512 (3 to 16), conductor 546, normal segment 547 of commutator 531, brush 538 and thence to ground through the upper left hand contact of sequence switch cam 506. Upon leaving position 14, the locking circuit of relay 518 is opened, but in position 17 a circuit is closed extending from grounded battery through the left hand winding of relay 518 and thence to ground through the upper left hand contact of sequence switch 515 (17) and through the interrupter 548. Relay 518 is intermittently energized in this circuit and at its left hand armature and front contact intermittently connects a source of busy tone currents 549 to the ring conductor 519 of the trunk circuit from ground through the secondary winding of tone coil 549, the lower right hand contact of sequence switch cam 508 (17), the left hand armature and front contact of relay 518, conductor 523, the upper left hand contact of sequence switch cam 511 (17), resistance 520 and the lower right hand and upper left hand contacts of sequence switch cam 505. The tone current is conducted over the trunk circuit extending through the calling subscriber's line since at this time the subscriber's line has become disconnected from the office sender at cams 212 and 213 of the district selector switch in the manner described hereinafter. The circuit of the final selector switch is maintained in this condition until the calling subscriber releases the connection in response to the busy signal in a manner to be described hereinafter.

Following the test for an idle intercepting trunk line, assuming that the final selector switch has made connection with the last intercepting trunk 610, 611 of the group extending to the intercepting operator's position, the sequence switch 500 of the final selector switch moves into the talking position 15 and upon leaving position 8½ opens the circuit previously traced extending over the ring conductor 519 and through the winding of relay 421 of the incoming selector switch, thereby causing the deenergization of this relay. Relay 421 upon deenergizing closes a circuit for driving sequence switch 400 out of position 8 and into position 9. This circuit may be traced from grounded battery through the winding of the magnet of sequence switch 400, the upper left hand contact of sequence switch cam 406 (8) and thence to ground at the inner left hand armature and back contact of relay 421. With sequence switch 400 in position 9, relay 421 is again connected to the fundamental circuit extending from the windings of sender stepping relay 310 and the windings of overflow relay 318 at the office sender, but at this time the winding of relay 421 is connected to the ring conductor of the fundamental circuit rather than to the tip conductor as heretofore described, so that current flowing in the fundamental circuit now flows in a direction reverse to that in which it originally flowed. The connection of relay 421 to the ring conductor 420 of the fundamental circuit at the incoming selector switch may be traced from grounded battery through the right hand winding of relay 421, the lower contacts of sequence switch cam 415 (9), resistance element 425 and the lower contact of sequence switch cam 404 (1 to 10). The tip conductor 419 of the fundamental circuit is connected to ground at the incoming selector switch over a circuit which may be traced from conductor 419, through the upper contact of sequence switch cam 405 (1 to 10) resistance element 424, the left hand contacts of sequence switch cam 408 (9) and thence to ground through the upper contacts of sequence switch 412.

The current now flowing in the fundamental circuit is in such a direction as to cause the energization of overflow relay 318 which at its armature and contact closes a circuit for the advance relay 317. The energization of advance relay 317 attracts its armature and opens the circuit extending over the conductor 316, wiper 262, the lower contact of sequence switch cam 217, the outer right hand armature and front contact of relay 235, the upper contact of sequence switch cam 216 and to grounded battery through the winding of relay 261. Relay 261 upon deenergizing opens the circuit of relay 228 which thereupon establishes a circuit for driving sequence switch 300 out of position 10 and into position 11, which may be traced from battery through the magnet winding of sequence switch 200, the right hand contact of cam 206 (10), the inner right hand armature and back contact of relay 228 to ground at the right hand contact of cam 207.

The energization of advance relay 317 also closes a circuit extending through the armature and front contact of relay 317 and the contact of cam 319 (16) for driving the sender sequence switch 300 into position 18, in which position a fundamental circuit extending through the windings of sender stepping relay 310 and the winding of line relay 228 of the district selector switch is closed. This circuit may be traced from battery through the left hand winding of relay 228, the upper right hand and lower left hand contacts of sequence switch cam 210, conductor 243, the inner right hand armature and front contact of relay 235, wiper 244, conductor 309, the contact of sequence switch cam 308 (18), the windings of overflow relay 318, the windings of stepping relay 310, the left hand armature and back contact of the No. 0′ counting

relay 311, and thence to ground at the right hand contacts of sequence switch cam 321 (18). Relays 228 and 310 energize in this circuit and relay 228 closes a circuit for driving sequence switch 200 out of position 11 and into position 15 unless the circuit is interrupted at the armature contacts of relay 228 prior to the sequence switch reaching position 15. This circuit may be traced from battery through the magnet winding of sequence switch 200, the upper left hand contact of cam 206 (11 to 14), the inner right hand armature and front contact of relay 228 to ground at the right hand contact of cam 207. After sequence switch 200 leaves position 11, relay 235 is maintained energized to hold the circuit of relay 228 closed, over a circuit which may be traced from grounded battery through the winding of magnet 233, the winding of relay 235, the lower contact of sequence switch cam 216 (11 to 14), the outer right hand armature and front contact of relay 235, the upper contact of sequence switch cam 217 (11 to 16), the outer right hand armature and front contact of relay 228 and thence to ground through the lower contacts of sequence switch cam 215.

During the rotation of sequence switch 200 from position 11 into position 15 an intermittent ground is connected to the fundamental circuit between the windings of relays 228 and 310 in such a manner as to hold the relay 228 energized and to intermittently shunt down relay 310. This intermittent ground connection extends from grounded battery through the left hand winding of relay 228, the left hand armature and front contact of this relay and thence to ground through the upper left hand and lower right hand contacts of sequence switch cam 215 and is closed in positions 11⅝, 12⅝ and 13⅝.

In the manner fully set forth in the patent to F. A. Stearn and F. J. Scudder hereinbefore mentioned the circuits of the office sender are so adjusted that upon intermittent energizations and deenergizations of relay 310, counting relays are energized and locked up in succession until the setting of the sender with respect to its talking selection condition is satisfied. It will be assumed that only a single energization and deenergization of relay 310 is necessary to satisfy the sender and that following the first deenergization of relay 310, the counting relay 311 becomes energized in series with counting relay 313 to open the fundamental circuit. When the fundamental circuit is opened at this time, relay 228 deenergizes opening the driving circuit of sequence switch 200 to arrest the sequence switch in position 12 in which position, the polarized charging relay 268 is connected over the contacts of cams 220 and 221 through windings of the repeating coil 267, contacts of cams 218 and 219, to the brushes 263 and 264 of the district selector switch.

As soon as sequence switch 200 leaves position 10½ in response to the energization of advance relay 317, the impulse leads 240 and 241, which up to this time connect the substation of the calling subscriber with the stepping relay 305 of the office sender are disconnected from the district selector trunk conductors 116 and 117 at the contacts of sequence switch cams 212 and 213, and the conductors 116 and 117 are connected through the right hand contacts of these cams to the left hand windings of repeating coil 267. Upon the deenergization of relay 228 following the completion of the talking selection movement of the sequence switch 200, the circuit of relay 235 is opened and this relay at its inner left hand armature and front contact opens the circuit of the relay 303. At its right hand armatures and front contacts relay 235 opens the fundamental circuit previously traced extending to the office sender. With relays 303 and 305 deenergized and the fundamental circuit opened, the office sender and all of its associated apparatus restores in the manner fully set forth in the aforesaid patent.

During the setting of the sequence switch 200 of the district selector switch 250 into its talking position, sequence switch 400 of the incoming selector switch 450 has been standing in position 9. In position 9 with relay 421 energized over the circuit previously traced through relays 310 and 318, a circuit for energizing relay 471 is established from grounded battery through the winding of relay 471 the right hand contact of sequence switch cam 416 (9 to 10), the right hand armature and front contact of relay 421, conductor 429 and thence to ground through the upper contacts of sequence switch cam 412. Relay 471 upon energizing closes a circuit for driving sequence switch 400 out of position 9. This circuit extends from grounded battery through the winding of sequence switch magnet 400, the armature and front contact of relay 471 and thence to ground through the left hand contacts of sequence switch cam 412. Upon leaving position 9, the fundamental circuit previously traced through the winding of relay 421 is opened and relay 421 deenergizes opening the circuit of relay 471 to arrest sequence switch 400 in position 10.

As soon as sequence switch 400 moves into position 10, if at this time sequence switch 200 of the district selector is advanced to the selected talking position, a circuit is established for relay 421 extending through the right hand winding of this relay, through the upper contacts of sequence switch cam 402, conductor 423 resistance

element 424, the upper contact of sequence switch cam 403 (1 to 10) trunk conductor 419, bank terminal 260 and brush 263 of the district selector switch, the upper contacts of sequence switch cam 218, the uppermost right hand winding of repeating coil 267, the upper contacts of sequence switch cam 220, the winding of polarized charging relay 268, the lower contact of sequence switch cam 221, the lowermost right hand winding of repeating coil 267, the upper contacts of sequence switch cam 219, brush 264 and terminal 259 of the district selector switch, trunk conductor 420, the lower contact of sequence switch cam 404 (1 to 10), resistance element 425, conductor 426 and thence through the lower contact of sequence switch spring 405 (10) to ground. Relay 421 upon energizing locks up to ground at the lower contact of cam 407 over a circuit extending from grounded battery through its left hand winding, the armature and back contact of relay 455, the upper left hand contact of sequence switch cam 409 (10 to 18), the outer left hand armature and front contact of relay 421, conductor 427, thence to ground at cam 407. When sequence switch 400 leaves position 10 locking ground is supplied over conductor 464 and the upper contact of cam 407 as previously traced to the contact of sequence switch cam 215. When relay 421 reenergizes the circuit of relay 471 is again established and the sequence switch is driven out of position 10 into position 11.

With the sequence switch 400 in position 11, the circuit of relay 471 is again established over the upper contact of cam spring 452 of the interrupter cam 453 and the upper left hand contact of sequence switch 416 (11). A circuit is also established in position 11 for applying a steady flow of ringing current to the trunk terminals which have been seized by the final selector switch. The circuit over which ringing current is transmitted may be traced from the source of ringing current 454 through the lower left hand and upper right hand contacts of sequence switch cam 417, through the winding of ringing trip relay 455, the lower contacts of sequence switch cam 402 (11 to 13), conductor 428, the right hand armature and front contact of relay 421, conductor 429, the lower right hand contact of sequence switch cam 414 (11 to 14), brush 448 and terminal 449 of the incoming selector switch, trunk conductor 519, the upper contacts of sequence switch cam 505, brush 553 and the terminal 566 of the final selector switch, and a return path to ground may be traced to bank terminal 565 through brush 552 of the final selector switch, the lower contacts of the sequence switch cam 502, trunk conductor 517, bank terminal 447 and brush 446 of the incoming selector switch and thence to ground at the upper left hand contact of sequence switch cam 413 (11 to 13½). This circuit, however, is not fully established unless the intercepting operator has at this time answered the call incoming upon trunk 610, 611. As soon as relay 471 energizes in position 11 of sequence switch 400, the circuit previously traced through the armature and front contact of relay 471 is again established for driving sequence switch 400 out of position 11. Upon leaving position 11 the circuit of relay 471 is opened and the sequence switch is arrested in position 12. In position 12 relay 471 is again energized as soon as a circuit therefor is established over the lower left hand contact of sequence switch cam 416 (12) and the lower contact of cam spring 452 of the interrupter cam 453, and upon its energization drives sequence switch 400 out of position 12 and into position 13. In position 13 the source of ringing current 454 is connected over the circuit previously traced through the interrupter 456 and the right hand contacts of sequence switch cam 417, and this circuit is maintained until the ringing current is tripped by the response of the intercepting operator.

The intercepting operator at position O upon noting the illumination of trunk lamp 608 inserts the answering plug P of an idle cord circuit at her position, into the jack of the trunk circuit 610 and 611 corresponding to the illuminated trunk lamp 608, whereupon a circuit is established from grounded battery through the winding of sleeve relay 612, the winding of marginal sleeve relay 613, conductor 614, the sleeve contacts of plug P and jack J and thence to ground through the left hand winding of relay 607. Since the winding of relay 607 is of low resistance, both relays 612 and 613 of the cord circuit energize and relay 607 in the sleeve strand of the trunk circuit also energizes. Relay 607 upon energizing opens the circuit previously traced through the trunk lamp 608 and at its right hand armature and front contact establishes a locking circuit for itself extending from grounded battery through the right hand armature and front contact of relay 605, the right hand armature and front contact of relay 607, the right hand winding of relay 607 and thence to ground. At the break contacts associated with the left hand armature of relay 607, the initial energizing circuit of relay 605 is opened and at the make contacts of this armature a new holding circuit for relay 605 is established which extends from the trunk conductor 606 through the make contacts of the left hand armature of relay 607, the left hand armature and front contact of relay 605 and thence to ground through the windings of relay 605. Relay 607 is thereby held energized after the intercepting opera-

tor pulls down the plug P from the jack J until after the calling subscriber has released the connection and the brushes of the final selector switch have been moved from the terminals of the trunk 610 and 611. Therefore the trunk lamp 608 cannot be relighted until a new connection is established with the trunk.

Relay 613 upon energizing closes a circuit for relay 614 which may be traced from grounded battery through the winding of relay 614, conductor 615 and thence to ground at the armature and contact of relay 613. Relay 614 upon energizing connects the right hand winding of relay 616 to the tip strand of the cord circuit over a circuit which may be traced from grounded battery through the right hand winding of relay 616, the inner right hand armature and front contact of relay 614, the upper left hand winding of repeating coil 617, tip strand 618 of the cord circuit, the upper normally closed contacts of flashing key 619, the tip contacts of plug P and jack J, trunk conductor 610, bank terminal 565 and brush 552 of the final selector switch, the lower contacts of sequence switch cam 502, trunk conductor 517, bank terminal 447 and brush 446 of the incoming selector, and thence to ground at the upper right hand contact of sequence switch cam 413 (11 to 13½). At its outer left hand armature relay 614 disconnects battery from the ring strand 620 of the cord circuit.

If the talking key 621 of the cord circuit has not been thrown into the talking position at this time, relay 616 upon energizing will establish a circuit for flashing lamp 622, which circuit may be traced from grounded battery through the lamp 622, the armature and front contact of relay 616, the right hand armature and back contact of relay 623, the outer left hand armature and back contact of relay 624, conductor 625 thence through the winding of relay 626 and interrupter 627 to ground. Relay 626 operates in this circuit and at its armature contacts closes a circuit for the buzzer 629. The operator noting the flashing of the lamp or hearing buzzer 629 will immediately throw the talking key 621 to the talking position, whereupon a circuit is established for relay 624 which may be traced from grounded battery through the winding of relay 624, conductor 651 and thence to ground at the lowermost contact 626 of key 621.

Relay 624 upon energizing in this circuit opens at its outer left hand armature and front contact the circuit previously traced through lamp 622 and through interrupter 627 and establishes a new circuit for lamp 622 extending from grounded battery through lamp 622, the armature and front contact of relay 616, the right hand armature and back contact of relay 623, the outer left hand armature and front contact of relay 624 and thence to ground through the winding of relay 628, and at its inner left hand armature and front contact relay 624 establishes a circuit for the counting relay 630 which is effective as soon as the interrupter 631 is in such a position that the brushes of the interrupter are in engagement with conducting portions of the interrupter. This circuit may be traced from grounded battery through the winding of relay 630, the left hand armature and back contact of relay 632, interrupter 631, the armature and front contact of relay 628, the normally closed contacts of the left hand armature of cutoff relay 633, the inner left hand armature and front contact of relay 624, conductor 634 and thence to ground at the outer right hand armature and front contact of relay 612, which relay it will be recalled was energized over the sleeve conductor 614 when the operator answered the call by inserting the plug P in the jack J. Relay 630 upon its energization establishes a locking circuit for itself extending from grounded battery through its winding, the winding of relay 632, the right hand armature and front contact of relay 630 and thence to ground at the contact of relay 612 over the circuit previously traced. Relay 632, however, does not energize in this locking circuit until the interrupter 631 has rotated sufficiently to position its insulating segments in contact with its brushes since the winding of relay 632 is shunted through its left hand armature and back contact and the interrupter 631. When this shunt is removed, relay 632 energizes opening at its left hand armature and back contact the initial energizing circuit previously traced through the winding of relay 630, and at its right hand armature and front contact closes a circuit for relay 635.

The circuit of relay 635 may be traced from grounded battery through the winding of relay 635, the inner left hand armature and front contact of relay 614, conductor 636, the inner right hand armature and front contact of relay 624 conductor 637, the right hand armature and front contact of relay 632 and thence to ground at the right hand armature and back contact of relay 633. Relay 635 energizes in this circuit and at its armature and front contact connects ground through resistance element 638 to the ring strand 620 of the cord circuit. A circuit is now effective for operating the ringing trip relay 455 at the incoming selector switch which may be traced from the source of current 454 through the interrupter 456, the right hand contacts of sequence switch cam 417, the winding of tripping relay 455, the lower contacts of sequence switch cam 402, conductor 428, the right hand armature and front contact of relay 421, the lower right

hand contact of sequence switch cam 414, brush 448 and terminal 449 of the incoming selector switch, trunk conductor 519, the upper contacts of sequence switch cam 505, brush 553 and terminal 566 of the final selector switch, trunk conductor 611, the ring contacts of jack J and plug P, the normally closed ring contacts of flashing key 619, ring strand 620 of the cord circuit and thence to ground through the armature and front contact of relay 635 and resistance element 638. Relay 455 energizes in this circuit and opens at its armature and back contact the locking circuit extending through the left hand winding of relay 421. Relay 421 thereupon deenergizes and at its right hand armature and front contact opens the ringing circuit previously traced and at its inner left hand armature and back contact closes a circuit extending through the upper left hand contact of sequence switch cam 406 (11 to 17) for driving sequence switch 400 out of position 13 and into position 16. When sequence switch 400 passes through position 14, relay 421 again energizes over a circuit extending from grounded battery through its left hand winding and the right hand contacts of sequence switch cam 411 and closes a locking circuit for itself extending through its left hand winding, the armature and back contact of ringing trip relay 455, relay 455 having deenergized when sequence switch 400 left position 13, the upper left hand contact of sequence switch cam 409, conductor 431, the outer left hand armature and front contact of relay 421, conductor 427, the upper contact of sequence switch cam 407 (2 to 18) and thence over the sleeve conductor 464 to ground through the contact of sequence switch cam 215 at the district selector switch.

As soon as sequence switch 400 reaches position 14 a direct current path is established through the lower right hand winding of repeating coil 458 and thence to ground on the sleeve strand of the intercepting operator's cord circuit which may be traced from the non-grounded pole of battery through the lower right hand winding of repeating coil 458, winding of supervisory relay 459, the upper right hand contact of sequence switch cam 414 (14 to 16), brush 448 and terminal 449 of the incoming selector switch, trunk conductor 519, the upper contacts of sequence switch cam 505, brush 553 and terminal 566 of the final selector switch, trunk conductor 611, the ring contacts of jack J and plug P ring contact of key 619, ring strand 620 and thence to ground through the armature and front contact of relay 635. The supervisory relay 459 energizes in this circuit and connects the terminals of the central station battery between the left hand windings of the repeating coil 458 in such a manner as to cause current to flow over the trunk line extending between the incoming selector switch and the district selector switch in such a direction as to energize the polarized charging relay 268 at the district selector switch, which closes its alternate contact. This circuit may be traced from the non-grounded pole of battery over conductor 460, the upper left hand contact of sequence switch cam 405 (11 to 16), conductor 426, resistance element 425, the upper contacts of sequence switch cam 415 (11 to 16), the lower left hand winding of repeating coil 458, the upper contact of sequence switch cam 404 (11 to 16), trunk conductor 420, bank terminal 259 and brush 264 of the district selector switch, the upper contacts of sequence switch cam 219, the lowermost right hand winding of repeating coil 267, the lower contact of sequence switch cam 221, the windings of relay 268, the upper contacts of sequence switch cam 220, the uppermost right hand winding of repeating coil 267, the upper contacts of sequence switch cam 218, brush 263 and terminal 260 of the district selector switch, conductor 419, the lower contact of sequence switch cam 403 (11 to 16), the upper left hand winding of repeating coil 458, resistance element 424 and thence to ground through the armature and contact of relay 459.

In the ordinary establishment of a successful connection the energization of charging relay 268 closes a circuit for relay 276 which may be traced from grounded battery through contact 298, operated by cam 278, the winding of relay 276, the lower contacts of sequence switch cam 224, conductor 229, the armature and contact of relay 268 and thence to ground at the upper left hand contact of sequence switch cam 214 (12 to 14½). Relay 267 energizing in this circuit locks up to the circuit independently of contact 298 and at its right hand armature and front contact establishes a circuit for charging relay 261 as soon as cam 278 has opened contact 298 and closed contact 279, this circuit extending from grounded battery through the winding of charging relay 261, the right hand armature and front contact of relay 276 and to ground at contact 279. Relay 261 upon energizing locks up independently of cam contact 279 over a circuit extending through its winding, the upper contacts of sequence switch cam 205 and thence to ground through its right hand armature and front contact. At its left hand armature and front contact relay 261 prepares a circuit for connecting booster battery current from the source 280 to the conductor 118 for operating the calling subscriber's message register 119 following the release of the connection by the calling subscriber.

When, however, the established connection has been routed as previously described to

an intercepting operator's position, it is not desirable to charge the call against the calling subscriber by the operation of his message register 119, and therefore it is essential that ground be connected to ring strand 620 of the intercepting cord circuit for only a sufficient period of time to trip the machine ringing but of insufficient duration to permit the energization of charging relay 268 at the district selector for a sufficient period to enable the charging relay 261 to be energized and locked up. Therefore the period during which relay 635 at the operator's cord circuit is energized is made less than the effective operating time of the charging relays at the district selector.

In order therefore that the circuit of relay 635 shall be established for only a specific period, a circuit is established upon the energization of counting relay 632 extending through the right hand winding of relay 633, the left hand armature and front contact of relay 632, interrupter 631, the armature and front contact of relay 628, the normal break contacts of the left hand armature of relay 633, the inner left hand armature and front contact of relay 624, and thence to ground at the outer armature and front contact of relay 612, this circuit being effective upon the first closure of the contacts of the interrupter following the energization of relay 632. Relay 633 upon energizing in this circuit locks up through its left hand winding its left hand armature and make contact and thence over the circuit previously traced to ground at the contact of relay 612. At its right hand armature and back contact relay 633 opens the circuit previously traced through the winding of relay 635 whereupon the ground connection is disconnected from the ring strand of the cord circuit.

The energization of relay 633 opens at the contacts of its left hand armature the locking circuit previously traced through the windings of relays 630 and 632 and these relays become deenergized. At its right hand armature and front contact relay 633 closes a circuit for relay 623 which may be traced from grounded battery through the left hand winding of relay 623, conductor 639, contacts 640 of talking key 621, conductor 641 and thence to ground at the right hand armature and front contact of relay 633. Relay 623 energizes in this circuit and at its right hand armature and back contact opens the circuit previously traced through the winding of relay 628 and through the lamp 622 and establishes a new circuit for the lamp 622 extending from grounded battery through the lamp, the armature and front contact of relay 623 and thence to ground through the right hand holding winding of relay 623. At its left hand armature and front contact relay 623 establishes a circuit for the operator's set connecting relay 642 which may be traced from grounded battery through the winding of relay 642, the intermediate right hand armature and front contact of relay 624, the left hand armature and front contact of relay 623 and to ground at the outer armature and contact of relay 612. Upon the energization of relay 642 the operator's set, represented at O. T. is connected through contacts of the talking key 621 to the strands of the cord circuit.

The operator may now converse with the calling subscriber and inform him that he has dialed a number inaccurately and may either request the calling subscriber to restore the connection and redial the number or may, if the subscriber so desires, secure the proper connection for the calling subscriber. If the subscriber has dialed the number of a line from which service has been discontinued and therefore the brushes of the final selector switch have been positioned upon the terminals of such a line which now are blank, the intercepting operator will inform the calling subscriber of the fact that the desired subscriber's service has been discontinued or that a new number has been assigned. If the called subscriber has been assigned a new directory number, the operator will give the calling subscriber such information.

Should the calling subscriber desire the operator to extend the connection to the desired line the operator may do so by inserting the calling plug P′ of her cord circuit in jack J′ of a trunk circuit extending into an intercepted cordless operator's position and will advise the cordless operator as to the number of the line desired. The cordless operator will then extend the connection through an incoming selector and a final selector switch to the terminals of the desired subscriber's line. The manner in which the cordless operator extends such a connection is substantially the same as shown and described in my co-pending application Serial No. 417,422 filed October 16, 1920. When the intercepting operator restores her talking key 621 to its normal position the circuit of relay 624 is opened and relays 633 and 642 thereupon become deenergized. Relay 623 will remain locked up through the supervisory lamp 622 under the control of relay 616. In case the operator desires to supervise on the established connection she will then operate the talking key 621 which will reestablish the circuit of relay 624 and since at this time relay 623 is energized the circuit previously traced for relay 642 will be immediately reestablished.

The calling subscriber upon being advised by the operator that he has dialed inaccurately, will restore his receiver to its switch hook thereby initiating the release of the

established connection. The restoration of the receiver to its switch hook now opens the circuit of supervisory relay 269, which becomes energized following the movement of the sequence switch 200 of the district selector into position 10¾, and at its armature and front contact has been maintaining a locking circuit for relay 227, over its armature and front contact and to ground at the armature and front contact of relay 227. Relay 269 now deenergizes and opens the locking circuit of relay 227 which in turn deenergizes closing a circuit for driving sequence switch 200 out of position 12 and into position 17, this circuit extending from grounded battery through the winding of the magnet of sequence switch 200, the left hand contacts of sequence switch cam 223 and thence to ground at the back contact of the right hand armature of relay 227. Upon leaving position 16, the holding circuit extending over the sleeve conductor 118 through the right hand winding of sleeve relay 226 is opened at sequence switch cam 203 (1¾ to 16), and this relay 102 at the subscriber's individual line switch become deenergized.

Relay 102 upon deenergizing closes a circuit for the stepping magnet 105 of the switch 100 which circuit may be traced from grounded battery through the winding, armature and back contact of stepping magnet 105, conductor 106, the lowermost armature and back contact of relay 102, the right hand armature and back contact of relay 101, conductor 125, wiper 112 and thence to ground over segment 124. Magnet 105 functions in this circuit to step the wipers of the switch on around to normal position when its circuit is opened at segment 124. Upon the deenergization of relay 226 with sequence switch 200 in position 17 a circuit is closed for advancing sequence switch 200 into position 18, this circuit extending from grounded battery through the winding of the magnet of sequence switch 200, the upper left hand and lower right hand contacts of sequence switch cam 223, and thence to ground at the right hand armature and back contact of relay 226. When sequence switch 200 reaches position 18 since at this time relay 227 is deenergized, a circuit is established for the down drive magnet of the district selector which may be traced from grounded battery through the winding of down drive magnet 283, the upper right hand and lower left hand contacts of sequence switch cam 223, conductor 275 and thence to ground at the back contact and right hand armature of relay 227. Down drive magnet 283 upon energizing presses the depending operation of the switch shaft 246 against the constantly rotating down drive drum 248 thereby causing the movement of the switch shaft downwardly into normal position. As soon as the switch shaft reaches its normal position, a circuit is closed for driving sequence switch 200 out of position 18 and into position 1, this circuit extending from grounded battery through the winding of the magnet of sequence switch 200, the lower left hand contact of sequence switch cam 206, the normal segment 285 of the commutator 251, brush 256 and thence to ground at the lower left hand contact of sequence switch cam 214.

As soon as sequence switch 200 of the district selector leaves position 14½ the circuit previously traced through the test brush 257, bank terminal 258, sleeve conductor 464, the upper contact of sequence switch cam 407, conductor 427, the outer left hand armature and front contact of relay 421, conductor 431, the upper left hand contact of sequence switch cam 409, the armature and back contact of relay 455 and thence to grounded battery through the left hand winding of relay 421 is opened at the contacts of sequence switch cam 215 and relay 421 thereupon deenergizes.

Upon the deenergization of relay 421 busy ground potential is connected to the sleeve conductor 464 over the upper contact of sequence switch cam 407 (2 to 18), the outer armature and back contact of relay 421 and the upper left hand and lower right hand contacts of sequence switch cam 411 for preventing the seizure of the trunk until after the incoming selector switch has been completely restored to normal. At its inner left hand armature and back contact, relay 421 closes a circuit extending through the upper left hand contact of sequence switch cam 406 for driving sequence switch 400 out of position 16 and into position 18. As soon as sequence switch 400 reaches position 18, a circuit is closed through the winding of the down drive magnet 461, extending from grounded battery through the winding of magnet 461 and thence to ground through the right hand contacts of sequence switch cam 410. Magnet 461 upon energizing presses the depending portion of the switch shaft 432 against the constantly rotating down drive drum 462 thereby restoring the switch shaft to normal position. As soon as the switch shaft reaches its normal position, a circuit is closed for driving sequence switch 400 out of position 18 and into normal position. This circuit may be traced from grounded battery through the winding of the magnet of sequence switch 400, the upper right hand contact of sequence switch cam 406, normal segment 463 of the commutator 435, brush 441, conductor 437 and thence to ground through the lower contact of sequence switch cam 410. As soon as sequence switch 400 leaves position 18, the cir-

cuit of the down drive magnet 461 is opened to arrest the downward movement of the switch shaft and the busy ground potential is removed from the sleeve conductor of the trunk 419, 420.

When sequence switch 400 of the incoming selector leaves position 16¼, the circuit previously traced through the contacts of sequence switch cam 412, over brush 442 and terminal 451 of the incoming selector, sleeve conductor 525, the left hand armature and front contact of relay 521, the armature and back contact of relay 524 and through the left hand winding of relay 521, over which circuit relay 521 has been held energized, is opened and relay 521 deenergizes closing a circuit for energizing relay 518. This latter circuit may be traced from grounded battery through the left hand winding of relay 518, the upper contacts of sequence switch cam 509 and thence to ground at the armature and back contact of relay 521. Relay 518 upon energizing closes a circuit for driving sequence switch 500 out of position 15 and into position 16. This circuit may be traced from grounded battery through the winding of the magnet of switch 500, the lower right hand contact of sequence switch cam 512 (15), the left hand armature and front contact of relay 518 and thence to ground at the upper right hand contact of sequence switch cam 508.

When sequence switch 500 leaves position 15, the energizing circuit of relay 518 is opened and since the final selector switch has made connection with a trunk line extending to an intercepting operator's position, the holding circuit for relay 518 which is ordinarily closed when connection is made with a subscriber's line until after the called subscriber has restored his receiver to its switch-hook, does not exist at this time. This locking circuit may be traced in part from grounded battery through the left hand contact of sequence switch cam 504, the right hand winding of relay 518, the lower contact of sequence switch cam 510, the right hand armature and front contact of relay 518, the lower left hand and upper right hand contacts of sequence switch cam 505, brush 553, bank terminal 566, trunk conductor 611, the ring contacts of the plug P and the jack J, ring strand 620 of the intercepting operator's cord circuit, the lower left hand winding of repeating coil 617 and thence to the outer left hand armature of relay 614. This circuit is open at this point since relay 614 is at the time energized. The locking circuit for relay 518 is held open when the final selector switch makes connection with an intercepting operator's position in order that the final selector may be released by the calling subscriber without waiting for the intercepting operator to take down the connection at her position.

Upon the deenergization of relay 518 a circuit is closed through its left hand armature and back contact for driving sequence switch 500 out of position 16 and into position 17. This circuit may be traced from grounded battery through the winding of the magnet of switch 500, the upper right hand contact of sequence switch cam 512 (16), the left hand armature and back contact of relay 518 and thence to ground at the upper right hand contact of sequence switch cam 508. Upon reaching position 17 sequence switch 500 is driven into position 18 over a circuit extending through its magnet winding, the lower right hand and upper left hand contacts of sequence switch cam 509, and to ground at the right hand armature and back contact of relay 521. When sequence switch 500 reaches poistion 18, a circuit is closed for down-drive magnet 544 extending from grounded battery through the winding of magnet 544, the lower right hand contact of sequence switch cam 511 (18), the upper right hand contact of sequence switch cam 507 (18) and thence to ground through the upper left hand contact of sequence switch cam 506. As soon as switch shaft 527 reaches normal position a circuit is closed for driving sequence switch 500 out of position 18 and into normal position 1, this circuit extending from grounded battery through the magnet winding of switch 500, the upper left hand contact of sequence switch cam 512 (18), conductor 546, normal commutator segment 547, brush 538, conductor 533 and thence to ground at the upper contact of sequence switch cam 506. The final selector switch and its associated circuits are now in normal position. During the restoration of the final selector switch to normal position, the trunk extending to multiple terminals in the banks of all incoming selector switches having access thereto, is held busy by ground potential connected to the sleeve conductor 525 of the trunk, over the left hand armature and back contact of relay 521 and the upper left hand contact of sequence switch cam 514 (2 to 18).

As soon as the sequence switch of the final selector leaves position 16¼, the circuit over which sleeve relay 605 of the trunk 610, 611 has been held energized is opened at the lower right hand contact of sequence switch cam 513 and relay 605 thereupon becomes deenergized, opening the locking circuit of cut-off relay 607. Relay 607, however, remains energized until the intercepting operator withdraws the plug P from the jack J. Following the termination of the conversation between the intercepting operator and the calling subscriber, the intercepting op-

erator proceeds to take down the connection at her position by withdrawing the plug P from the jack J and if she has extended the connection for the calling subscriber by withdrawing calling plug P′ from jack J′. The withdrawal of plug P from jack J opens the circuit previously traced through the windings of relays 607, 612 and 613. Relay 607 upon deenergizing retracts its armatures and prepares the circuit for trunk lamp 608 so that this lamp may be lighted upon a new connection incoming to the operator's position. The deenergization of relay 613 opens the circuit previously traced through the winding of relay 614 and this relay deenergizes opening the circuit of relay 616. The deenergization of relay 616 opens the locking circuit of relay 623 which thereupon releases. The circuits at the operator's position are now restored to normal position.

If the operator has not taken down the connection at the time the calling subscriber causes the release of the selector switches then, when the final selector switch is restored to normal position, the circuit previously traced over the tip strand 618 of the cord circuit and through the right hand winding of relay 616 is opened at the brush 552 of the final selector switch. Relay 616 upon deenergizing closes a circuit for the supervisory lamp 622 which may be traced from grounded battery through the lamp 622, the left hand armature and back contact of relay 616 and thence to ground at the inner armature and contact of relay 612. The operator noting the illumination of lamp 622 proceeds to take down the connection in the manner previously described.

In the previous description it has been explained how a connection to a bank terminal in a final selector switch is trunked to the intercepting operator's position when the call has been set up entirely by mechanical means through the act of the calling subscriber. It is also possible that final selector switches may be set upon blank terminals in connections which have been established through a semi-mechanical operator's position or from a long distance position through a cordless operator's position. In Figure 7 circuits have been diagrammatically shown illustrating the manner in which calls may be extended from a semi-mechanical operator's position O′ to the intercepting operator's position O and from a long distance toll operator's position O^2 through the cordless operator's incoming selector switch 750 to the intercepting operator's position. A calling subscriber such as the subscriber A may desire to have the semi-mechanical operator establish a connection for him and in the well known manner causes the extension of a connection from his line through his individual line switch 100, the district selector switch 250, and the trunk 700 to the operator's position O′. The operator at position O′ then sets up the number of the desired line upon the sender 701 which through the semi-mechanical district selector 725, the incoming selector 450 and the final selector 550 proceeds to extend the connection to the terminals of the desired line. If the semi-mechanical operator misunderstands the instructions of the calling subscriber or sets up the number incorrectly upon the sender 701, the final selector switch 550 may be set upon blank terminals appearing in its bank and in substantially the same manner as previously described the connection will be extended to a trunk line 611, 612 extending to the intercepting operator's position O. When a connection is so extended to the intercepting operator's position, the intercepting operator answers in substantially the same manner as previously set forth.

If a subscriber B in a distant exchange desires a connection with a subscriber's line terminating in the bank terminals of final selector switch 550, such connection may be established in the well known manner over a toll line through the recording toll operator's cord circuit O^2 thence over a long distance cordless trunk 702 and 703 extending to a cordless position O^3. The cordless operator then receives instructions from the toll operator and sets up upon her sender 704 the designation of the desired line terminating in the final selector switch 550. The sender 704 then controls the setting of the cordless incoming switch 750 and the final selector switch 550 to select terminals of the desired line. If the cordless operator misunderstands the directions given to her or inaccurately sets up the number upon the sender 704, the final selector switch 550 may be set upon blank terminals appearing at its terminal bank and in such event the connection will be extended over trunk 611, 612 to the intercepting operator's position O as previously described.

In order that the intercepting operator may be able to recall the operator at the semi-mechanical position O′ or the operator at the toll position O^2 when connections are extended to her position through either of these positions her cord circuit is provided with a flashing recall key 619. Referring to Fig. 7 taken in connection with Figs. 4, 5 and 6, when the key 619 is depressed, the tip and ring strands of the cord circuit are opened and if the call has been extended from the long distance operator's position O^2, the opening of the strands of the cord circuit at key 619 will cause the operation of the supervisory relay at position O^2 in the well known manner to give the long dis-

tance operator the usual recall signal. If the call has been extended to an intercepting operator's position through a semi-mechanical operator's position such as O', the depression of the key is without effect at the semi-mechanical operator's position O'. When, however, the key is depressed a circuit is established for the slow to release relay 643 which may be traced from ground through contact 644 of key 619 and to grounded battery through the winding of relay 643. Relay 643 upon energizing closes a circuit for relay 623 extending from grounded battery through the left hand winding of relay 623 and thence to ground at the left hand armature and front contact of relay 643. This circuit is closed at this time in order to maintain relay 623 energized, as when key 619 is depressed the circuit through relay 616 is opened and the holding circuit of relay 623 is thereby opened at the armature and front contact of relay 616.

Relay 643 at its right hand armature and front contact closes a circuit for relay 635 which may be traced from grounded battery through the winding of relay 635, the inner left hand armature and front contact of relay 614 and thence to ground at the right hand armature and contact of relay 643. Relay 635 upon energizing connects ground through resistance element 638, to the ring strand 620 of the cord circuit, but this ground connection is without effect until key 619 is released. When key 619 is released this ground connection is rendered effective for completing the circuit of supervisory relay 459 at the incoming selector switch 450 in the manner previously described and this circuit is maintained until relay 643 releases, the relay 643 deenergizing as soon as the key 619 is restored and contacts 644 of the key are opened. The circuit of relay 459 is therefore maintained during the releasing period of slow to release relay 643. Supervisory relay 459 upon energizing establishes a circuit extending through the windings of polarized supervisory relay 705 at the semi-mechanical operator's position O' (Fig. 7) which may be traced from grounded battery (Fig. 4) over conductor 460, the upper left hand contact of sequence switch cam 405, conductor 426, resistance element 425, the upper contacts of sequence switch cam 415, the lower left hand winding of repeating coil 458, the upper contact of sequence switch cam 404, conductor 420, bank terminal 259, brush 706 (Fig. 7), the right hand contact of sequence switch cam 707, the lower right hand winding of repeating coil 708, the contact of sequence switch cam 709, the windings of polarized relay 705, the contact of sequence switch cam 710, the upper right hand winding of repeating coil 708, the upper contact of sequence switch cam 711, brush 712, bank terminal 260, trunk conductor 419, the lower contact of sequence switch cam 403 (Fig. 4), the upper left hand winding of repeating coil 458, resistance element 424, and thence to ground at the armature and contact of supervisory relay 459. The current flowing through the windings of supervisory relay 705 is now in such a direction as to cause this relay to open the circuit of the usual supervisory lamp at the operator's position O'. The circuits at the semi-mechanical operator's position may be substantially the same as disclosed in my co-pending application Serial No. 417,421 filed October 16, 1920. The supervisory lamp at position O' may thus be made to flash each time the intercepting operator at position O' depresses and releases the key 619. The operator at position O' noting the flashing of the lamp then throws her talking key and a talking circuit is then established between the operator's position O' and the intercepting position O as soon as the operator at position O depresses the talking key 621.

Should the intercepting operator depress the flashing recall key 619 through error on a call which has been extended to her position from a subscriber in a full mechanical office the depression and release of the key and the consequent connection of ground to the ring strand of the cord circuit will not cause the effective operation of polarized charging relay 268 at the district selector switch 250 for charging a call against the calling subscriber, since the connection of the ground is for a period measured by the releasing time of slow to release relay 643 which is of too short duration to enable relay 268 to establish a circuit for energizing and locking up the charging relay 261.

The cord circuits at the intercepting operator's position O are arranged for originating and answering other calls which the operator may desire to make from her position or calls which may come into her position over other trunks such as verifying trunk circuits or other miscellaneous tie lines. When the operator answers a call upon a verifying trunk line or tie line sufficient current does not flow over the sleeve conductor 614 to cause the energization of marginal relay 613 and therefore relay 614 does not become energized and talking current is therefore supplied to the answering strands of the cord circuit from grounded battery through the left hand winding of relay 616 and the outer left hand armature and back contact of relay 614, and from ground through the inner right hand armature and back contact of relay 614. Since at this time relay 614 is not energized the depression of key 619 is without effect upon

the relay 635. When the operator depresses the talking key 621, a circuit is closed for relay 624 as previously traced, whereupon a circuit is established for relay 645 which may be traced from grounded battery through the winding of relay 645, the left hand armature and normal contact of relay 633 the inner left hand armature and front contact relay 624 and thence to ground at the outer armature and contact of relay 612. Relay 645, upon energizing, establishes a circuit for relay 633 which may be traced from grounded battery through the winding of relay 633, the armature and front contact of relay 645, the outer right hand armature and front contact of relay 624, the outer right hand armature and back contact of relay 614, and thence to ground at the outer armature and front contact of relay 612. In the manner previously described relay 633 then establishes a circuit for relay 623 which in turn closes a circuit for relay 642. Relay 642 upon energizing connects the operator's set O. T. through contacts of talking key 621 to the strands of the cord circuit. The operator's telephone set is therefore connected to the strands of the cord circuit without waiting for the relays 630 and 632 to energize and therefore no delay is occasioned in establishing the connection. The relay 645 is made slightly slow to energize in order that the relay 614 may have time to energize in case the operator makes connection with an intercepting trunk such as 610, 611 before relay 645 closes the alternate circuit for relay 633.

The operator may complete calls with the cord circuit by the insertion of plug P' in the jack J' of an outgoing trunk. The insertion of plug P' closes a circuit for sleeve relays 646 and 647 which may be traced from grounded battery through the windings of relays 646 and 647 thence to ground over the sleeve contacts of plug P' and jack J'. The current flowing over this circuit is insufficient to energize marginal relay 647, but relay 646 energizes and at its right hand armature and front contact closes the tip strand of the cord circuit and at its left hand armature and front contact closes a circuit for the calling supervisory lamp 648. When the call upon the outgoing trunk is answered supervisory relay 649 becomes energized in the well known manner and opens the circuit of lamp 648.

Should the intercepting operator through mistake attempt to answer a call on an intercepting trunk by inserting the calling plug P' in the jack J, the circuit closed over the sleeve contact of jack J and plug P' and through the windings of relay 646 and 647 will not cause connection of ground over the conductor 611 of the intercepting trunk which might cause a false registration of a call on the calling subscriber's message register, since marginal sleeve relay 647 will be energized in this circuit and will close a circuit for relay 650 which will open the ring strand of the cord circuit and thereby prevent the connection of ground through the winding of supervisory relay 649, the ring contacts of plug P' and jack J and through the winding of supervisory relay 459 at the incoming selector switch.

If the verifying operator has answered the call upon a verifying trunk line or other tie line and the operator at the distant end of such trunk line or tie line desires to recall the intercepting operator the circuit of relay 616 is intermittently opened at the distant operator's position by the operation of a flashing key at such position or the withdrawing of the plug from the jack at the outgoing end of the trunk circuit or tie line. Upon the deenergization of relay 616, the locking circuit of relay 623 is opened at the armature and front contact of relay 616. When relay 616 reenergizes, relay 623 now being deenergized, a circuit is established for lamp 622 extending through the armature and front contact of relay 616, the right hand armature and back contact of relay 623, the outer left hand armature and back contact of relay 624, conductor 625, the winding of relay 626 and thence to ground through the interrupter 627.

The lamp 622 is thereupon flashed until the operator listens in upon the connection by throwing the talking key 621 into its talking position, when in the manner previously described relay 624 becomes energized and at its outer left hand armature and back contact opens the flashing circuit of lamp 622.

In the foregoing description the invention has been described in connection with intercepting trunks extending to blank terminals appearing in final selector switches, but it is to be understood that the invention is equally applicable in connection with the extension of connections from blank terminals appearing in the banks of incoming selector switches over intercepting trunk lines to the intercepting operator's position. If it is assumed that no lines have been installed in the exchange whose numbers are above 8999 then the groups of terminals of the incoming selector which would normally have access to final selector switches in which such lines would appear would be blank. A subscriber who inadvertently dials such a number and sets the brushes of an incoming selector switch upon such a blank terminal would then have his line connected in substantially the manner hereinbefore set forth from such blank terminals over intercepting trunks directly to an intercepting operator's position.

What is claimed is:

1. In a telephone exchange system, a calling subscriber's line, automatic switching mechanism for extending a connection from said line to a desired subscriber's line, terminals in the terminal banks of said switching mechanism to which no subscriber's lines are connected, an operator's position, trunk lines extending from a portion only of said terminals to such operator's position, means for controlling said switching mechanism and means effective when said switching mechanism is operated by said controlling means to make connection with one of said terminals to which no subscribers' lines are connected to cause said switching mechanism to connect with an idle one of said trunk lines.

2. In a telephone exchange system, a calling subscriber's line, automatic switching mechanism for extending a connection from said line to a desired subscriber's line, a plurality of terminals in the terminal banks of said switching mechanism to which no subscribers' lines are connected, an operator's position, trunk lines extending from a portion only of said terminals to said operator's position, means for controlling said switching mechanism and means effective when said switching mechanism is operated by said controlling means to make connection with one of said terminals to which no subscribers' lines are connected to cause said switching mechanism to connect with an idle one of said trunk lines.

3. In a telephone exchange system, a calling subscriber's line, automatic switching mechanism for extending a connection from said line to a desired subscriber's line, a plurality of terminals in the terminal banks of said switching mechanism to which no subscriber's lines are connected, an operator's position, trunk lines extending from a portion only of said terminals to said operator's position, means for placing a permanent busy condition on the remainder of said terminals, means for controlling said switching mechanism and means effective when said switching mechanism is operated by said controlling means to make connection with one of said terminals to which no subscribers' lines are connected to cause said switching mechanism to connect with an idle one of said trunk lines.

4. In a telephone exchange system, a calling subscriber's line, selector switches and a connector switch for extending a connection from said line to a desired subscriber's line, a plurality of terminals in the bank of said connector switch to which no subscribers' lines are connected, an operator's position, trunk lines extending from a portion only of said terminals to said operator's position, means for controlling said switches and means effective when said connector switch is operated by said controlling means to make connection with one of said latter terminals to cause said connector switch to connect with an idle one of said trunk lines.

5. In a telephone exchange system, a calling subscriber's line, selector switches and a connector switch for extending a connection from said line to a desired subscriber's line, a plurality of terminals in the terminal bank of said connector switch to which no subscribers' lines are connected, an operator's position, trunk lines extending from a portion only of said terminals to said operator's position, means for placing a permanent busy condition on the remainder of said terminals, means for controlling said switches and means effective when said connector switch is operated by said controlling means to make connection with one of said latter terminals to cause said connector switch to hunt over all terminals upon which said busy condition appears and to connect with an idle one of said trunk lines.

6. In a telephone exchange system, a calling subscriber's line, selector switches and a connector switch for extending a connection from said line to a desired subscriber's line, a plurality of terminals in the terminal bank of said connector switch to which no subscribers' lines are connected, an operator's position, a group of trunk lines extending from a portion only of said terminals to said operator's position, means for placing a permanent busy condition on the remainder of said terminals, means for controlling said switches, means effective when said connector switch is operated by said controlling means to make connection with one of said latter terminals to cause said connector switch to hunt over all terminals upon which said busy condition appears and over the terminals of the busy trunk lines of said group and means associated with said connector switch for transmitting a busy signal to said calling subscriber's line if all trunk lines of said group are busy.

7. In a telephone exchange system, a telephone line, an automatic switching mechanism for extending a connection from said line, terminals in the terminal banks of said switching mechanism to which no service lines are connected, an operator's position, trunk lines extending from a portion only of said terminals to such operator's position, means for controlling said switching mechanism and means effective when said switching mechanism is operated by said controlling means to make connection with one of said first mentioned terminals to cause said switching mechanism to connect with an idle one of said trunk lines.

8. In a telephone exchange system, a tele-

phone line, an automatic switch for extending a connection from said line, terminals in the terminal bank of said switch to which no connections extend, an operator's position, trunk lines extending from other bank terminals to said operator's position, means for controlling said switch and means effective when said switch is set by said controlling means upon one of said first mentioned terminals for causing said switch to connect with an idle one of said trunk lines.

In witness whereof, I hereunto subscribe my name this 23rd day of November A. D., 1920.

JOHN W. GOODERHAM.