

Nov. 12, 1935.

J. F. DAHL

2,020,458

TELEPHONE SYSTEM

Filed June 9, 1934

17 Sheets-Sheet 1

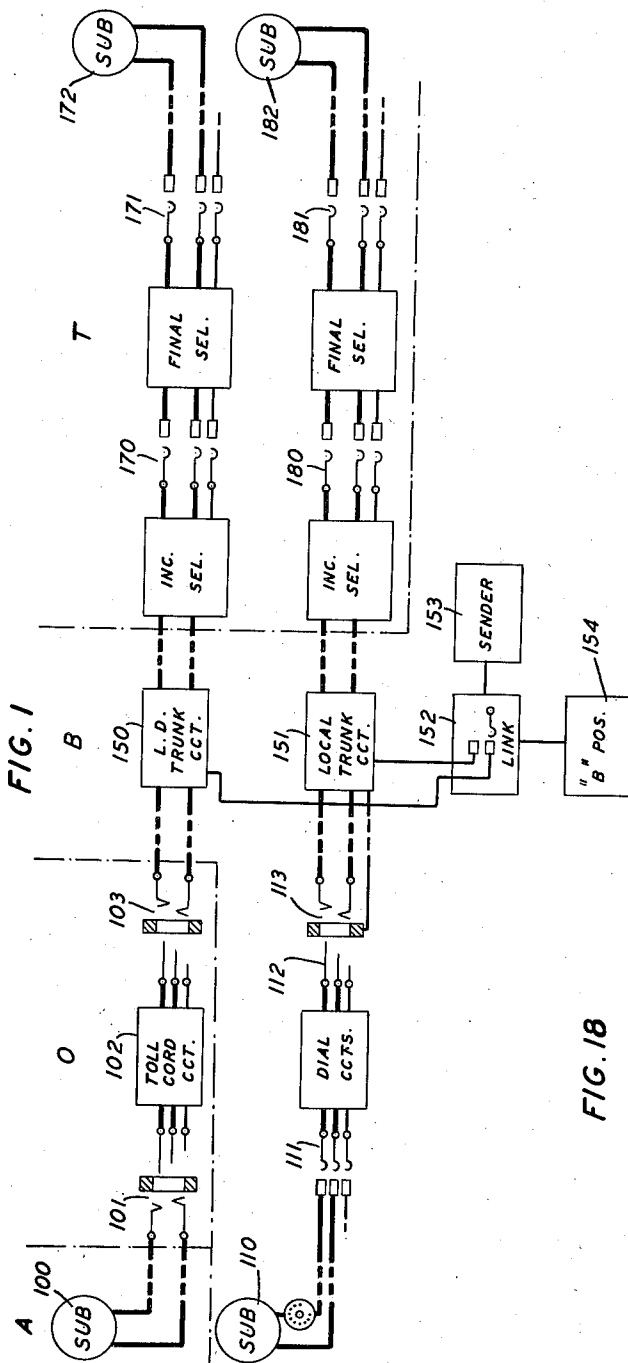


FIG. 18

FIG. 2	FIG. 16	FIG. 17
FIG. 3	FIG. 9	FIG. 10
FIG. 4	FIG. 6	FIG. 11
FIG. 5	FIG. 7	FIG. 12
	FIG. 8	FIG. 13
		FIG. 14
		FIG. 15

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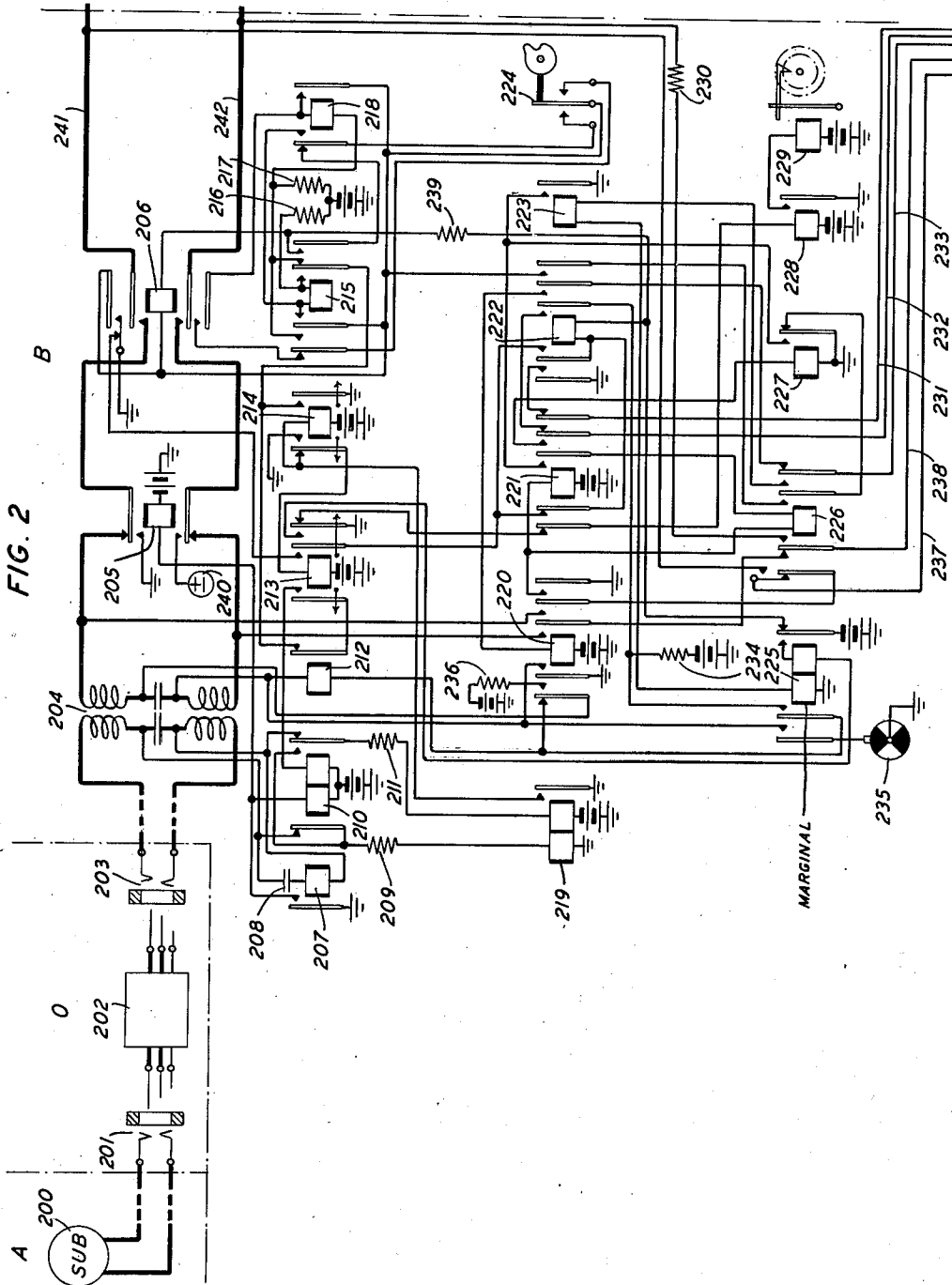
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TELEPHONE SYSTEM

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17 Sheets-Sheet 2



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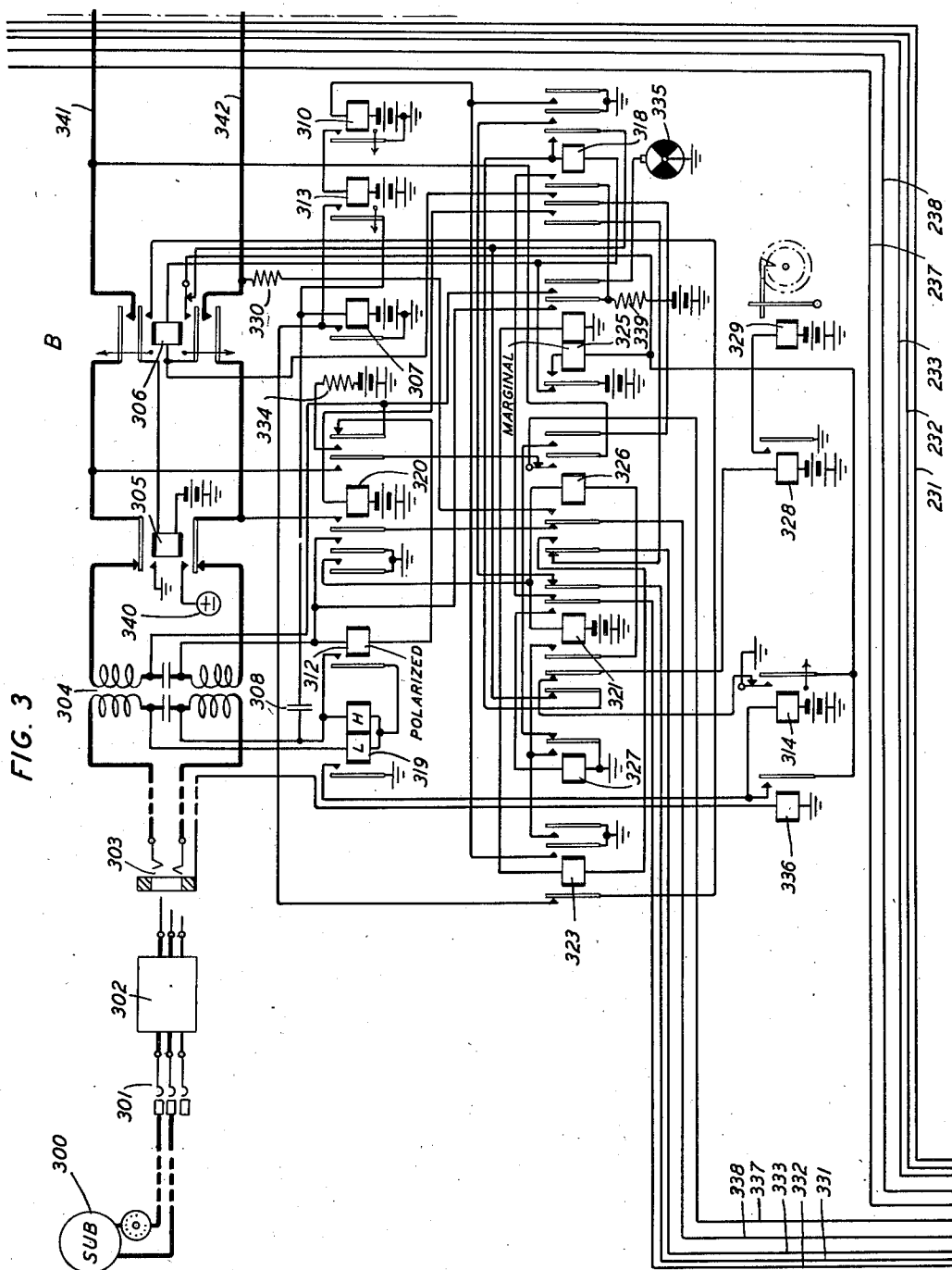
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17 Sheets-Sheet 4

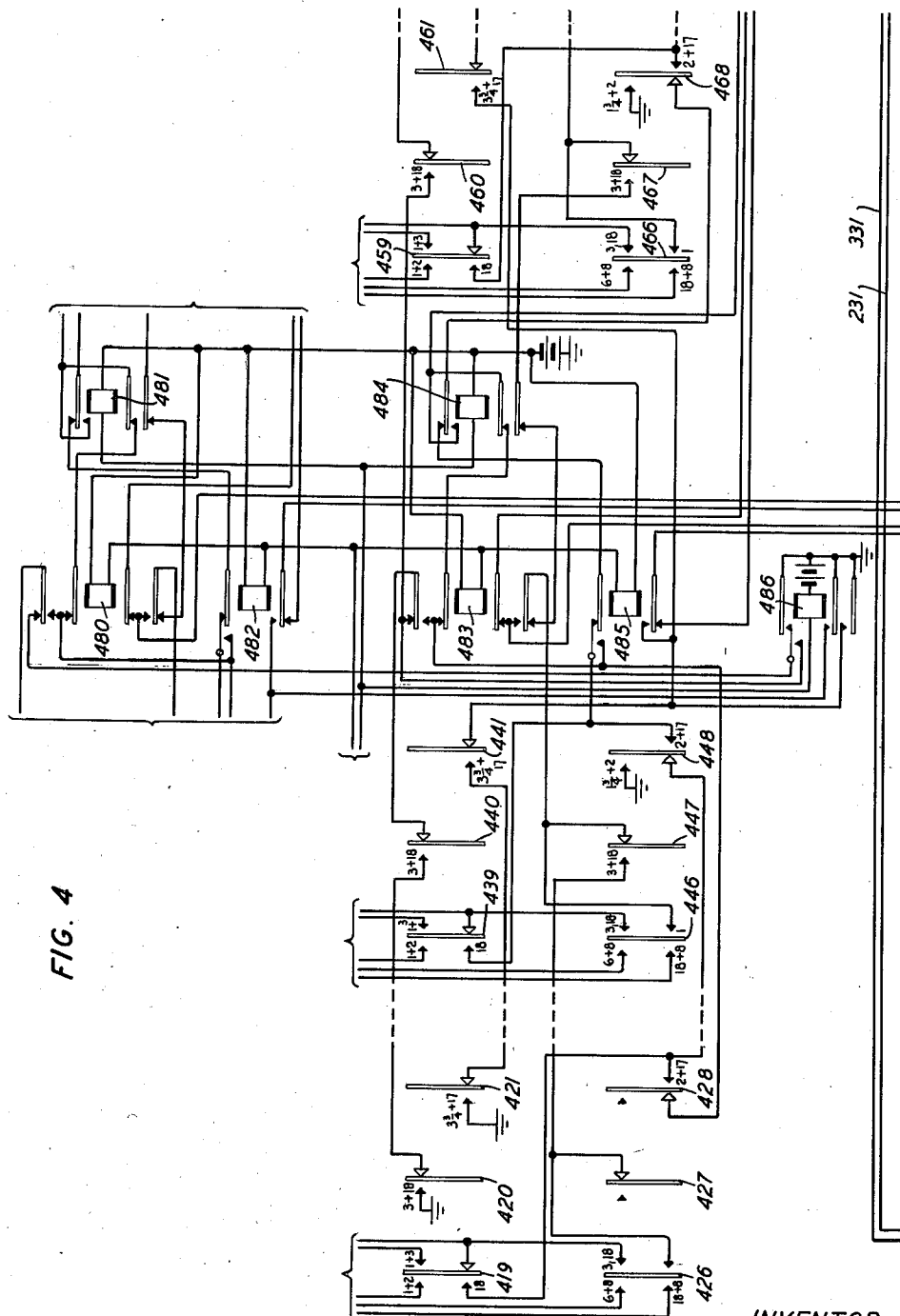


FIG. 4

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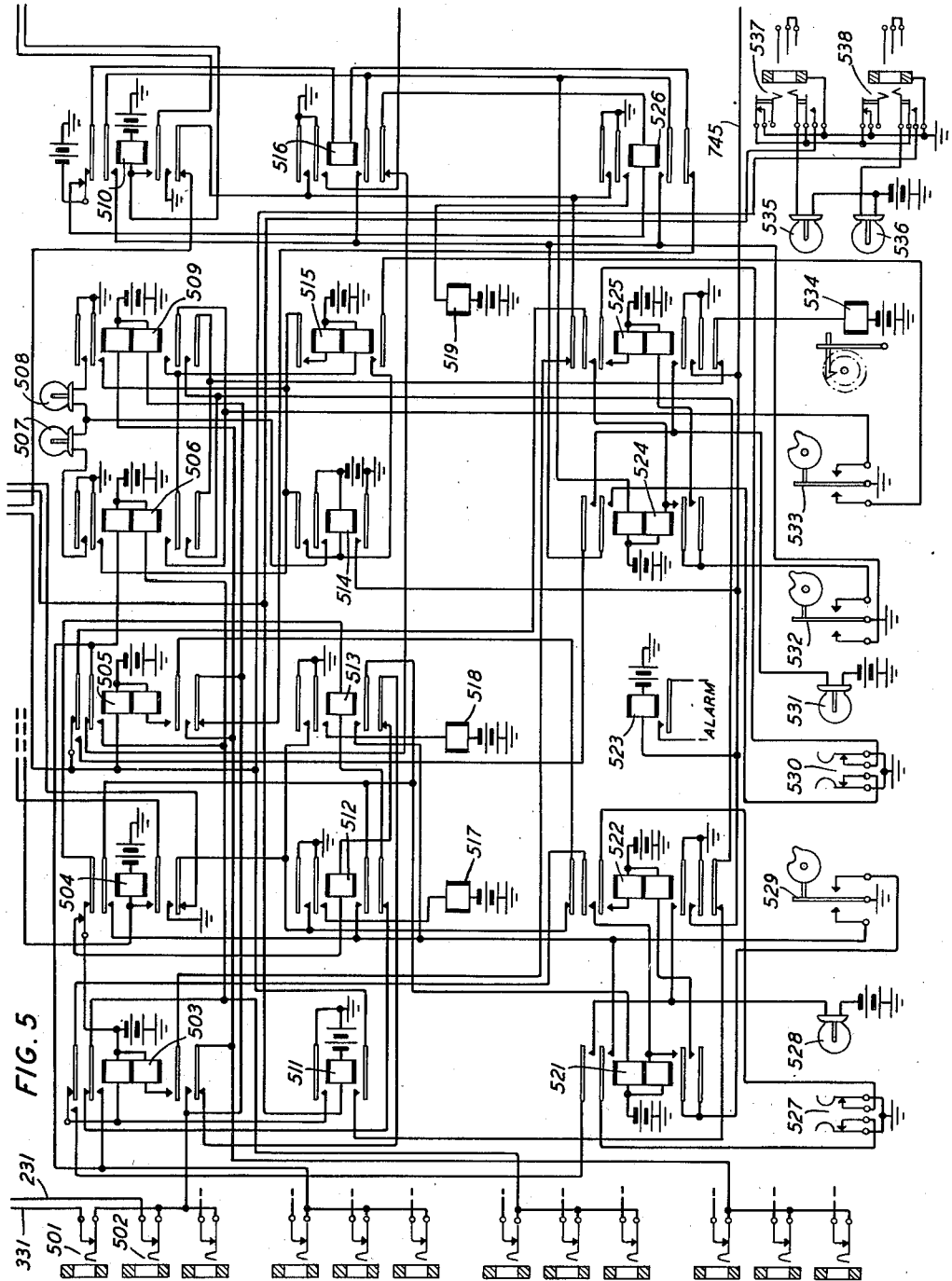
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17 Sheets-Sheet 6

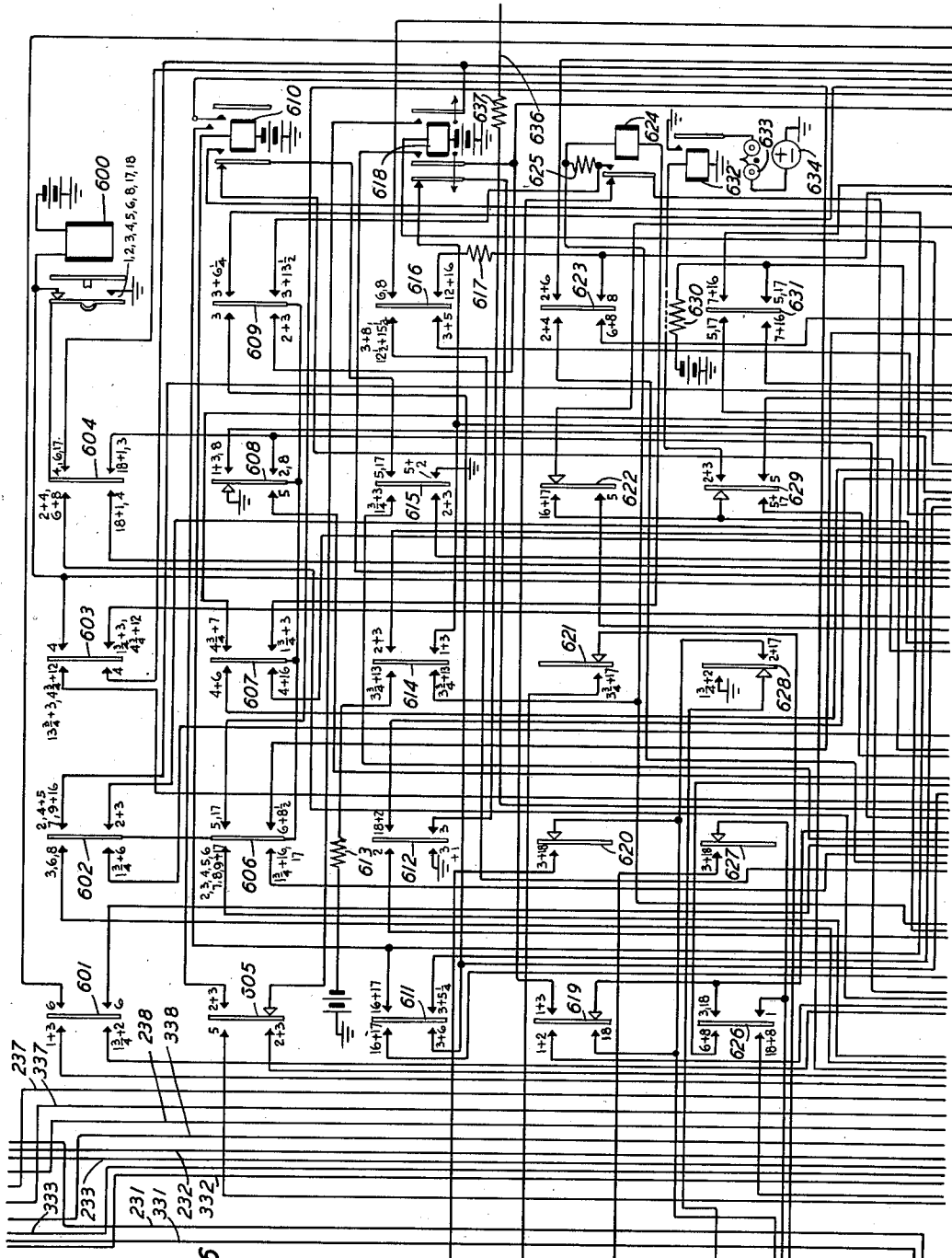


FIG. 6

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17 Sheets-Sheet 7

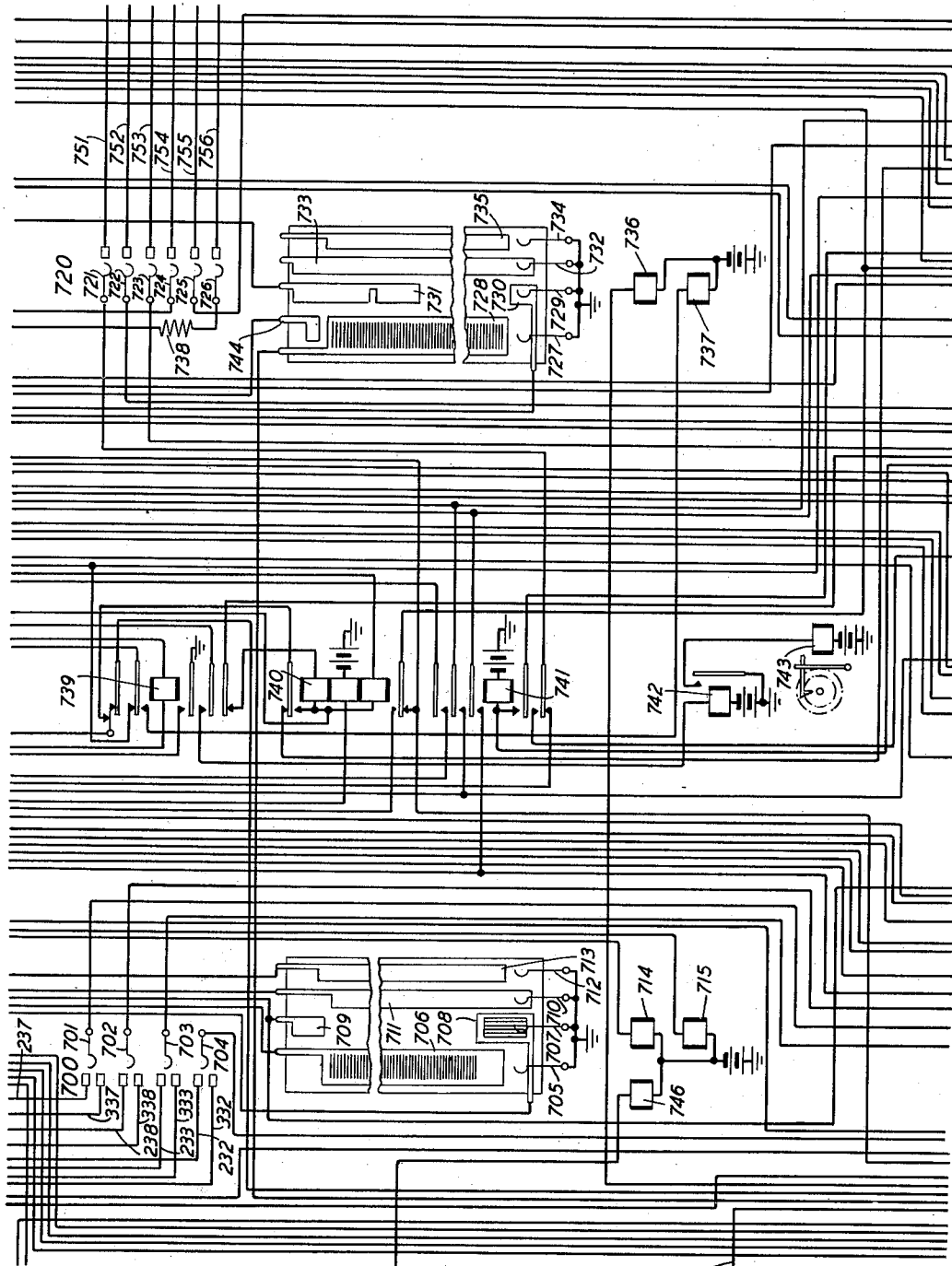


FIG. 7

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17 Sheets-Sheet 8

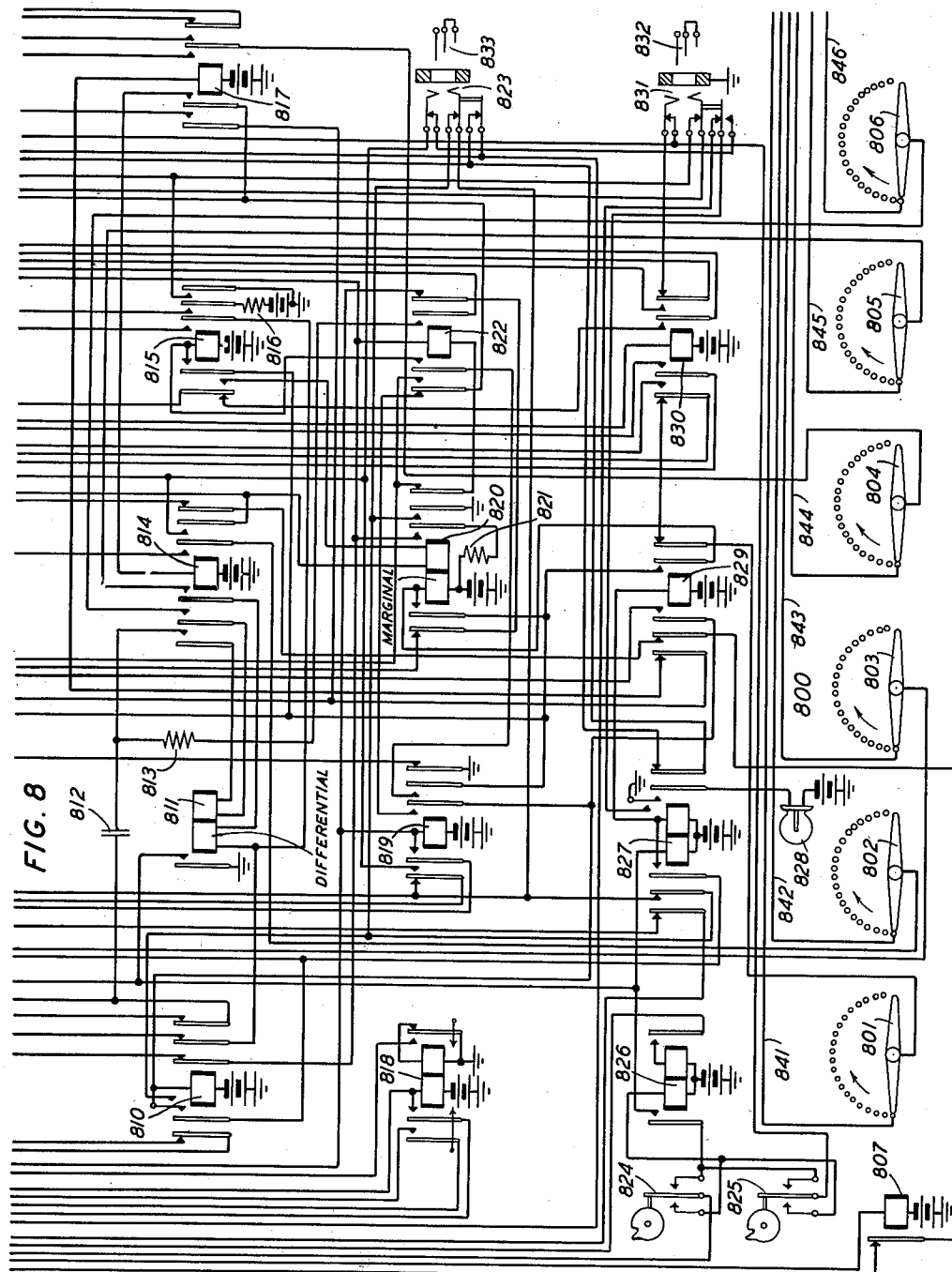


FIG. 8

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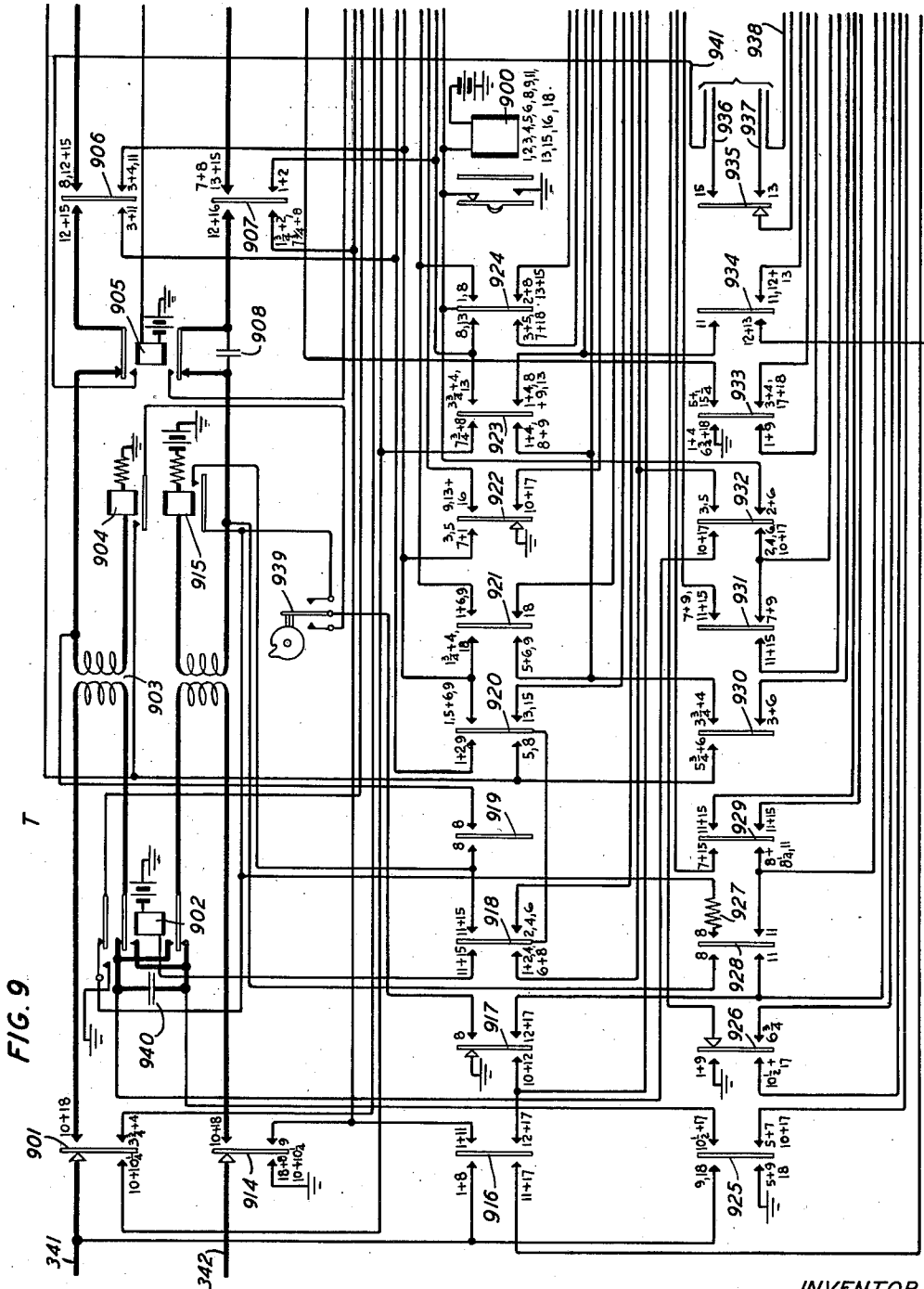
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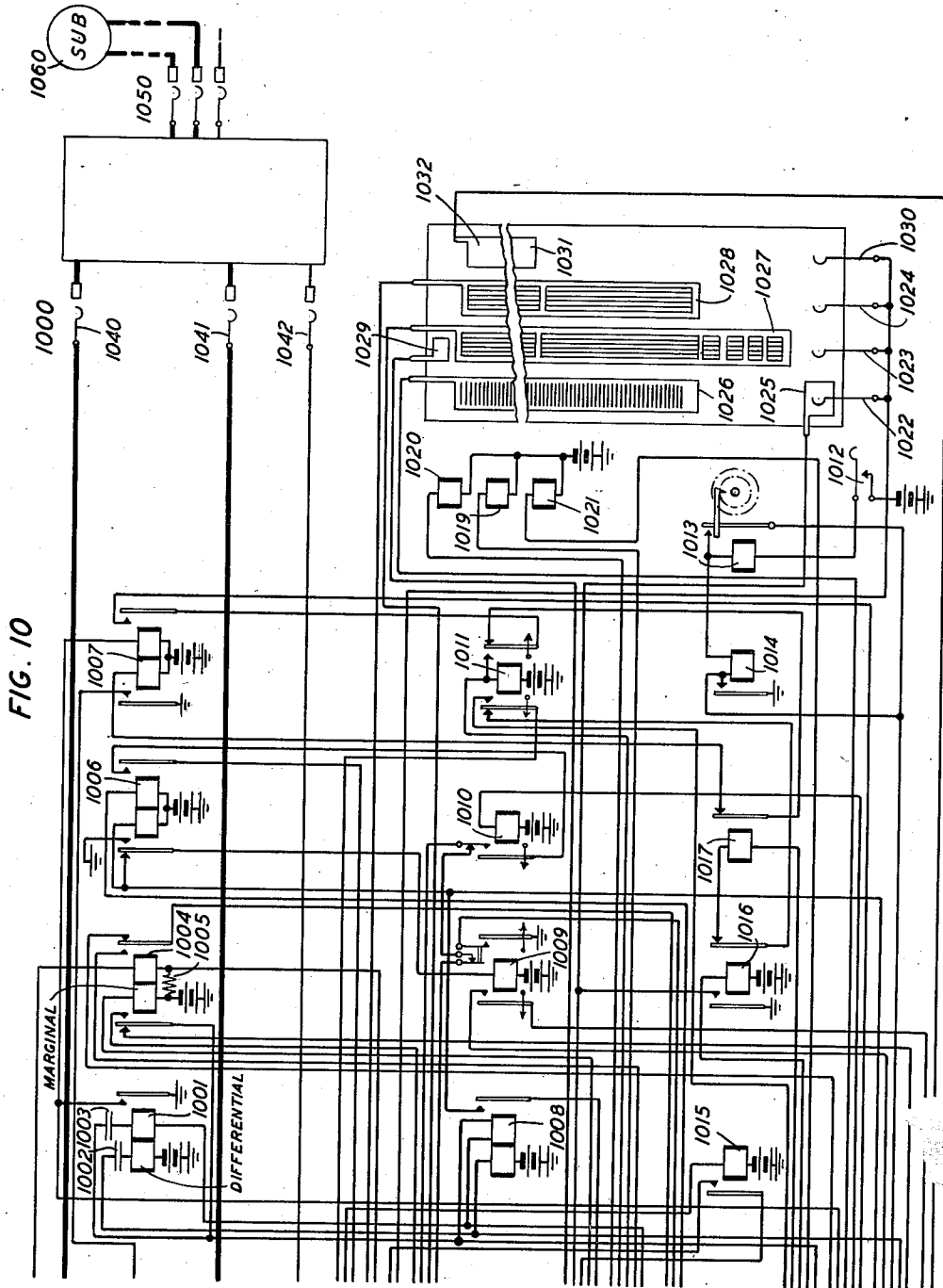
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17, Sheets-Sheet 11

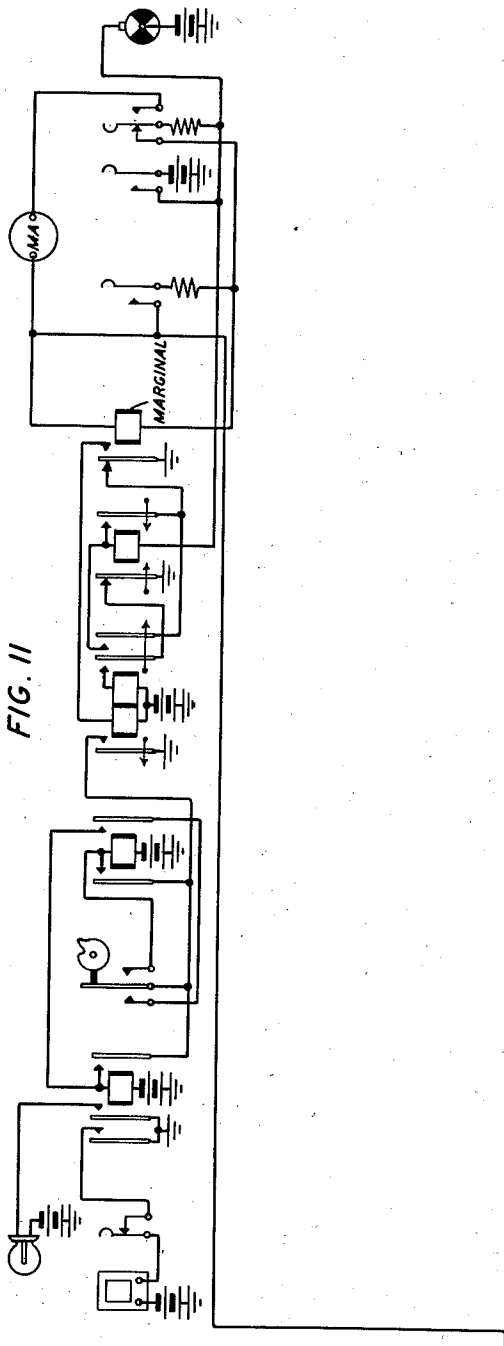
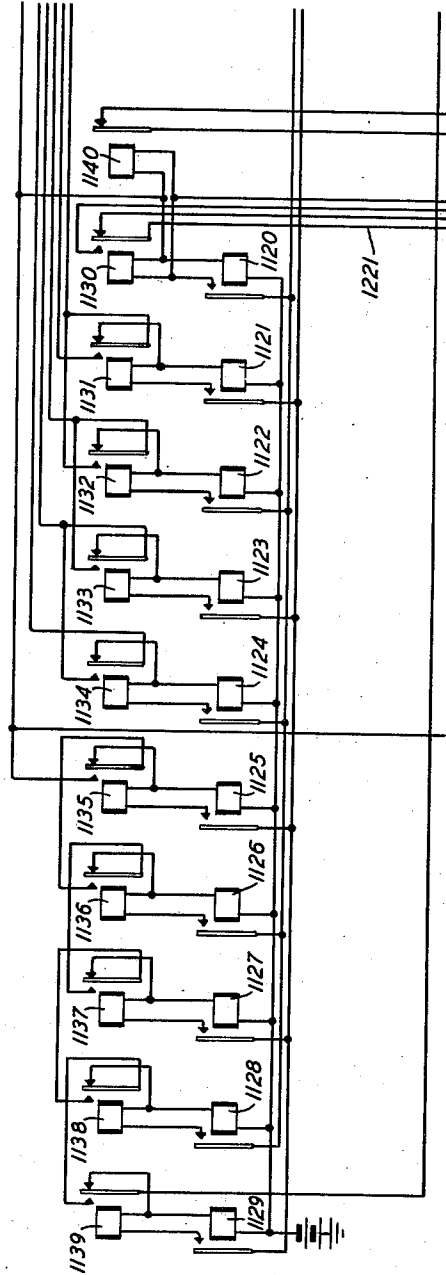


FIG. 11 A



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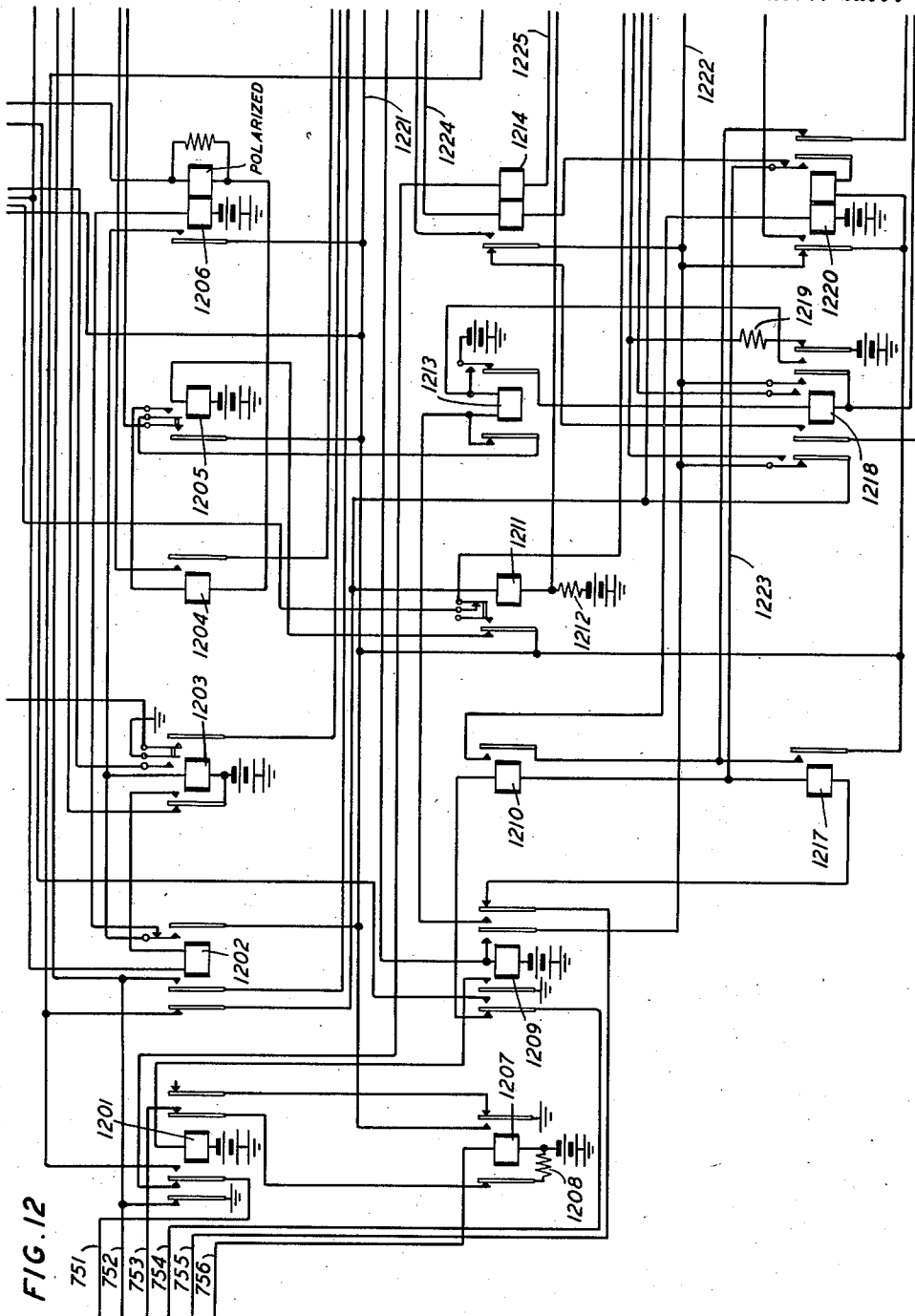
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17 Sheets-Sheet 12



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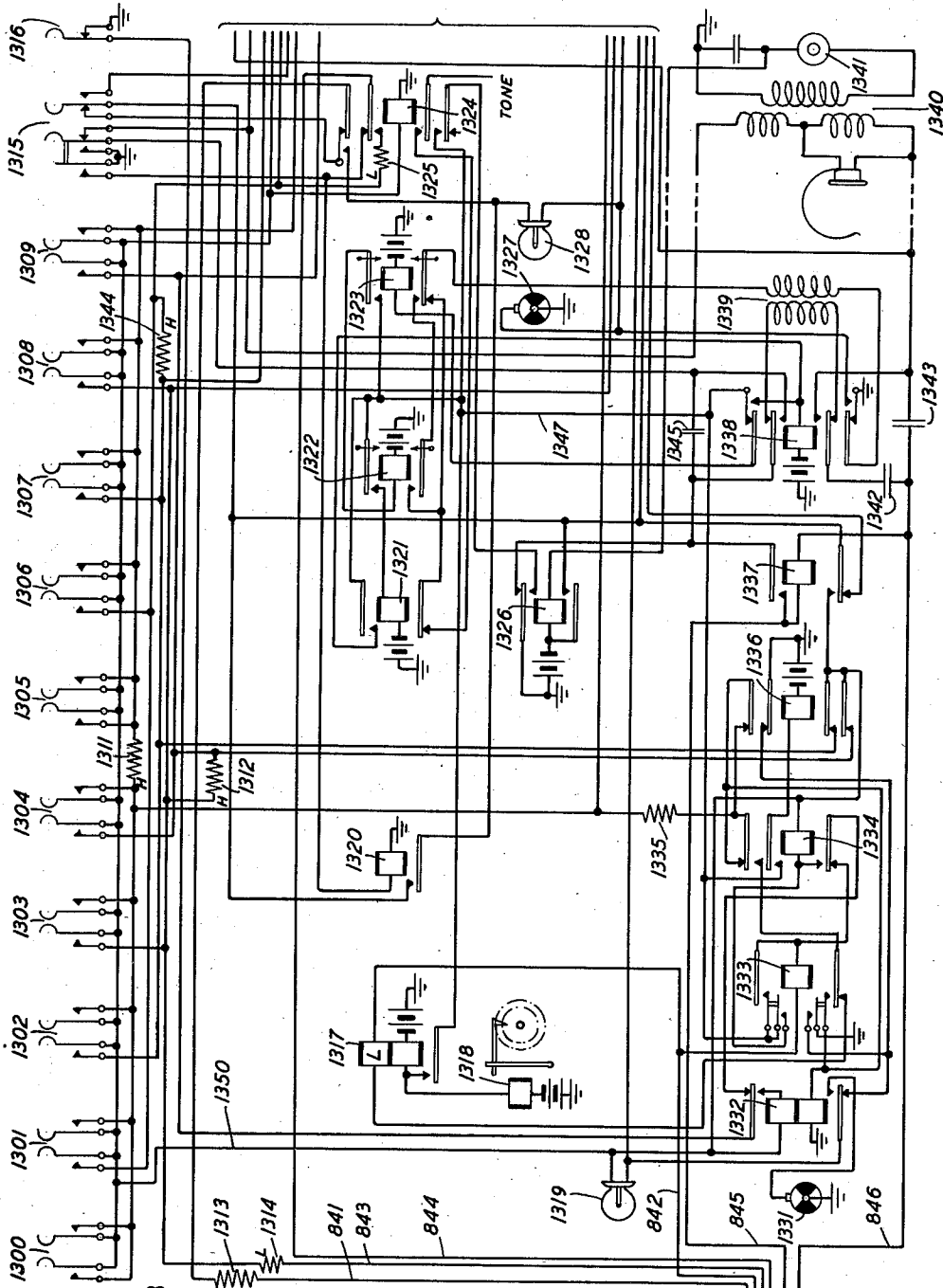


FIG. 13

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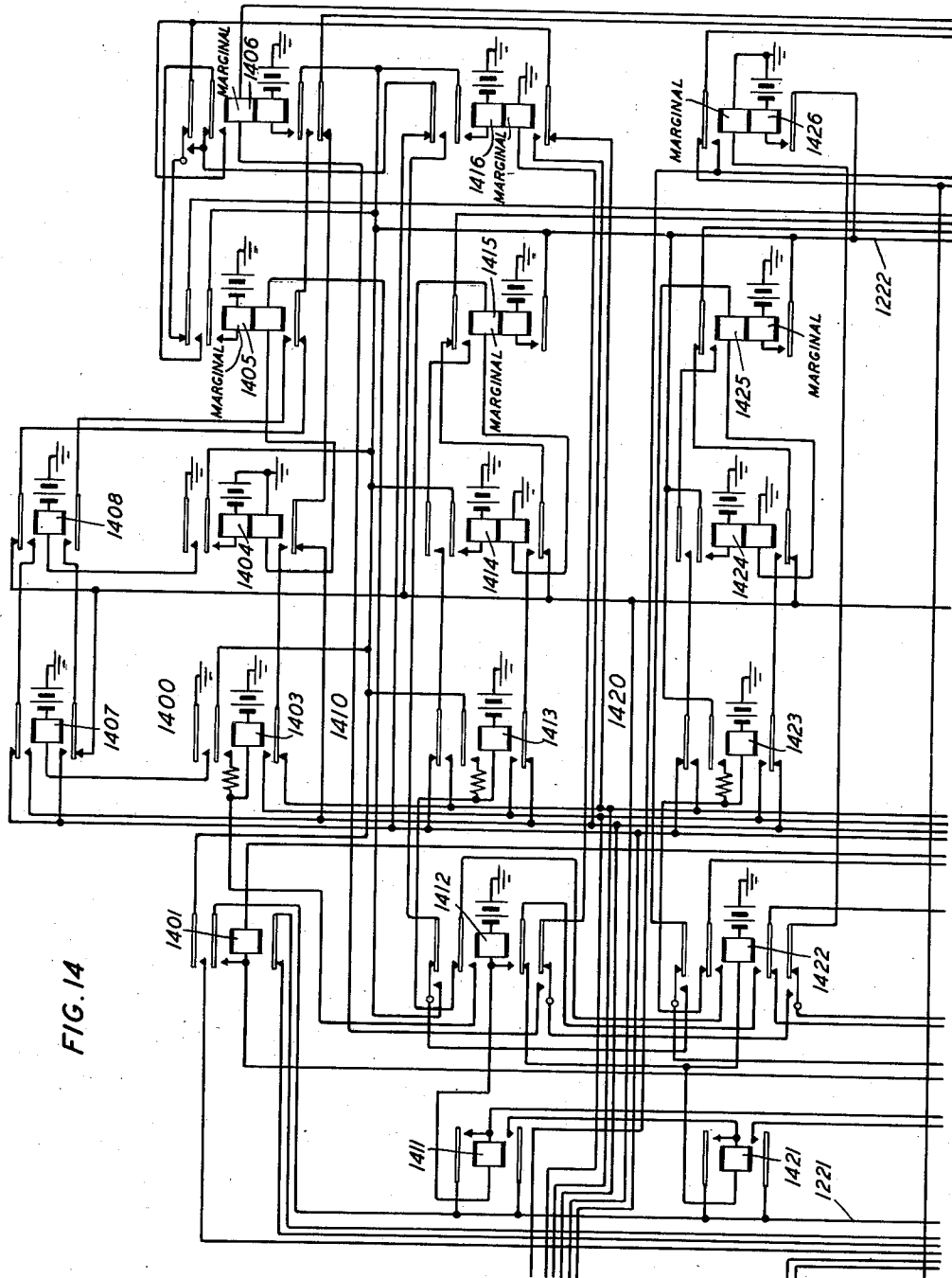


FIG. 14

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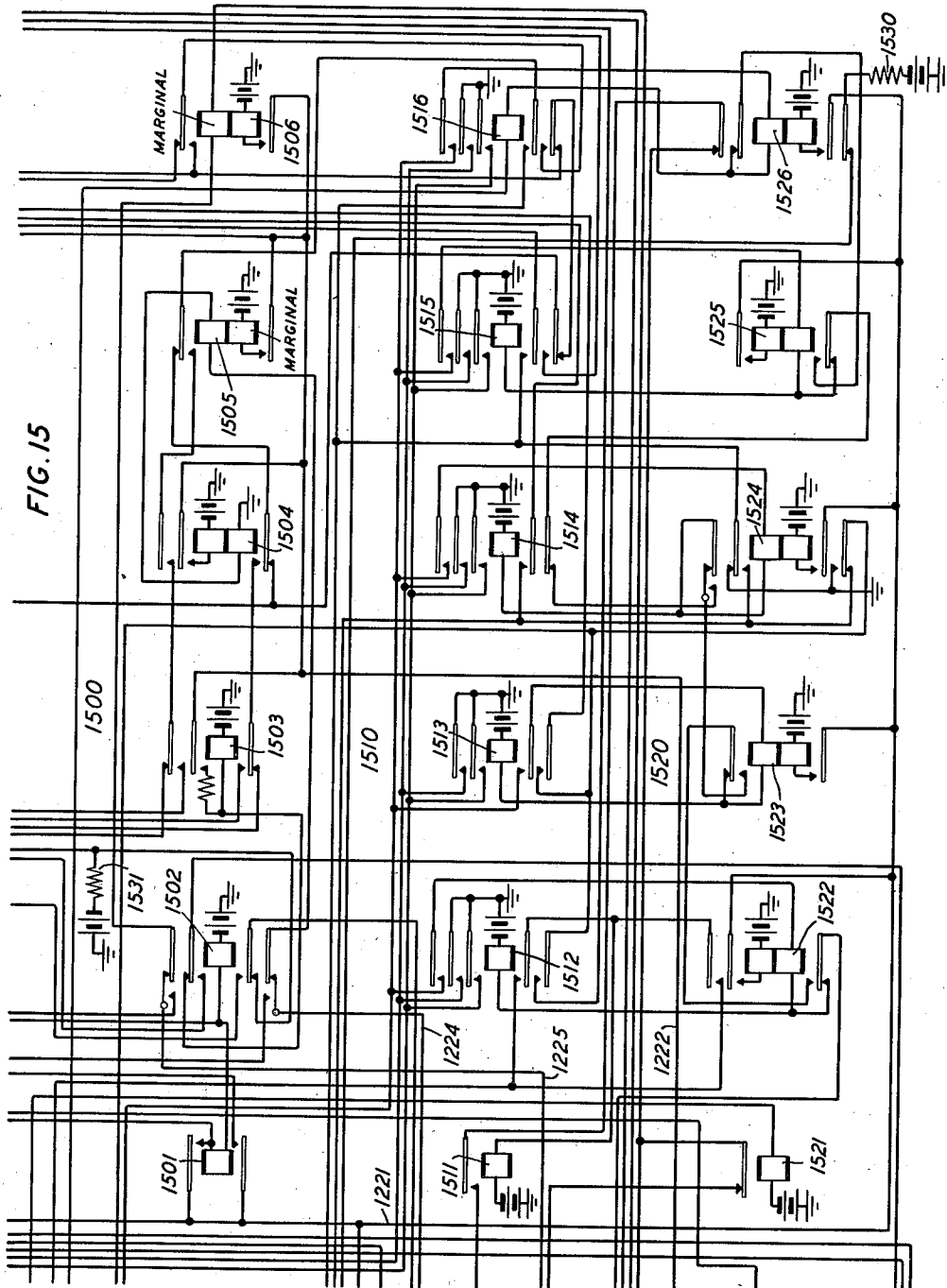
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TELEPHONE SYSTEM

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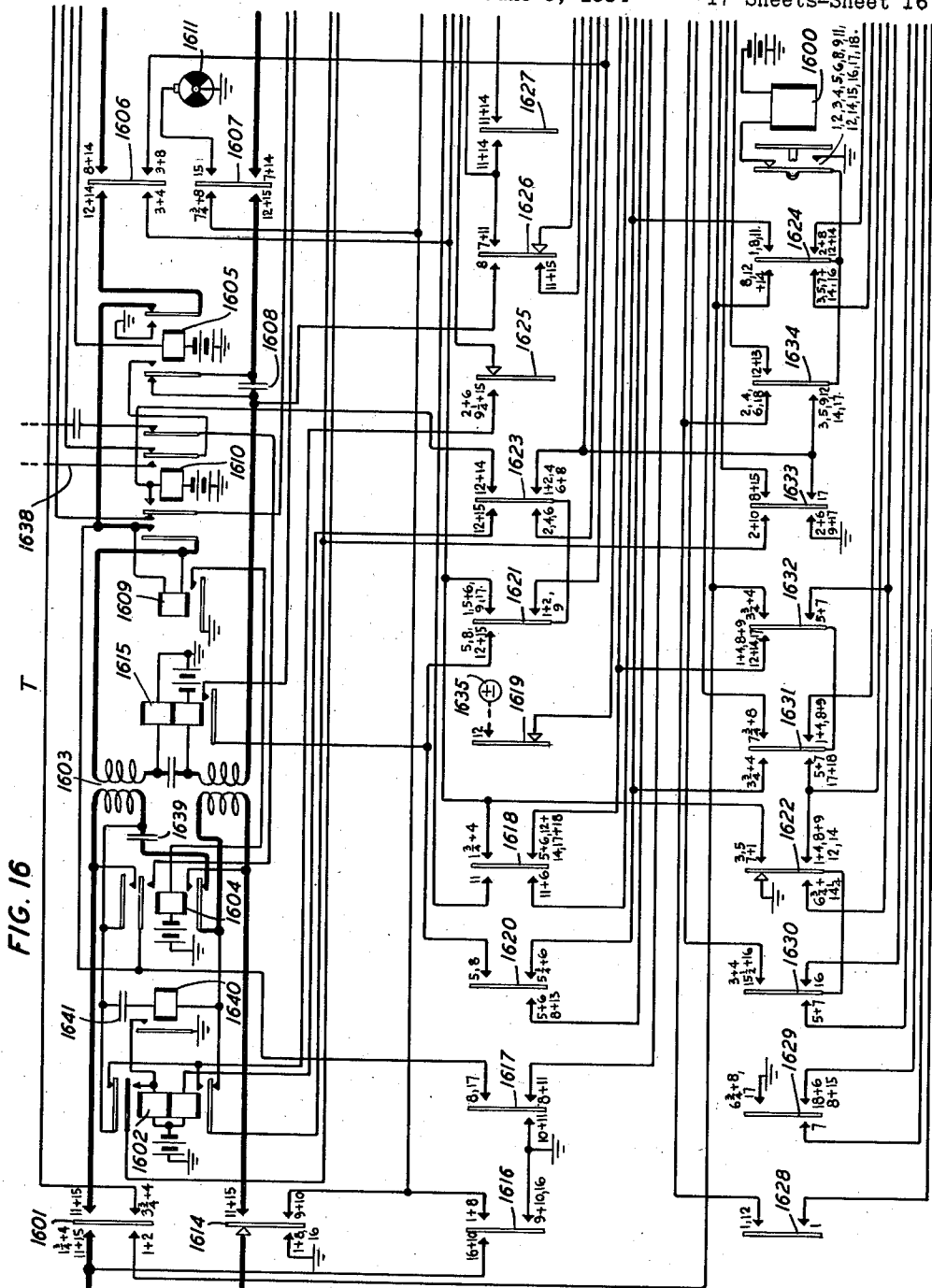
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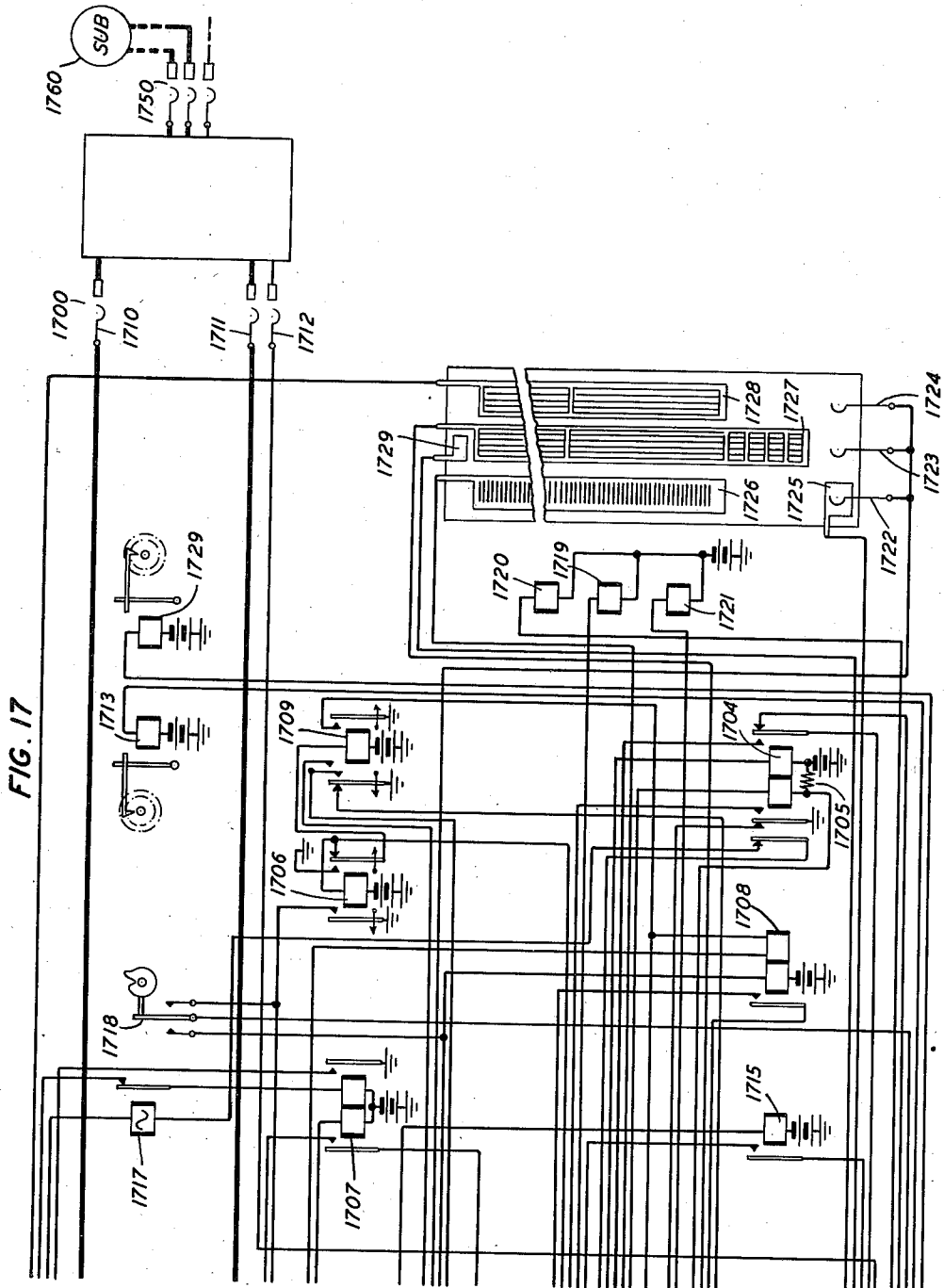
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17 Sheets-Sheet 17



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UNITED STATES PATENT OFFICE

2,020,458

TELEPHONE SYSTEM

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Application June 9, 1934, Serial No. 729,782

21 Claims. (Cl. 179—27)

This application relates to telephone systems and more particularly to telephone systems in which the establishment of connections involves more than one operator.

5 More specifically, the invention relates to a modification of the operator's equipment disclosed in Patent No. 1,753,348 granted to J. B. Newsom, April 8, 1930 in which the operator's equipment is located at a centralized office in
10 which no switching takes place. In such an arrangement, while automatic ringing is used at the terminating office, it is desirable for certain types of calls to place the start of ringing under the control of the originating operator. Depend-
15 ing on the nature of the call being handled, the operator may or may not wish to talk with the called party. Heretofore it has been necessary for the originating operator to await a signal indicating that the called line has been reached
20 before she could operate her ringing key. In accordance with the present invention, the originating operator may operate her ringing key as soon as she has passed the wanted line number to the control operator and the ringing signal
25 is thereupon held in abeyance until the connection has been completed at which time it becomes effective to start the machine ringing equipment.

In trunking systems, such as the present, where
30 an alternating current relay is connected across the trunk line to respond to an application of ringing current to initiate machine ringing, the surges of direct current which take place in the trunk due to disconnections, etc. are often suf-
35 ficient to operate the ring-up relay falsely. To obviate this difficulty, in accordance with the present invention, the ring-up relay has two differentially wound windings which are connected in series with condensers, one to each side of
40 the line, the opposite ends of the windings being connected to battery and ground. The ring-up relay is therefore responsive to ringing current applied to either side of the line but is unaffected by surges which occur over the two sides of the
45 line.

The operator's equipment used at the centralized office includes a link circuit which interconnects the register sender and the trunk. Timing means is associated with the link circuit
50 for giving an alarm if any of the functions of the equipment is delayed unduly. Normally, this timing means causes the transmission of a signal to the trunk which in turn transmits the signal to the originating operator and releases the oper-
55 ating equipment. However, in the case of a

link circuit suspected of faulty operation, means is provided whereby the operation of the timing means prevents the release of one or more parts of the equipment so that the cause of the trouble may be determined. At a certain stage of the
55 operation only the link circuit is held and in that case the signal to the originating operator is not given. The signal transmitted to the trunk circuit causes the disconnection of the outgoing supervisory relay from the trunk conductors and
60 its connection to a source of battery and interrupted ground so that the supervisory signal at the originating office is intermittently operated as a reorder signal.

A clearer understanding of the invention will
65 be obtained from a consideration of the following description in connection with the accompanying drawings in which:

Fig. 1 shows in diagrammatic form the circuits shown in detail in the remaining drawings.

Figs. 2 and 3 show the relay equipment of
70 trunks of two types.

Figs. 4 to 8 and 11 show the link circuit for connecting the operator's position equipment and
75 sender with the trunk equipment.

Figs. 9 and 10 show the incoming selector in which the trunk of Fig. 3 terminates.

Figs. 11—A, 12, 14 and 15 show the sender.

Fig. 13 shows the position circuit.

Figs. 16 and 17 show the incoming selector in
80 which the trunk of Fig. 2 is terminated; and

Fig. 18 shows the manner in which the remaining figures are to be arranged.

Referring first to Fig. 1, the equipment at four telephone offices is disclosed, that is, equipment
85 at office A, at a toll or long distance office O, a centralized office B and a terminating office T. The centralized equipment at office B may be employed in the completion of toll calls which, having been extended from the calling substa-
90 tion 100 at a local office A to a toll operator's position at the office O, may be further extended by means of jack 101, cord 102 and jack 103 to the long distance trunk circuit 150 at the cen-
95 tralized office B. The establishment of a connection with the trunk circuit 150 causes the link circuit 152 to associate itself with the trunk, with the position circuit 154 and with the sender
100 153. The link circuit first connects the incoming end of the trunk with the position circuit so that the toll operator may give the wanted number to the B operator. It then connects the posi-
105 tion circuit with the sender to permit the registration of the number in the sender and then connects the sender with the outgoing end of the
110 55

trunk so that the sender may control the incoming selector 170 and the final selector 171 in the selection of the wanted line 172.

The centralized equipment may also be used in the completion of calls from an A operator's position in the same building. In this case the subscriber reaches the A operator over the dial equipment indicated by line finder 111 and the trunk terminating in the plug 112. The insertion of plug 112 in jack 113 results in the seizure of trunk 151 and the same operations of the centralized equipment as for the long distance trunk. Trunk 151 is permanently connected to incoming selector 180 which differs from the incoming selector 170 in which the long distance trunk 150 terminated. However, final selectors 181 and 171 may be of the same type. The incoming selectors 170 and 180 have been shown as located at the same terminating office. However, it is to be understood that while each trunk passing through the centralized B office connects a particular originating office with a particular terminating office, each of a plurality of originating offices may be connected to a plurality of terminating offices by groups of trunks which may be served by the centralized B office equipment.

Incoming toll call

Referring now to the detailed drawings, the subscriber at substation 200 in originating a call for a subscriber at substation 1760 will be connected by suitable equipment with a long distance operator's position having access through the centralized B office with the office at which substation 1760 is located.

When the long distance operator inserts the calling plug of her cord 202 in the jack 203 leading to the trunk circuit of Fig. 2, a circuit is closed from battery through the right winding of relay 219, resistance 211, right back contact of relay 210, lower left winding of repeating coil 204, over the ring conductor of the incoming inter-office trunk and through the repeating coil and supervisory relay in the long distance operator's cord (not shown), back over the tip conductor to the upper left winding of repeating coil 204, left back contact of relay 210, resistance 209 to ground through the left winding of relay 219. Relay 219 closes an obvious circuit for relay 214 which in turn operates relay 213. Both relays 214 and 213 are slow to release to prevent a false release of the connection in case the incoming end of the trunk circuit is opened momentarily. Relay 214 also connects ground over its right front contact, right back contact of relay 215, to resistance 217 in shunt of the winding of relay 218 to prevent its premature operation. In addition, relays 214 and 213 close a circuit from ground over the right contact of relay 214, back contact of relay 212, left front contact of relay 213, right winding of relay 210 to battery. Relay 210 closes a holding circuit for relay 219 extending from battery through the right winding of relay 219, resistance 211, right front contact of relay 210, resistance 209, left winding of relay 219 to ground. Relay 219 remains operated independent of the control of the toll operator until the trunk circuit is closed through to the incoming selector circuit. Relay 213 closes a circuit from ground at the upper normal contact of relay 206, inner right contact of relay 213, inner left back contact of relay 221, winding of relay 222 to battery at the right back contact of relay 225. Relay 222 locks over its

inner left front contact to its operating ground independent of relay 221.

The operation of relay 222 initiates the association of the trunk circuit with the operator's equipment. It therefore connects ground over its outer left contact and the outer right back contact of relay 221 to the start conductor 231. It also connects battery through resistance 234 over its inner right front contact and the inner right back contact of relay 221 to conductor 232 which terminates in a test terminal of trunk selector 700. In addition, relay 222 closes a circuit from battery through the winding of relay 220, the middle right contact of relay 222, right back contact of relay 226 to conductor 233 which likewise terminates in a terminal of selector 700.

The connection of ground to conductor 231 completes a circuit which extends over the normal contact of jack 502, lower back contact of relay 505, back contact of relay 526 through the winding of relay 516 to battery over the upper back contacts of relay 510. Relay 516 operates in this circuit closing an obvious circuit for the trip magnet 746 of the trunk finder. It also closes a circuit from ground over its outer upper front contact, lower back contact of relay 510, inner lower back contact of relay 483, lower contacts of cam 626 to the winding of relay 819 and battery, to initiate the operation of the link circuit. A parallel circuit also extends from conductor 231 through the lower winding of relay 509 to battery.

The start circuit of Fig. 5 closely resembles that disclosed in the above identified Newsom patent and serves to prevent interference between calls originating in close succession. Relay 509 controls that part of the circuit which acts in case of trouble to delay the handling of a call to sound an alarm and automatically disable the group of link circuits on which the trouble occurred. Relays 480 to 486 cooperate with the start circuit and function in case the motors driving a part of the trunk finders stop running. Fig. 4 also shows portions of three link circuits for the purpose of indicating the method of allotting links for service. This is also disclosed in the above mentioned Newsom patent and will not be described in detail here.

When relay 819 is operated, it locks in a circuit from battery through its winding, over its inner left front contact, right contacts of cam 619, left back contact of relay 624 to ground over commutator strip 711 and brush 710. Another holding circuit is also closed for relay 819 over the lower right and upper left contacts of cam 619 which extends to ground over the commutator strip 706 and brush 705 after the selector moves off-normal for the purpose of centering the brushes of the selector properly. With relay 819 operated, a circuit is closed from battery through the winding of sequence switch magnet 600, lower right contact of cam 604, outer left front contact of relay 819, upper right and lower left contacts of cam 612 to ground, advancing sequence switch 600 from position 1. With sequence switch 600 in position 2, a circuit is closed from battery through the winding of the updrive magnet 714, upper contacts of cam 612, outer left front contact of relay 819, over the lower right and upper left contacts of cam 608 to ground.

As the selector starts upward, ground is connected over brush 707 and commutator segment 708, left contacts of cam 601, to the winding of relay 510 and battery. Relay 510 locks over its inner lower front contact, left back contact of

ating circuit of relay 1120 so long as relay 1204 is held operated.

When relay 1715 operates in the reverse battery fundamental circuit, it closes a circuit from battery through the right winding of relay 1704, upper left contact of cam 1632, lower right contact of cam 1631, front contact of relay 1715, right contacts of cam 1621 to ground over the upper contacts of cam 1622. With relay 1704 operated in position 9 of sequence switch 1600 a circuit is closed from battery through the winding of sequence switch magnet 1600 over the lower left contact of cam 1634, inner left contact of relay 1704 to ground, advancing sequence switch 1600 to position 10 and thence to position 11 over its normal cam. The reverse battery closure is maintained through position 10 to insure the operation of the sender relays, but when sequence switch 1600 reaches position 11, relays 1715 and 1704 release.

When sequence switch 1600 reached position $9\frac{1}{4}$ battery through the left winding of relay 1703 is connected over the upper contacts of cam 1625 and the upper back contact of relay 1602 to the upper left winding of repeating coil 1603, and the upper terminal of condenser 1641, while the lower terminal of the condenser and the lower left winding of repeating coil 1603 are connected over the lower back contact of relay 1602 to ground over the left contacts of cam 1633.

When sequence switch 1600 reaches position 11, battery through the left winding of relay 1703 is extended from the upper left winding of repeating coil 1603 over the upper contacts of cam 1601 to the tip conductor 241 of the inter-office trunk. As sequence switch 1600 leaves position 10, the ground above traced is disconnected and when the sequence switch reaches position 11, the ring conductor 242 of the inter-office trunk is extended over the upper contacts of cam 1614, lower left winding of repeating coil 1603, lower back contact of relay 1602, right winding of relay 1703 to ground over the lower contacts of cam 1617. The incoming selector now awaits trunk closure by the link or trunk circuit.

In the sender when the reverse battery circuit is opened, relays 1130 and 1140 operate in the circuit closed by relay 1203. Relay 1140 opens the fundamental circuit in the usual manner and relay 1130 closes a circuit from grounded conductor 1221, front contact of relay 1130 through the winding of relay 1202 to battery over the left front contact of relay 1203. Relay 1202, in operating, opens the locking circuit for relay 1206 and that relay releases. Relay 1202 also disconnects ground at its left back contact from conductor 751.

The removal of ground from conductor 751 indicating that the sender has completed its function, opens the circuit of relay 819 which now releases closing a circuit from battery through the winding of sequence switch magnet 600, upper left contact of cam 604, left back contact of relay 819 to ground over the lower right contact of cam 608, advancing sequence switch 600 to position 9 from whence it is advanced to position 17 over its local cam. As soon as sequence switch 600 leaves position $8\frac{1}{2}$ ground is disconnected from conductor 756 releasing relay 1207 and disconnecting ground from off-normal conductor 1221, thereby releasing all relays which are locked to that conductor and, since it removes ground from conductor 1222, releasing all of the register relays and putting the sender in condition to control another call.

As sequence switch 600 passes through positions $12\frac{1}{2}$ to $15\frac{1}{4}$, a circuit is closed from the tip conductor 241 of the inter-office trunk which was connected as previously traced to battery through the right winding of relay 1708 over the left alternate contact of relay 226, conductor 237, brush 701, middle right contact of relay 810, inner right front contact of relay 815 through resistance 617, lower right and upper left contacts of cam 616, outer right back contact of relay 810, brush 702, conductor 238, over the inner left front contact of relay 226 through resistance 230 to the ring conductor 242 and thence to ground through the left winding of relay 1708 as above traced.

When sequence switch 600 reaches position 13, battery through resistance 613 is removed from conductor 232 thereby releasing relay 227 but since relay 223 is still operated, the locking circuit of relays 221 and 226 is maintained and a circuit is closed from ground over the back contact of relay 227, inner right front contact of relay 226, outer right front contact of relay 222, through the winding of relay 206, resistance 238, right back contact of relay 225 to battery. Relay 206, in operating, closes a locking circuit for itself from battery over the back contact of relay 225, resistance 239, winding of relay 206, outer upper front contact of relay 206 to ground. Relay 206 disconnects ground from the holding circuit of relay 222 which now releases. Relay 206 also connects the tip conductor 241 of the inter-office trunk over its inner upper front contact, upper back contact of relay 205, upper right winding of repeating coil 204, back contact of relay 220, winding of relay 212, lower right winding of repeating coil 204, lower back contact of relay 205, inner lower front contact of relay 206 to the ring conductor 242 of the inter-office trunk, thereby making a second trunk closure which overlaps the trunk closure made by the link circuit.

Relay 1708 operates in response to the trunk closures by the link and trunk circuits, completing a circuit from ground over the lower left and upper right contacts of cam 1633, front contact of relay 1708, lower contacts of cam 1623 through the winding of relay 1706 to battery. Relay 1706 closes an obvious circuit for relay 1709 which closes a substitute ground to the right winding of relay 1708. It also connects ground over its inner left front contact, left contacts of cam 1618, upper right contact of cam 1624 to battery through the winding of sequence switch magnet 1600, advancing the sequence switch to position 12 and in this position ringing and talking take place.

When sequence switch 600 leaves position 16, battery through resistance 816 is disconnected from conductor 233 thereby releasing relay 223 which in turn releases relays 221 and 226. The link circuit is thereby completely disconnected from the trunk circuit.

When sequence switch 600 reaches position 16, a circuit is closed from battery through the winding of relay 610, upper contacts of cam 611, commutator strip 713, brush 712 to ground. Relay 610 closes a circuit from battery through the winding of downdrive magnet 715 of the trunk finder 700, left front contact of relay 610, right contacts of cam 615 to ground, restoring the trunk finder to normal. When the trunk finder reaches the bottom of its bank, brush 712 leaves commutator strip 713 and relay 610 releases, in turn releasing downdrive magnet 715.

With sequence switch 600 in position 16, a test is made to determine the location of the sender selector by means of a circuit from ground over brush 729, commutator strip 731, upper contacts of cam 622, winding of relay 739, resistance 630 to battery. If the selector is not engaging one of the predetermined top groups, relay 739 is not operated and sequence switch 600 is advanced to position 18 as soon as relay 610 releases over the upper right contact of cam 604, inner lower normal contact of jack 831, inner upper back contact of relay 739 to ground over the back contact of relay 610 and the right contacts of cam 615. If the selector is engaging a sender in such a top group, relay 739 will operate and lock over its inner lower front contact and the left contacts of cam 629. When sequence switch 600 reaches position 17, a circuit is closed from battery through the winding of downdrive magnet 737, inner upper front contact of relay 739, left back contact of relay 610 to ground over the right contacts of cam 615. The sender selector is restored to the bottom of its bank in this circuit and when it reaches this position, a circuit is closed from ground over brush 729, commutator segment 730, upper left and lower right contacts of cam 631 to resistance 630 and battery in shunt of the winding of relay 739 which now releases. With relay 739 released, the circuit above traced through the winding of sequence switch magnet 600 is closed and the sequence switch is advanced to position 18 in which position it remains until it is assigned for use by the advance of the next link to position 2.

Relay 212 operates in series with relay 1708 when the trunk closure is removed by the link circuit, opening the circuit of relay 210 which releases and again connects the windings of relay 219 to the incoming trunk conductors thereby giving a signal to the long distance operator that she may ring the called subscriber. When she applies ringing current to the incoming end of the trunk, ringing relay 208 operates, closing an energizing circuit for relay 210 which in turn holds relay 219 operated over its front contact to prevent false disconnection of this circuit during the ringing interval. Relay 207 also operates relay 205. Relay 205 disconnects relay 212 from the outgoing trunk, releasing it to restore the holding circuit for relay 210. Relay 205 also connects ringing current and generator ground to the tip and ring conductors of the outgoing inter-office trunk. The ringing circuit extends over the tip conductor 241, upper contacts of cam 1601, upper left winding of repeating coil 1603 through condenser 1641 and ringing relay 1640, lower left winding of repeating coil 1603, upper contacts of cam 1614 to the ring conductor. Relay 1640 operates in this circuit, in turn operating relay 1602 which extends its operating ground over its inner upper contact to the left winding of relay 1707 and battery. Relay 1707 locks in a circuit from battery through its right winding, back contact of relay 1717, left back contact of relay 1610, left front contact of relay 1707, upper contacts of cam 1627, to ground over the outer left front contact of relay 1709. Relay 1707, in turn, operates relay 1605 which connects generator ground over its right front contact and the upper contacts of cam 1606 to the tip brush 1710 of the incoming selector and through the final selector 1750 to the subscriber's line. It also opens the shunt around condenser 1608 and connects ringing current from source 1635 over the contacts of cam 1619, left back contact of relay 1704,

through the winding of relay 1717, inner right back contact of relay 1610, left front contact of relay 1605, lower contacts of cam 1607 to the ring brush 1711 of the incoming selector and through final selector 1750 to the subscriber's line. At the same time, relay 1602 disconnects relay 1708 from the trunk conductors and closes a holding circuit for that relay which extends from battery through the left winding of relay 1708, contacts of cam 1625, lower front contact of relay 1602 to the right winding of relay 1708 and ground at the right front contact of relay 1709, to hold the relay operated during the application of ringing current from the trunk circuit. When the toll operator disconnects ringing current from the trunk, relays 207 and 210 release restoring the connection of relay 219 to the incoming trunk. Relay 207 also releases relay 205, disconnecting ringing current from the outgoing inter-office trunk, releasing relay 1640. Relay 1640 releases 20 relay 1602 which restores the connection of relay 1708 to the inter-office trunk. Relay 1707 being locked, holds relay 1605 operated and the ringing continues intermittently until the called subscriber answers, ringing tone being given to the toll operator through condenser 1608.

When the called subscriber answers, relay 1717 operates over the subscriber's line, thereby opening the circuit of relay 1707 which in turn releases relay 1605 and connects the called line 30 through to the supervisory relay 1615. Relay 1615 operates over the called subscriber's line and closes a circuit from battery through the winding of relay 1610, upper right contact of cam 1623, upper left contact of cam 1621, front contact of 35 relay 1615, left front contact of relay 1706 to ground. A parallel circuit extends from battery through the lower winding of relay 1602 over the upper left contacts of cams 1623 and 1621 to the front contact of relay 1615 and thence to ground 40 as traced. Relay 1610 has no function at this time. Relay 1602 disconnects battery and ground through the windings of relay 1708 from the inter-office trunk, at the same time closing the previously traced holding circuit for relay 45 1708. The removal of battery and ground from conductors 241 and 242 releases relay 212. Relay 212 released, recloses the circuit for relay 210 which holds relay 219 operated and disconnects battery and ground from the tip and ring leads 50 towards the long distance office thereby extinguishing the cord supervisory signal at the long distance office as an indication that the called subscriber has answered.

If it is desired to rering the called line, for 55 example, in the case of a call completed to a private branch exchange, the functions at office B are the same as those previously described. At the incoming selector, relay 1615 is held operated from the branch exchange, in turn holding re- 60 lays 1602 and 1619 operated. The fact that relay 1610 is operated opens the locking circuit of relay 1707 so that that relay remains operated only as long as relay 1640 is operated under the control of the distant operator. Relay 1707 in 65 turn operates relay 1605 to apply ringing current to the called line as previously described. Since relay 1610 is operated, steady ringing current is connected over conductor 1638 in place of the intermittent ringing current applied on the first 70 ringing signal, the circuit extending from conductor 1638 over the right front contact of relay 1610 to the left front contact of relay 1605.

When the called subscriber restores his receiver to the switchhook, relay 1615 releases, in 75

relay 827 to ground over the upper left and lower right contacts of cam 615 and is therefore held operated until after the trunk has been found. Relay 510, in operating, disconnects battery from the winding of relay 516, thereby rendering the start circuit unresponsive to calls over other trunks of this group. Calls over trunks of the groups served by relays 512 or 513 may be extended.

As the brushes of selector 700 move upward over the terminals leading to various trunk circuits, a test is made for the calling trunk which is marked by battery connected to conductor 232. When this is found, a circuit is completed from battery on conductor 232, brush 704, left back contact of relay 810, through the winding of relay 624 to ground over the lower right contact of cam 607. Relay 624, in operating, opens one holding circuit for relay 819 and that relay releases when the brushes are properly centered, as indicated by the position of brush 705 on commutator strip 706. Relay 819, released, closes a circuit from battery, through the winding of sequence switch magnet 600, upper left contact of cam 604, left back contact of relay 819 to ground over the lower right and upper left contacts of cam 608, advancing sequence switch 600 to position 2. With sequence switch 600 in position 3 a circuit is closed from ground over the upper left contact of cam 609, right back contact of relay 820, winding of relay 822, over the inner right contact of relay 810 to brush 703, conductor 233, right back contact of relay 226, middle right contact of relay 222 to the winding of relay 220 and battery. Relays 822 and 220 operate in this circuit.

The operation of relay 220 prepares the trunk circuit for the connection between the toll operator's position and the B operator's position. For this purpose it closes a circuit from battery through resistance 236 over the outer left front contact of relay 220, upper right winding of repeating coil 204, middle right contact of relay 220, left normal contact of relay 226, conductor 237 to brush 701 of the trunk finder, and connects ground over its inner left contact through the lower right winding of repeating coil 204, inner right front contact of relay 220, inner left back contact of relay 226 to conductor 238 and brush 702. Relay 220 also opens the circuit of supervisory relay 212 to prevent its premature operation and furthermore closes an obvious circuit for relay 221 which prepares a locking circuit for itself from battery through its winding and the winding of relay 226, inner left front contact of relay 221 to ground at either the front contact of relay 227 or the front contact of relay 223 depending upon which of these is operated, neither being operated at the present time. Relay 221, in operating, signals the link circuit that the operator's talking circuit has been established through the trunk circuit by transferring conductor 232 from battery through resistance 234 to ground through the winding of relay 227.

In the link circuit, relay 822 which operated in series with relay 220, locks in a circuit from battery over conductor 233, brush 703, inner right back contact of relay 810, winding of relay 822, right back contact of relay 820, left front contact of relay 822, to ground over the upper right contact of cam 609. With sequence switch 600 in position 3, conductor 232 is extended over brush 704, left back contact of relay 810, through resistance 625 to ground at the lower right contact of cam 609 in parallel with the circuit previously traced through the winding of relay 624 to ground

over the lower right contact of cam 607. Therefore, when relay 221 substitutes ground for battery on conductor 232, relay 624 releases quickly, closing a circuit from battery through the winding of relay 819, lower left and upper right contacts of cam 626, right contacts of cam 619, back contact of relay 624 to ground over commutator strip 711 and brush 710. Relay 819 locks over its inner left front contact, right contacts of cam 619, back contact of relay 624 to commutator strip 711.

As soon as sequence switch 600 arrived in position 2, a circuit was closed from battery through the winding of relay 618, lower back contact of relay 740, lower left contact of cam 609 to ground. Relay 618, in operating, prepares the test circuit for the position finder 800 by closing a circuit from battery through the middle winding of relay 740, upper left and lower right contacts of cam 603, lower winding of relay 740, left front contact of relay 618, lower left contact of cam 609 to ground. At the same time a branch of this circuit is extended from ground through the lower winding of relay 740, as traced, and thence through the upper winding of relay 740, over the lower back contact of relay 739, left back contact of relay 830, right back contact of relay 829, to brush 801 of switch 800 which has access to the operators' positions. Relay 618 also causes the operation of the position finder by closing a circuit from ground over the lower left contact of cam 602, outermost upper contact of relay 739, upper back contact of relay 740, lower contact of jack 823 or the back contact of relay 827, right front contact of relay 618, lower contacts of cam 605, back contact of stepping magnet 807, inner left back contact of relay 829, right back contact of relay 814 to the winding of relay 610 and battery. Relay 610 closes an operating circuit for magnet 807 which may be traced from battery through the winding of that magnet, over the right contacts of relay 610 to the upper right contact of cam 605 and thence over the operating circuit for relay 610. Magnet 807 opens the operating circuit for relay 610 which thereupon releases and in turn releases the magnet which advances position finder 800 to the next position. On the release of magnet 807, the circuit for relay 610 is reclosed and the magnet and relay operate alternately until an idle position is found.

The operator's position shown in Fig. 13, is occupied by the connection of the operator's headset to the position circuit by means of a plug and jack arrangement (not shown). When the connection has been made, a circuit is closed from ground through the right winding of repeating coil 1340 through transmitter 1341, winding of relay 1326 to battery. Relay 1326, in operating, connects battery over its lower front contact, normal contact of key 1315, upper normal contact of relay 1324 through resistance 1313 to conductor 841 to mark the position idle and occupied.

When the idle position is found, battery connected over conductor 841 to the terminal of brush 801 operates relay 740 which opens the operating circuits of relay 610 and magnet 807, bringing the position finder 800 to rest. Relay 740 locks in a circuit from battery on brush 801 through its upper winding as previously traced and thence over its upper front contact and the upper normal contact of relay 739 to ground at the lower left contact of cam 602. The operation of relay 740 opens the circuit of relay 618 which releases after an interval. When relay 618 closes its back contact, a circuit is completed from bat-

tery through the winding of relay 817, outer left back contact of relay 829, right contacts of cam 614, left back contact of relay 618, lower front contact of relay 740 to ground at the lower left contact of cam 609. Relay 817 locks in a circuit which extends through its winding over the left back contact of relay 829, outer left front contact of relay 817, over the lower contacts of cam 611, outer left front contact of relay 822 to ground at the upper right contact of cam 609. Relay 817 also closes a circuit from battery through the winding of relay 814, inner left front contact of relay 817, to ground over the upper right contact of cam 609. With relay 814 operated, a circuit is closed from battery through the winding of sequence switch magnet 600, lower right contact of cam 604, outer left front contact of relay 819, outer right front contact of relay 814 to ground over the upper contacts of cam 608, advancing sequence switch 600 to position 4.

As soon as the sequence switch reaches position 3 $\frac{3}{4}$, battery through resistance 613 is also connected to brush 704 over the left contacts of cam 614. When sequence switch 600 leaves position 3, relay 624 is disconnected from brush 704, although ground through resistance 625 remains connected thereto. This potentiometer arrangement holds the terminal on which brush 704 is resting at such a potential that no other trunk selector will pick this trunk but relay 227 operates. The advance of sequence switch 600 from position 3 also opens the locking circuit of relay 510 and permits the further extension of calls in this group. With relay 814 operated, the tip and ring brushes of the trunk finder are connected through to the tip and ring brushes of the position finder. The circuits may be traced from the tip brush 701, middle right back contact of relay 810, right winding of relay 811, inner left front contact of relay 814 to brush 805 and from ring brush 702, outer right back contact of relay 810, left contacts of cam 616, right front contact of relay 822, resistance 813, left front contact of relay 814, right winding of relay 811, middle left contact of relay 814 to brush 806. Condenser 812 is bridged across resistance 813 and the contacts of cam 616.

In the operator's position, a circuit extends from brush 805, conductor 845, winding of relay 1337, conductor 846 to brush 806. Since battery and ground are supplied to brushes 701 and 702 as previously described, a circuit is completed in which relay 1337 operates. However, the windings of relay 811 are differentially arranged so that it does not operate at this time. Relay 1337, in operating, connects the tip conductor over its upper front contact and the inner upper back contact of relay 1338 through the secondary winding of tone coil 1339, inner lower back contact of relay 1338 and condenser 1342 to the ring conductor, thereby establishing the order tone circuit from the trunk to the position. With relay 1337 operated, a circuit is closed from battery over the lower front contact of relay 1326, lower front contact of relay 1337 through lamp 1319, lower back contact of relay 1332 to ground at the inner upper contact of relay 1336, thereby lighting lamp 1319 as an indication to the operator that a call is incoming at her position. This same battery extends over conductor 1350 to the operating contacts of keys 1309 to 1309 to prepare the keyset for pulsing. A circuit also extends from conductor 1350 through the winding of relay 1324 to ground. Relay 1324, in operating, disconnects battery from brush 801 thereby

releasing relay 740 in the link circuit. In addition, relay 1324 closes a circuit from battery over the lower front contact of relay 1326, right normal contact of key 1315, outer upper front contact of relay 1324 through lamp 1328 to interrupter 1327 causing lamp 1328 to flash. Relay 1324 connects tone over its inner lower front contact, lower back contact of relay 1321, lower back contact of relay 1323, right winding of tone coil 1339 to ground at the back contact of relay 1338. This tone is induced in the left winding of repeating coil 1339 and is transmitted thence to the toll operator's headset. A portion of this tone is also transmitted to the B operator's headset through condenser 1343, left windings of repeating coil 1340, left normal contact of key 1315 and condenser 1345. Relay 1324 also closes a circuit from battery through the winding of relay 1323, upper back contact of relay 1338, conductor 1347, outer lower front contact of relay 1324 to ground at the upper front contact of relay 1326. Relay 1323, in operating, opens the circuit of the tone coil 1339, interrupting the tone to the toll or A operator. It also closes a circuit from grounded conductor 1347 over its front contact to the winding of relay 1322. This relay again completes the circuit of the tone coil over the front contacts of relays 1323 and 1322 and the back contact of relay 1321. It further closes a circuit from battery through the winding of relay 1321, upper front contact of relay 1322 to grounded conductor 1347. Relay 1321, in operating, again opens the tone circuit and completes a circuit from battery through the winding of relay 1338, upper front contact of relay 1321 to ground on conductor 1347. Relay 1338 further opens the primary circuit of the tone coil and opens the secondary circuit as well. It extends the tip and ring conductors to the left windings of the operator's repeating coil 1340, through condenser 1342. Relay 1338 connects ground over its lower front contact in shunt of interrupter 1327 so that lamp 1328 is now lighted steadily as an indication that the wanted number will now be passed by the A or toll operator. The operation of relay 1338 furthermore releases relays 1323, 1322, and 1321 in turn.

The release of relay 740 as previously described, closes a circuit from battery through the winding of sequence switch magnet 600, upper right and lower left contacts of cam 603, lower contact of jack 823, upper back contact of relay 740, outer upper back contact of relay 739 to ground over the lower left contact of cam 602 advancing sequence switch 600 to position 5. In this position a circuit is closed from battery through the winding of relay 830, upper right contact of cam 607 to ground. Relay 830 initiates the connection of the link circuit with an idle sender. It closes a circuit from battery through the winding of relay 618, lower back contact of relay 740, outer right front contact of relay 830, upper right contact of cam 606 to ground. With both relays 830 and 618 operated, the test relay 740 is again prepared and associated with the sender finder 720. A circuit is closed from battery through the middle winding of relay 740, upper left and lower right contacts of cam 603, lower winding of relay 740, left front contact of relay 618, outer right front contact of relay 830 to ground at the upper right contact of cam 606. A circuit also extends from ground through the lower winding of relay 740 as traced and from there through the upper winding of relay 740, lower back contact of relay 739, outer left front contact of relay 830 to brush 75

723 of the sender selector. An idle sender is characterized by the connection of battery through resistance 1208 over the left back contact of relay 1207 and the inner right back contact of relay 1201 to conductor 753 and the terminal to which brush 723 has access. If the sender selector 720 is resting on the terminal of a busy sender when the circuits for relay 740 are closed, relay 740 will remain unoperated, and a circuit will be closed from battery through the left winding of relay 818, upper left and lower right contacts of cam 605, right front contact of relay 618, lower contacts of jack 823, upper back contact of relay 740, upper back contact of relay 739 to ground at the lower left contact of cam 602. Relay 818 is made slow to operate by its short-circuited right winding to prevent its operating prematurely when an idle sender is encountered. When relay 818 closes its right contact, a circuit is closed from ground over that contact, to the winding of relay 618 to hold that relay energized. A circuit is also closed from battery through the winding of updrive magnet 736 of the sender selector, outer left front contact of relay 818, upper back contact of relay 739 to ground at the lower left contact of cam 602, causing the sender selector to move upward in search of an idle sender. Relay 818 is held operated over its inner left front contact to ground over the commutator strip 728 and brush 727 to insure that the selector brushes will be centered.

When an idle sender is found, relay 740 operates and when the sender selector is centered, relay 818 releases, in turn releasing the updrive magnet 736 and bringing the selector to rest. With relay 818 released and relay 740 operated, the circuit of relay 818 is opened and that relay releases after an interval. When relay 818 closes its back contact, a circuit is closed from battery through the winding of relay 741, inner left front contact of relay 830, left back contact of relay 618, lower front contact of relay 740, outer right front contact of relay 830 to ground at the upper right contact of cam 606. Relay 741 locks over its inner lower front contact and the inner right front contact of relay 830, back contact of relay 815 to brush 722 which is connected over conductor 752 and the left back contact of relay 1201 to ground, holding relay 741 operated. Relay 741 closes a circuit from battery through the winding of sequence switch magnet 600, outer upper front contact of relay 741 to ground over the left contacts of cam 608, advancing sequence switch 600 to position 6. Relay 741, in operating, closes a new holding circuit for relay 817 which extends as previously traced to the outer left contact of relay 817 and thence over the middle upper front contact of relay 741, outer left front contact of relay 822, upper right contact of cam 609 to ground.

With sequence switch 600 in position 6, a circuit is closed from ground over the lower right contact of cam 606 through resistance 738 to brush 726 to mark the sender busy. In the sender this circuit extends over conductor 756 through the winding of relay 1207 to battery. Relay 1207, in operating, disconnects battery through resistance 1208 from the terminal of brush 723 thereby releasing relay 740. The operation of relay 1207 in the sender, in addition to removing the idle battery indication, closes an off-normal ground at its right contact to conductor 1221 to provide locking circuits for the sender relays. The connection of ground to conductor 1221 also completes a circuit over the left back

contact of relay 1211 to the winding of relay 1205 and battery. In addition, it completes a circuit over the back contact of relay 1130, inner left normal contact of relay 1211, back contact of relay 1522, through the winding of relay 1512 to battery. Relay 1512 locks through the lower winding of relay 1522, outer upper front contact of relay 1512, left front contact of relay 1205 to grounded conductor 1221. Relay 1512 closes a circuit from battery through the winding of relay 1511, inner lower front contact of relay 1512 to ground at the outer left back contact of relay 1201.

With both sender and position circuits connected to the link circuit, a circuit is established from battery over the lower front contact of relay 1326, lower front contact of relay 1337, inner lower back contact of relay 1336, through resistances 1344 and 1325, inner upper front contact of relay 1324, conductor 844, brush 804, inner right front contact of relay 817, upper right and lower left contacts of cam 623, brush 724, conductor 754, left back contact of relay 1209 through the winding of relay 1210, conductor 1223, inner right normal contact of relay 1220, left winding of relay 1214, conductor 1224, lower back contact of relay 1502, upper winding of relay 1505, lower winding of relay 1504 to ground. A similar circuit is closed from the lower front contact of relay 1326, front contact of relay 1337, outer lower back contact of relay 1336 through resistances 1312 and 1314 in series, conductor 843, brush 803, right contacts of cam 601, outer right front contact of relay 817, brush 725, conductor 755, right back contact of relay 1209 through the winding of relay 1217 to conductor 1223 and thence to ground as traced. Relays 1210, 1217, 1214 and 1504 operate. Relay 1505, being marginal, does not operate. The joint operation of relays 1210 and 1217 closes a circuit from battery through the left winding of relay 1220, front contacts of relays 1210 and 1217 to grounded conductor 1221. The operation of relay 1220 disconnects the windings of relays 1214 and 1505 from conductor 1223 thereby releasing these relays. At the same time it closes a holding circuit for itself and relays 1210 and 1217 from grounded conductor 1221 through the right winding and right front contact of relay 1220 to the windings of relays 1210 and 1217 in parallel and thence to battery at the position as previously traced.

Relay 1220 operates the transfer relays to prepare the sender for registration, closing a circuit from battery through the winding of relay 1412, winding of relay 1411, left front contact of relay 1220 to grounded conductor 1221. Relays 1412 and 1411 lock over the front contact of relay 1411 to grounded conductor 1221. With relay 1411 operated, a circuit is closed from battery through the windings of relays 1422 and 1421 over the lower front contact of relay 1411 to grounded conductor 1221 and these two relays lock over the contact of relay 1421 to conductor 1221. Similarly, the operation of relay 1421 causes the operation and locking of relays 1502 and 1501 and they, in turn, close a circuit from battery through resistance 1531, winding of relay 1401, lower front contact of relay 1501 to grounded conductor 1221. Relay 1401 also locks directly to conductor 1221.

With the transfer relays 1412, 1422 and 1502 operated, a signal is transmitted to the position to indicate that the sender is ready to receive the wanted number, by closing a circuit from 75

battery over the right back contact of relay 1218, through resistance 1219, upper winding of relay 1406, outer lower front contacts of relays 1412 and 1422 and the outer upper front contact of relay 1502, conductor 1225, right winding of relay 1214, inner left back contact of relay 1201, conductor 751, over brush 721, lower front contact of relay 741, inner right front contact of relay 814, brush 802, conductor 842, winding of relay 1333, lower back contact of relay 1334, upper back contact of relay 1332 to ground over key 1316. Relay 1333 operates in this circuit closing a circuit from battery over conductor 842 as previously traced, through the winding and upper front contact of relay 1333 to ground over conductor 1347. It also connects a substitute ground over its inner lower front contact and the back contact of relay 1332 to lamp 1319. In addition, a circuit is closed from battery over the lower front contact of relay 1326, lower front contact of relay 1337 through the winding of relay 1334, inner upper front contact of relay 1333 to ground over the locking circuit of relay 1333. Relay 1334, in turn, locks over its lower front contact and the upper back contact of relay 1332 to ground over key 1316. With relay 1334 operated, a circuit is closed from battery through the winding of relay 1335, inner upper front contact of relay 1334 to grounded conductor 1347. Relay 1336, in operating, disconnects battery from conductors 843 and 844 and ground from lamp 1319.

The removal of battery from conductors 843 and 844 releases relays 1210, 1217 and 1220. Relay 1220 at its left back contact again connects ground from conductor 1221 to conductor 1222. A circuit is thereupon closed from battery over the right back contact of relay 1213 through the winding of relay 1218 over the upper front contact of relay 1401 to grounded conductor 1222. Relay 1218 locks over its middle right contact to grounded conductor 1222, connects battery to the winding of relay 1213 and ground to the windings of relays 1406 and 1506 in preparation for registration. Relay 1218 also opens the circuit through relays 1214 and 1333 thereby releasing both of these relays. The release of relay 1333 extinguishes lamp 1319 to indicate to the operator that she may now record the wanted number.

In the registration of designations on the sender, three circuits are selectively employed. These circuits are as follows: (A) from battery on conductor 1350 over contacts of keys 1301 and 1306 directly or through high resistance 1344 over contacts of keys 1302 and 1307 through low resistance 1325, inner upper front contact of relay 1324, conductor 844, brush 804, inner right front contact of relay 817, upper right and lower left contacts of cam 623, brush 724, conductor 754, left back contact of relay 1209, winding of relay 1210, conductor 1223, inner right normal contact of relay 1220, left winding of relay 1214 to conductor 1224 and through the register relays according to the transfer relays operated. For the first digit, this circuit extends over the outer lower front contact of relay 1502, outer upper front contacts of relays 1422 and 1412, through the lower windings of marginal relay 1405 and sensitive relay 1404 to ground. (B) From battery on conductor 1350 over contacts of keys 1303 and 1308 directly or through high resistance 1312 over the contacts of keys 1304 and 1309, low resistance 1314, conductor 843, brush 803, right contacts of cam 601, outer right front contact of relay 817, brush 725, conductor 755, right back contact of

relay 1209 through the winding of relay 1217, conductor 1223, inner right back contact of relay 1220, left winding of relay 1214 to conductor 1224 and through the register relays as traced for circuit A. (C) From battery on conductor 1350, over contacts of keys 1300 to 1304 directly or through high resistance 1311 over contacts of keys 1305 to 1309 through low resistance 1335, outer upper front contact of relay 1334, lower back contact of relay 1333 through the upper winding of relay 1317, conductor 842, brush 802, inner right front contact of relay 814, outer lower front contact of relay 741, brush 721, conductor 751, inner left back contact of relay 1201, right winding of relay 1214 to conductor 1225 and through the registers according to the operated condition of the transfer relays. For the first digit, the circuit extends over the outer upper front contact of relay 1502, outer lower front contacts of relays 1422 and 1412, through the upper winding of relay 1406, over the outer left front contact of relay 1218 to grounded conductor 1222.

It will be apparent from the foregoing that the circuit of relay 1317 is closed whenever a digit key is operated. Therefore, relay 1317 operates when the first digit key is operated and locks in a circuit from battery through its lower winding and front contact to grounded conductor 1347, remaining operated throughout the registration. It also connects peg count meter 1318 to grounded conductor 1347 thereby recording the handling of one call.

Assuming that the wanted number is 1379, keys 1301, 1303, 1307 and 1309 will be operated in succession. As set forth in a previous paragraph, key 1301 connects battery through low resistance 1325 to conductor 844 and through the winding of relay 1317 to conductor 842. Key 1303 connects battery through low resistance 1314 to conductor 843 and through the winding of relay 1317 to conductor 842. Key 1307 connects battery through high resistance 1344 and low resistance 1325 to conductor 844 and through high resistance 1311, low resistance 1335 and the winding of relay 1317 to conductor 842. Key 1309 connects battery through high resistance 1312 and low resistance 1314 to conductor 843 and through high resistance 1311, low resistance 1335 and the winding of relay 1317 to conductor 842. In the sender the connection of battery to conductor 844 by key 1301 completes a circuit for relays 1210, 1214, 1405 and 1404 and the connection of battery to conductor 842 completes the circuit for relays 1214 and 1406. Since only a low resistance is included in either circuit, relays 1210, 1214, 1404, 1405 and 1406 operate. Relays 1404, 1405 and 1406 lock to grounded conductor 1222 and relay 1404 closes an obvious circuit for relay 1408. Relay 1210 has no function at this time, but relay 1214 closes a circuit from grounded conductor 1222 over its left front contact, inner lower front contact of relays 1502, 1422 and 1412, winding of relay 1412 holding that relay operated and shunting the winding of relay 1411 thereby releasing relay 1411 and opening the locking circuit of relay 1412. When the operator releases key 1301, battery is removed from conductors 842 and 844, releasing relays 1210 and 1214 and the release of relay 1214 permits relay 1412 to release and prepare the circuits for receiving the next digit. Relays 1404, 1405, 1406 and 1408 remain operated to register the digit 1.

The operation of key 1303 with relays 1411 and 1412 released, completes the circuit of relays 1217, 75

1214, 1415 and 1414 over conductor 843 and the circuit of relays 1214 and 1416 over conductor 842. A low resistance being connected to both circuits, relays 1414, 1415 and 1416 operate and lock to conductor 1222. Relay 1217, in operating, closes a circuit from grounded conductor 1221 over the front contact of relay 1217, outer right back contact of relay 1220 over the inner upper front contacts of relays 1502 and 1422, inner upper back contact of relay 1412 to the winding of relay 1413 and battery. Relay 1413 also locks over its inner upper front contact to conductor 1222. Relay 1214 closes a circuit from grounded conductor 1222 over its left front contact, inner lower front contacts of relays 1502 and 1422 inner lower back contact of relay 1412 to the winding of relay 1422, holding that relay operated and shunting relay 1421 which releases. When key 1303 is released, relays 1217 and 1214 release, permitting relay 142 to also release and prepare the sender for receiving the tens digit. Relays 1413, 1414, 1415 and 1416 remain operated to record the hundreds digit 3.

The operation of key 1307 records the tens digit and with relays 1421 and 1422 released, completes the circuit of relays 1210, 1214, 1425 and 1424 as well as the circuit of relays 1214 and 1426. Since a high resistance is included in each of these circuits, marginal relays 1425 and 1426 are not operated and the only register relay to operate is relay 1424 which locks to grounded conductor 1222. Relay 1214 functions in the usual manner to release transfer relay 1501 at the beginning of the digit and relay 1502 at the termination of the digit, thereby preparing the sender circuit for the reception of the units digit. Relay 1424 is the only relay of the tens register to remain operated.

The operation of key 1309 to record the units digit with relays 1501 and 1502 released, completes the circuit of relays 1217, 1214, 1505 and 1504 as well as the circuit of relays 1214 and 1506. As in the case of the tens digit, the inclusion of a high resistance in these circuits prevents the operation of the marginal relays 1505 and 1506 but relay 1504 operates and locks to conductor 1222. In this case, however, the operation of relay 1217 closes a circuit from grounded conductor 1221 over its front contact, back contact of relay 1220, inner upper back contact of relay 1502 through the winding of relay 1503 and battery. Relay 1503 locks over its inner upper contact to grounded conductor 1222 and therefore relays 1503 and 1504 are operated to register the units digit. The operation of relay 1214 during the reception of the units digit closes a circuit from grounded conductor 1222 over the front contact of relay 1214, inner lower back contact of relay 1502 to resistance 1531 and battery in shunt of the winding of relay 1401 so that at the termination of the last digit, relay 1401 is also released. The release of relay 1401 followed by the release of relay 1214 when key 1309 is released, closes a circuit from battery through the winding of relay 1209, lower back contact of relay 1401, inner left front contact of relay 1218, left back contact of relay 1214 to grounded conductor 1222. Relay 1209 locks over its inner right contact to conductor 1222 and closes an obvious circuit for relay 1201.

The operation of relay 1201 indicates the completion of registration. Accordingly, relay 1201 disconnects ground from conductor 752, opening the locking circuit of relay 741 and releasing that relay. Relay 1209 disconnects conductors 754 and 755 from the windings of relays 1210 and 1217,

respectively, and connects them together over the outer left front contact of relay 1209, back contact of relay 1140, through the right winding of relay 1206, winding of relay 1204, inner front contact of relay 1205, back contact of relay 1204, inner front contact of relay 1205, back contact of relay 1213, and outer right front contact of relay 1209 thereby preparing the fundamental circuit for selections. At this time the winding of relay 1213 is connected between battery at the outer right front contact of relay 1218 and the fundamental circuit at the contact of relay 1213.

The release of relay 741 as above described opens the locking circuit for relay 817 which also releases in turn releasing relay 814. With relay 814 released, the circuit of relay 1337 is opened and that relay releases in turn releasing relays 1334, 1336, 1324, 1338 and 1317 thereby restoring the position circuit to normal.

With relay 817 released, the tip conductor of the fundamental circuit is opened at the inner right contact of that relay but the ring conductor is extended from conductor 755, brush 725, right back contact of relay 817, upper contacts of cam 616, outer right back contact of relay 810, brush 702 to conductor 238. Since relay 220 is still operated, a circuit is closed from ground over the inner left front contact of relay 220, lower right winding of repeating coil 264, inner right front contact of relay 220, inner left back contact of relay 226 to conductor 238 over the ring conductor of the fundamental circuit as above traced to conductor 755, right front contact of relay 1209, winding of relay 1213, outer right front contact of relay 1213 to battery. Relay 1213 operates in this circuit locking to battery at its right front contact. It also disconnects the windings of relays 1206 and 1204 from the fundamental ring conductor to prevent their premature operation. Relay 1213 opens the circuit of relay 1218 and that relay releases, disconnecting battery from the operating circuit of relay 1213. The release of relay 1213 prepares a local circuit for relay 1211 from grounded conductor 1222, left back contact of relay 1218, through the winding of relay 1211 and resistance 1212 to battery but relay 1211 can not operate since its winding is short-circuited at the back contact of relay 1521. A branch of this circuit extends from ground on conductor 1222, over the left back contact of relay 1218, left back contact of relay 1202, left front contact of relay 1201, conductor 751, brush 721, lower back contact of relay 741, left contacts of cam 626 to the winding of relay 819 and battery. Relay 819, in operating, closes a circuit from battery through the winding of relay 815, inner left front contact of relay 822, middle right contact of relay 819, lower left contact of cam 607 to ground. Relay 815 locks over its inner right front contact directly to this same ground and closes a circuit from ground over its outer right front contact, upper right contact of cam 604 to the winding of sequence switch magnet 600 and battery, advancing the sequence switch to position 7 from which position it is advanced to position 8 over its normal cam. With relay 815 operated and sequence switch 600 in position 3, the circuit of relay 1511 is extended over brush 722, outer left front contact of relay 815 through the right winding of relay 820 to ground over the upper contacts of cam 608. The resistance of relay 1511 is too great to permit relay 820 to operate but relay 1511 is held operated. The advance of sequence switch 600 from position 6 also releases relay 822.

Relay 815 also connects battery through re-

istance 816 over the middle right contact of relay 815, upper right and lower left contacts of cam 631, inner right back contact of relay 810, brush 703, conductor 233, right back contact of relay 226, middle right contact of relay 222 to the winding of relay 220 and battery. This releases relay 220, permitting relay 226 to operate in the locking circuit of relay 221. The release of relay 220 disconnects battery and ground from the right winding of repeating coil 204, opens the talking conductors extending from the repeating coil to the link circuit and reconnects relay 212 to the right windings of repeating coil 204. The disconnection of ground from the repeating coil opens the circuit of relay 1213 which releases, closing the fundamental circuit in the sender.

Relay 226, in operating, disconnects the incoming end of the trunk from the link circuit and connects the link circuit with the outgoing trunk, transferring conductor 237 from association with the repeating coil into direct connection with the tip conductor 241 of the outgoing trunk and conductor 238 from the connection with the repeating coil into connection with the ring conductor 242 of the outgoing trunk through resistance 230. Relay 226 disconnects relay 220 from conductor 233 and connects that conductor to ground through the winding of relay 223 and the left winding of relay 225. Since battery is connected to conductor 233 through resistance 816, over the circuit previously traced, relay 223 operates but relay 225 which is marginal does not. The operation of relay 223 closes a circuit from ground over the right contact of relay 223 to the locking circuit of relays 221 and 226, in parallel, with the front contact of relay 227.

With relay 226 operated and sequence switch 600 in position 8, the fundamental circuit may be traced from battery through the winding of relay 1715 of the incoming selector circuit, upper contacts of cam 1616 over the tip conductor 241 of the outgoing trunk, outer left front contact of relay 226, conductor 237, brush 791, middle right back contact of relay 810, inner right front contact of relay 815, lower contacts of cam 623, brush 724, conductor 754, outer left front contact of relay 1209, back contact of relay 1140 through the right winding of polarized relay 1206, winding of stepping relay 1204, inner contact of relay 1205, left back contact of relay 1213, outer right front contact of relay 1209, conductor 755, brush 725, right back contact of relay 817, upper contacts of cam 615, outer right back contact of relay 810, brush 792, conductor 238, inner left front contact of relay 226, resistance 230, over the ring conductor 242 extending between the two offices to ground over the left contacts of cam 1614 at the incoming selector. Relay 1715 operates in the fundamental circuit, closing a circuit from battery through the right winding of relay 1704, upper left contact of cam 1632, lower right contact of cam 1631, front contact of relay 1715, right contacts of cam 1621, upper contacts of cam 1622 to ground. Relay 1704 locks in a circuit which may be traced over its operating circuit as far as the lower right contact of cam 1621 and thence over the lower right contact of cam 1623, inner left front contact of relay 1704 to ground. Relay 1704, in operating, closes a circuit from battery through the winding of sequence switch magnet 1600, upper right contact of cam 1624, right front contact of relay 1704 to ground over the lower right and upper left contacts of cam 1622, advancing sequence

switch 1600 to position 2. When sequence switch 1600 reaches position 2, a circuit is closed from battery through the winding of updrive magnet 1719 over the lower contacts of cam 1623, left front contact of relay 1704 to ground, advancing the incoming selector in its brush selecting movement. As the selector moves upward a circuit is closed intermittently from ground over the upper left and lower right contacts of cam 1622, right front contact of relay 1704, lower left and upper right contacts of cam 1618, brush 1723, commutator strip 1727, lower left contact of cam 1601 to the fundamental circuit, holding relay 1715 and shunting the winding of relay 1204.

In the sender, relay 1204 operates in the fundamental circuit but relay 1206 being polarized does not receive current in the proper direction to operate it. Relay 1204 closes the counting relay circuit which extends at this time from ground over the inner upper back contact of relay 1524, front contact of relay 1204, outer lower front contact of relay 1512, outer lower front contact of relay 1406, lower front contact of relay 1405, lower front contact of relay 1408, lower back of relay 1407, lower back contacts of relays 1515 and 1516, winding of relay 1120 to battery. Relay 1120 locks through the windings of relays 1130 and 1140 in parallel, front contact of relay 1120 to ground at the middle upper front contact of relay 1512 but relays 1130 and 1140 do not operate at this time, being shunted by the operating circuit of relay 1120. When relay 1204 releases in response to the first revertive pulse from commutator 1727, it opens the operating circuit for relay 1120 and permits relays 1130 and 1140 to operate in the locking circuit of that relay. Relay 1140 opens the fundamental circuit causing relay 1715 to release. Relay 1130, in operating, first opens the operating circuit of relay 1512 thereby permitting relay 1522 to operate in the locking circuit of relay 1512. Relay 1522 closes an independent locking circuit for itself over its inner upper front contact to grounded conductor 1221. It also closes a substitute circuit for relay 1511. Relay 1130 then closes a circuit from grounded conductor 1221 over the front contact of relay 1130 to the winding of relay 1521 and battery. Relay 1521, in operating, opens the shunt around the winding of relay 1211, permitting that relay to operate. Relay 1211 opens the operating circuit for relay 1205 and that relay releases. Relay 1205, in releasing, opens the locking circuit for relay 1512 thereby permitting that relay to release. It also holds open the fundamental circuit until after the counting relays have been restored to normal. The release of relay 1512 opens the locking circuit for the counting relays and these relays release. Relay 1140 recloses the break made in the fundamental circuit at its contact and relay 1130 opens the circuit of relay 1521 which releases, reclosing the shunt around the winding of relay 1211 which again releases and closes the circuit for relay 1205. When relays 1130 and 1211 close their back contacts, a circuit is closed from grounded conductor 1221, over the back contact of relay 1130, inner back contact of relay 1211, over the lower front contact of relay 1522, which remains locked after relay 1512 releases, over the upper back contact of relay 1523 to the winding of relay 1513 and battery, preparing for incoming group selection. When relay 1205 reoperates, a locking circuit is closed for relay 1513 through the upper winding

of relay 1523, inner lower front contact of relay 1513, outer front contact of relay 1205 to grounded conductor 1221 and thereafter the fundamental circuit is closed at the inner contact of relay 1205.

In the incoming selector, the release of relay 1715, at the termination of brush selection, also releases relay 1704 which opens the circuit for the updrive magnet. 1719, bringing the selector to rest in position to trip the first set of brushes. The release of relay 1704 also closes a circuit from battery through the winding of sequence switch magnet 1600 over the upper left contact of cam 1634, inner left back contact of relay 1704 to ground. When sequence switch 1600 advances to position 3 and the fundamental circuit is reestablished in the sender, relay 1715 again operates, in turn operating relay 1704 over the circuit previously traced to the front contact of relay 1715 and from thence over the lower contacts of cam 1606, at the upper contacts of cam 1622 to ground. Relay 1704 locks in a circuit which extends as above traced to the contacts of cam 1606 and thence over the upper right and lower left contacts of cam 1618, right front contact of relay 1704 to ground over the lower right contact of cam 1622. Relay 1704, in operating, advances sequence switch 1600 to position 4 in a circuit over the lower left contact of cam 1634, left front contact of relay 1704 to ground. In position 4, the updrive magnet is reenergized and the selector advances in a group selecting operation. When sequence switch 1600 reached position 3, a circuit was closed for trip magnet 1721 extending from battery through the winding of that magnet over the upper right contact of cam 1630 to ground and this circuit is maintained through position 4 so that the proper brush set is tripped as the selector moves upward. For group selection, ground is connected to the commutator brushes over the front contact of relay 1704 the same as for brush selection and ground is intermittently connected over brush 1724, commutator strip 1728, the lower right and upper left contacts of cam 1601 to the tip conductor in shunt of the winding of relay 1204.

Relay 1204, in operating in the fundamental circuit for incoming brush selection, closes a circuit from ground over the inner upper back contact of relay 1524, front contact of relay 1204, outer lower front contact of relay 1513, outer upper front contact of relay 1405, inner upper front contact of relay 1406, lower front contact of relay 1416, right back contact of counting relay 1132, winding of counting relay 1122 to battery. Relay 1122 locks through the winding of relay 1132, front contact of relay 1122, to ground at the outer upper front contact of relay 1513, but relay 1132 does not operate, being shunted by the operating circuit of relay 1122. The first closure of the commutator circuit releasing relay 1204 permits relay 1132 to operate. When the commutator circuit is opened, relay 1204 reoperates and since relay 1132 is operated, the circuit controlled by relay 1204 is transferred over the front contact of relay 1132 and the back contact of relay 1131 to the winding of relay 1121 and battery. Relay 1121 locks through the winding of relay 1131 and the front contact of relay 1121 to ground at the inner upper front contact of relay 1513. The next closure of the commutator circuit permits the operation of relay 1131 in the locking circuit of relay 1121. With relay 1131 operated, the count-

ing relay circuit extends over the front contact of relay 1131, lower back contacts of relays 1515 and 1516 to the winding of relay 1128. In response to the third reverte pulse, relays 1130 and 1140 operate in the locking circuit of relay 1120 as previously described. As before, relay 1140 opens the fundamental circuit and relay 1130 operates relay 1521 to operate relay 1211 and release relay 1205. The operation of relay 1130 permits relay 1523 to operate and lock while the release of relay 1205, in turn, releases relay 1513. When the functions previously described have taken place and relays 1211 and 1130 are again released, relay 1514 is operated, locking through the upper winding of relay 1524, upper front contact of relay 1514 to ground over the outer contact of relay 1205 and grounded conductor 1221.

At the incoming selector, the opening of the fundamental circuit releases relay 1715 which in turn releases relay 1704. Relay 1704 advances sequence switch 1600 to position 5 in a circuit over the upper left contact of cam 1634, left back contact of relay 1704 to ground. In position 5, a circuit is closed from battery through resistance 1705, left winding of relay 1704, lower left and upper right contacts of cam 1620, to ground over the upper contacts of cams 1621 and 1622. Relay 1704 closes a circuit from battery through its right winding, lower contacts of cam 1618, right front contact of relay 1704, lower left contact of cam 1631, lower right contact of cam 1632 to sleeve brush 1712 to test whether the first final selector of the group on which the incoming selector is now resting is busy or idle. Relay 1704 also closes a circuit from battery through the winding of sequence switch magnet 1600, lower left contact of cam 1634, left front contact of relay 1704 to ground, to advance the sequence switch 1600 to position 6. In this position, the operating circuit of relay 1704 is opened, but the holding circuit is maintained if the final selector is busy. Assuming that it is busy, a circuit will be closed from battery through the winding of updrive magnet 1719 over the lower contacts of cam 1623, left front contact of relay 1704 to ground, advancing the selector in search of an idle final selector. During trunk hunting, ground is connected to the commutator brushes over the upper right contact of cam 1621, the lower right contact of cam 1623 and the front contact of relay 1704 and commutator strip 1726 is connected over the lower contacts of cam 1620 to the left winding of relay 1704. When an idle final selector is found, the circuit over brush 1711 for relay 1704 is opened and when the brushes are properly centered, the circuit over the commutator strip 1726 is also opened and relay 1704 releases, releasing magnet 1719 and bringing the selector to rest with its brushes engaging the 60 idle final selector. As soon as relay 1704 releases, ground is connected to the sleeve brush 1712 to mark the final selector busy to other incoming selectors. This circuit may be traced from ground over the upper left contact of cam 1622, left contact of cam 1630, right back contact of relay 1704, lower left contact of cam 1631, lower right contact of cam 1632 to brush 1712. With relay 1704 released, a circuit is closed from battery through the winding of sequence switch magnet 1600, upper left contact of cam 1634, inner left back contact of relay 1704 to ground, advancing sequence switch 1600 to position 7 from which position the sequence switch is ad-

vanced to position 8 over its local cam. When sequence switch 1600 reaches position 6¾, ground is connected to brush 1712 over the left contacts of cam 1622.

5 During trunk hunting, relay 1715 is held operated over the fundamental circuit, relay 1204 also remaining operated. With sequence switch 1600 in position 8, relay 1715 closes a circuit from battery through the right winding of relay 1704,
10 upper left contact of cam 1632, lower right contact of cam 1631, front contact of relay 1715, right contacts of cam 1606 to brush 1710 and thence over the tip conductor to the final selector. A circuit is also closed from battery through resistance 1705, right contacts of cam 1631 over
15 the front contact of relay 1715, right contacts of cam 1606 to brush 1710. Under these conditions, relay 1704 does not operate but a relay in the final selector does operate to prepare that circuit for functioning. During final selections,
20 commutator pulses are connected over brush 1711 and the lower right and upper left contacts of cam 1607 to the winding of relay 1715 in shunt of the winding of the stepping relay 1204 and relay
25 1715 is held operated.

In the sender, the counting relay circuit for final brush selection extends from the back contact of relay 1524 over the front contact of relay 1204, lower back contact of relay 1524, inner
30 lower front contact of relay 1514, upper front contact of relay 1415, outer upper front contacts of relays 1414 and right back contact of counting relay 1133 through the winding of relay 1123 to battery. Four commutator pulses from the
35 final selector result in the operation of relays 1130 and 1140 in the locking circuit of relay 1120. Relay 1140 opens the fundamental circuit releasing relay 1715 which disconnects relay 1704 from the final selector and advances that selector for the next selection. The operation of relay 1130 results in the previously described series
40 of operations after which the fundamental circuit is again established, operating relays 1715, 1204 and connecting relay 1704 to the final selector. The operation of relay 1130 also permits the operation of relay 1524 in the locking circuit
45 of relay 1514, relay 1524 locking to conductor 1221 independent of relay 1514 which releases when relay 1205 releases. When relays 1211 and 1130 release, relay 1515 operates in a manner
50 similar to relay 1514, etc.

The counting relay circuit for final tens selection now extends from ground over the lower front contact of relay 1524, over the front
55 contact of relay 1204 in the opposite direction from that formerly used, over the inner lower front contact of relay 1515, upper back contact of relay 1425, lower front contact of relay 1424, lower back contact of relay 1423, over the back
60 contact of relay 1132 to the winding of relay 1122 and battery. Two commutator pulses from the final selector permit the operation of relay 1131 in the locking circuit of relay 1121. Since relay 1515 is now operated, the counting relay circuit extends from the front contact of relay
65 1131, over the outer lower front contact of relay 1515 to the armature of relay 1426 and since this relay is unoperated, over the back contact thereof and the back contact of relay 1130 to the winding of relay 1129 and battery. The next
70 five reverte pulses operate relays 1129 to 1125 and 1139 to 1135, inclusive, while the eighth pulse permits relays 1130 and 1140 to operate in the locking circuit of relay 1120, opening the fundamental circuit and releasing relays 1715 and 1204.
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The operation of relay 1211 permits the operation of relay 1525 in the locking circuit of relay 1515. Relay 1525 locks independently to conductor 1221 and relay 1515 is released.

The counting relay circuit for final units selection extends over the lower front contact of relay 1524, front contact of relay 1204, inner
lower front contact of relay 1516, upper back contact of relay 1505, lower front contact of relay 1504, lower front contact of relay 1503, over the
10 right back contact of relay 1134 to the winding of relay 1124 and battery. When relay 1131 operates after four pulses, the counting relay circuit extends over its front contact, outer lower back contact of relay 1515, lower front contact of
15 relay 1516 over the upper back contact of relay 1506 to the right back contact of relay 1139 and through the winding of relay 1129 to battery. After five additional pulses, relays 1125 and 1135 are operated and the counting relay circuit extends
20 over the front contact of relay 1135 through the winding of relay 1120 which terminates the final units selection. At the end of this selection, relay 1526 is operated, locking to conductor 1221 and relay 1516 releases.
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When the final selector completes its units selection, it connects ground to both brushes 1710 and 1711. The connection of ground to brush 1711 holds relay 1715 operated, which closes the
previously traced circuit for relay 1704 to brush
30 1710. The connection of ground to that brush, therefore operates relay 1704. Relay 1704 closes a locking circuit for itself from battery through resistance 1705, left winding of relay 1704, lower left and upper right contacts of cam 1620, upper
35 left contact of cam 1621, lower right contact of cam 1623, left front contact of relay 1704, to ground. It also closes a circuit from battery through the winding of sequence switch magnet 1600, upper right contact of cam 1624, right front
40 contact of relay 1704 to ground over the lower right contact of cam 1622, advancing sequence switch 1600 to position 9, in which position relay 1704 releases. In this position reverse battery is connected to the fundamental circuit by means
45 of circuits which extend from the tip conductor 241 of the inter-office trunk over the upper left and lower right contacts of cam 1616 to ground, and from the ring conductor 242 of the inter-office trunk over the upper left and lower right
50 contacts of cam 1614 to battery through the winding of relay 1715.

After the completion of final selections the fundamental circuit is reestablished in the sender as previously traced. The connection of reverse
55 battery to the circuit as a signal for the sender dismissal operates both relays 1204 and 1205. Relay 1206 in operating closes a locking circuit for itself from battery through its left winding over the right normal contact of relay 1202, front
60 contact of relay 1205 to grounded conductor 1221. Relay 1206 also closes a circuit from grounded conductor 1221 over its front contact to the winding of relay 1203 and battery. Relays 1203 and 1204 jointly close a circuit from battery through
65 the winding of relay 1120 over the outer right front contact of relay 1203, inner upper front contact of relay 1524, front contact of relay 1204 to ground over the outer lower front contact of relay 1524. Relays 1120, 1130 and 1140 are
70 connected in a circuit from battery through the winding of relay 1120, windings of relays 1130 and 1140 in parallel, to ground over the inner right front contact of relay 1203, but relays 1130 and 1140 can not operate being shunted by the oper-
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turn releasing relay 1602 which again connects relay 1708 to the inter-office trunk, reoperating relay 212 which again releases relay 210, connecting battery and ground to the trunk conductors leading to the long distance office and causing the lamp at that office to light as a disconnect signal. When the long distance operator removes the plug of cord 202 from jack 203, relay 219 releases, in turn releasing relays 214 and 213. Relay 214, in releasing, disconnects ground from in shunt of the winding of relay 218. When interrupter 224 closes its right contact, a circuit is closed from ground at the outer upper front contact of relay 206, right contact of interrupter 224, left back contact of relay 215, outer lower front contact of relay 206, winding of relay 218, resistance 217 to battery. Relay 218 operates in this circuit locking over its right front contact to ground at the upper contact of relay 206. When now interrupter 224 closes its left contact, ground from the front contact of relay 206 extends over the left contact of interrupter 224, left front contact of relay 218, winding of relay 215, resistance 216 to battery. Relay 215 locks over its inner left contact to ground at the front contact of relay 206. When interrupter 224 closes its right contact ground is connected over the outer left front contact of relay 215, to resistance 217 in shunt of the winding 218 which thereupon releases. With relay 218 released and relay 215 operated, the next closure of the left contact of interrupter 224 connects ground over the left back contact of relay 218, the outer right front contact of relay 215 to the winding of relay 206 in shunt of battery through resistance 239 thereby causing the release of relay 206. The release of relay 206 opens the locking circuit of relay 215 which also releases.

The release of relay 206 disconnects relay 212 from the windings of relay 1708 and that relay in turn releases, releasing relays 1706, 1709 in cascade. With relay 1709 released, a circuit is closed from battery through the winding of sequence switch magnet 1600, upper right contact of cam 1634, over the left back contact of relay 1709 to ground, advancing sequence switch 1600 to position 16. In position 16, a circuit is closed from battery through the winding of downdrive magnet 1720, lower right contact of cam 1630, upper left contact of cam 1622 to ground, restoring the incoming selector to normal. When the selector reaches its lowermost position, a circuit is closed from battery through the winding of sequence switch magnet 1600, lower left contact of cam 1624, normal commutator segment 1725, brush 1722, upper contacts of cam 1622 to ground, advancing sequence switch 1600 to position 17. Sequence switch 1600 is advanced to position 13 over the lower contacts of cams 1634 and 1633 and to position 1 over the upper left contact of cam 1634 and the inner left back contact of relay 1704. The advance of sequence switch 1600 from position 14 1/4 removes ground from the sleeve brush 1712, thereby permitting the final selector to restore to normal.

Local call

As mentioned above, while the centralized B office forming the subject matter of this application is intended primarily to act as an intermediary between two outlying offices, it is also used to complete calls originated in the same building, in which case the calling A operator may have access to the B operator by means of a three-wire trunk instead of the two-wire trunk described and shown in Fig. 2. Since the subscriber

at substation 300 is located in a panel dial office, he would ordinarily reach a wanted subscriber's line by means of his own dial equipment but if difficulty is encountered or for some other reason he may call on the A operator for assistance. The A operator will then insert the calling plug of her cord circuit 302 in jack 303 of the local trunk. This completes a circuit from battery on the sleeve of the cord through the winding of relay 336 to ground. At the same time a circuit is closed from battery over the operator's cord circuit, over the ring of the plug and jack 303, lower left winding of repeating coil 304, both windings of relay 319 in series, upper left winding of repeating coil 304, tip contacts of jack 303 and cord 302 to ground. Relay 319 operates in this circuit, closing a circuit from ground over its left front contact through the winding of relay 314 to battery. Relay 314 closes a circuit from ground over its front contact, lower normal contact of relay 306, outer left back contact of relay 321, winding of relay 318 to battery at the left back contact of relay 325. Relay 318, in operating, closes a holding circuit for itself from battery over the back contact of relay 325, winding of relay 318, inner right front contact of that relay, over the lower normal contact of relay 306 to ground over the front contacts of relay 314 or of relays 336 and 319. It also closes a circuit from ground over its outer right front contact through the winding of relay 310 to battery, relay 310 in turn operating relay 313. Relay 314 closes a locking circuit for itself over the front contact of relay 336 to ground at the front contact of relay 314. Relay 318, in operating, closes a circuit from ground at its middle right front contact, over the outer right back contact of relay 321 to start conductor 331 which extends over the normal contact of jack 501 to the lower winding of relay 509 in parallel with the circuit previously traced from the trunk of Fig. 2. It likewise closes a circuit from battery through resistance 339 over its inner left front contact, inner right back contact of relay 321 to conductor 332 which terminates before brush 704 of the link circuit to mark the trunk as calling to the link circuit. The link circuit functions as previously described to hunt for and connect with the calling trunk. When brush 704 engages the terminal marked by battery, relay 624 of the link circuit operates. When the link sequence switch 600 reaches position 3, ground through the winding of relay 822 is connected to conductor 333 and thence over the outer left back contact of relay 326, outer left contact of relay 318, through the winding of relay 320 to battery. Relay 320 prepares the operator's talking circuit by closing a circuit from ground over its middle left front contact through the lower right winding of repeating coil 304, lower back contact of relay 305, inner left front contact of relay 320, inner left back contact of relay 326, conductor 338 to brush 702 and from brush 701, conductor 337, inner right normal contact of relay 326, inner right front contact of relay 320, upper back contact of relay 305, upper right winding of repeating coil 304, outer right front contact of relay 320 to battery through resistance 334, thus preparing for the transfer of the wanted number. Relay 320 also closes a circuit from ground over its outer left front contact through the winding of relay 321 and battery. Relay 321 prepares a locking circuit for itself through the winding of relay 326, inner left front contact of relay 321 to ground at the front contact of either relay 323 or relay 327, 75

the winding of relay 326 being shunted by the front contact of relay 320. The link circuit continues to function as previously described to find an idle position circuit which then transmits the order tone to the A operator who in turn passes the number to the B operator. Relay 321, in operating, also disconnected ground from start conductor 331 permitting the start circuit to assign another link. It also closes a circuit from ground through the winding of relay 327, inner right front contact of relay 321, conductor 332, brush 704, left back contact of relay 810, left contacts of cam 614 to battery through resistance 613 and through resistance 625 and the lower right contact of cam 609 to ground, this potentiometer arrangement serving to mark the trunk busy to other link circuits. Relay 327 operates in series with the reduced battery potential provided by battery and ground through resistances 613 and 625, completing the holding circuit for relay 321 at its right front contact but relay 326 is still non-operated, being shunted by the front contact of relay 320. When the sender is ready to make selections, this is indicated to the link circuit as above described and the link circuit connects battery through resistance 816 over the middle right contact of relay 815, upper right and lower left contacts of cam 631, inner right back contact of relay 810, brush 703 to conductor 333 and thence to the winding of relay 320 causing that relay to release. With relay 320 released, relay 326 operates in the locking circuit above traced. A circuit is also closed from ground through the right winding of relay 325, winding of relay 323, outer left front contact of relay 326 to conductor 333 and battery as above traced thereby operating relay 323, but not operating relay 325 which is marginal. Relay 323 closes a second holding ground for relays 321 and 326 and also closes a parallel holding circuit for relay 310. The release of relay 320 disconnects the battery and ground supplied to the link circuit and position circuit and reconnects relay 312 over the right back contact of relay 320 to the right windings of repeating coil 304.

With relay 325 operated, the fundamental circuit is established from battery through the winding of relay 1015, upper contacts of cam 916, tip conductor 341 of the inter-office trunk, inner right front contact of relay 326, conductor 337, brush 701 and thence through the link circuit and sender including the windings of relays 1204 and 1206 back to brush 702, conductor 338, inner left front contact of relay 326, resistance 330, ring conductor 342 of the inter-office trunk to ground over the left contacts of cam 914. The incoming selector functions in a manner similar to the incoming selector of Figs. 16 and 17. Relay 1015 operates relay 1004 which in turn controls the updrive magnet and the sequence switch 900 in the selection of an idle final selector. As in the previously described case, relay 1015 is connected to the ring brush 1041 during final selections, connecting relay 1004 to the tip brush 1040. When final selections are completed, the final selector connects ground to both tip and ring conductors operating relays 1015 and 1004 in succession. Relay 1004 locks in a circuit from battery through resistance 1005, right winding of relay 1004, lower left contacts of cams 920 and 918, right front contact of relay 1004 to ground over the upper contacts of cam 926. Relay 1004 also closes a circuit from battery through the winding of sequence switch magnet 900, upper right contact of cam 924, left front contact of relay 1004 to ground over the

left contacts of cam 933. Sequence switch 900 advances to position 9, releasing relay 1004. In position 9 the tip conductor 341 of the inter-office trunk is extended over the left contacts of cam 925 to ground and the ring conductor 342 is extended over the upper left and lower right contacts of cam 914 to the winding of relay 1015 and battery. This reverse battery circuit causes the sender to release and advance the link circuit as previously described.

With sequence switch 900 in positions 7 to 9, a circuit is closed from battery through the right winding of relay 1006, right contacts of cam 931, right back contact of relay 1004 to ground over the upper contacts of cam 926. Relay 1006 closes a circuit for relay 1009 which in turn closes a holding circuit for relay 1006 in positions 8 and $8\frac{1}{4}$ through the left winding of that relay, left contacts of cam 929 to ground at the outer right contact of relay 1009. This circuit holds relay 1006 operated during the time that relay 1004 is operated.

Relay 1015 operates in the reverse battery circuit, in turn operating relay 1004 which locks in a circuit from battery through the left winding of relay 1004, lower left and upper right contacts of cam 921, left front contact of relay 1004, left contacts of cam 933 to ground. When relay 1004 operates, relay 1006 releases, in turn releasing relay 1009. Since relay 1009 is slow to release, it delays the advance of sequence switch 900 from position 9 to give additional time for the reverse battery interval to the sender to insure the sender relays properly performing their function. When relay 1009 closes its normal contact, a circuit is closed from battery through the winding of sequence switch magnet 900, normal contact of relay 1009, normal contact of relay 1010 to ground over the upper right and lower left contacts of cam 922. Sequence switch 900 advances out of position 9 in this circuit and moves to position 11 under the control of its local cam. Relay 1004 releases when sequence switch 900 leaves position 9.

As sequence switch 900 passes through positions 10 to $10\frac{1}{4}$, battery through the resistance 1005 is connected over the left contacts of cam 901 to conductor 341 and over the upper right contact of cam 901 to the tip side of condenser 940 while ground is connected over the left contacts of cam 914 to conductor 342 and over the upper right contact of cam 914 to the ring side of condenser 940 to charge the capacity of the cable as well as the condenser 940. When sequence switch 940 reaches position 11, the tip conductor 341 is extended over the upper contacts of cam 901, upper left winding of repeating coil 903, inner upper back contact of relay 902, left contacts of cam 932, right back contact of relay 1004, upper right and lower left contacts of cam 926, left winding of relay 1008 to battery, while the ring conductor 342 is extended over the upper contacts of cam 914, lower left winding of repeating coil 903, lower back contact of relay 902, right contacts of cam 925, left back contact of relay 1004, right winding of relay 1008 to ground over the left contacts of cam 917. The incoming selector circuit then waits for trunk closure at the B office.

As the link circuit sequence switch advances in response to the reverse battery closure, a bridge is connected across the fundamental circuit in positions $12\frac{1}{2}$ to $15\frac{1}{4}$ in the manner previously described. When the link sequence switch 600 leaves position 13, the circuit for relay 327 is

opened and that relay releases. With relay 327 released and relays 326 and 318 operated, a circuit is closed from battery over the left back contact of relay 325, winding of relay 306, middle left contact of relay 318, outer right front contact of relay 326 to ground at the back contact of relay 327. Relay 306, in operating, opens the holding path for relay 318 which thereupon releases. Relay 306 closes a holding circuit for itself from battery over the left back contact of relay 325, winding of relay 306, inner lower front contact of relay 306 to ground at the front contact of relay 314. It also connects the right windings of the repeating coil 304 over its outermost contacts to the inter-office trunk conductors 341 and 342 to provide an overlapping trunk closure to the incoming selector. When sequence switch 600 leaves position 16, ground is removed from conductor 333 thereby releasing relay 323 which in turn releases relays 321 and 326.

When the link circuit and trunk circuit make trunk closure as described, relay 1008 operates, closing a circuit from battery through the left winding of relay 1008, front contact of relay 1008, lower contacts of cam 922 to ground. Relay 1006 operates relay 1009 as before. Relay 1009 closes a circuit from ground at its right contact over the upper contacts of cam 929 to the winding of relay 1010 and battery. Relay 1009 also closes a circuit from battery through the winding of relay 1015, upper right and lower left contacts of cam 916, left front contact of relay 1009, lower contacts of cam 928, left contacts of cam 929 to ground at the right front contact of relay 1009, relay 1015 closing a circuit from battery through the winding of relay 1016, lower right and upper left contacts of cam 934, front contact of relay 1015, lower contacts of cam 906, left contacts of cam 922 to ground. Relay 1016 closes a circuit from ground at its front contact over the lower left contact of cam 924, to battery through the winding of sequence switch magnet 900 advancing the sequence switch out of position 11. It is then advanced to position 13 over its local cam. Relay 1015 releases when the sequence switch leaves position 11.

If the called number is reached by a final selector which appears in the groups 0 or 2 on the incoming selector frame, relay 1016 releases when sequence switch 900 leaves position 11 and sequence switch 900 comes to rest in position 13. Assuming, however, that the final selector 1059 was in group 1, relay 1016 will reoperate in position 12 over the lower contacts of cam 934, commutator strip 1031, brush 1030, left contacts of cam 922 to ground, and holds the circuit of sequence switch magnet 900 closed through position 13, advancing the sequence switch to position 14 where it advances to position 15 under the control of the local cam. Relay 1016 releases as soon as sequence switch 900 leaves position 13. Relay 1016 opens the ringing circuit at its right contact to prevent the application of ringing current to the line as the sequence switch passes through position 13. With sequence switch 900 in position 15, positive superimposed ringing current is connected over conductor 936, upper right and lower left contacts of cam 935, through the winding of relay 1017, back contact of relay 1016, right back contact of relay 1011 to the lower front contact of relay 905.

This trunk and incoming selector circuit give no indication to the A operator as to when she should operate her ringing key, and therefore she may operate it immediately after passing

the number to the B operator. If she does so, an impulse of ringing current will be transmitted to the trunk circuit of Fig. 3 from her cord circuit operating relay 307 through condenser 308. Relays 310 and 313 are held operated under the control of relay 318, wherefore the operation of relay 307 closes a circuit from ground over the front contact of relay 307, front contact of relay 313 to the winding of relay 307 and battery, holding that relay operated as long as relay 318 or relay 323 remains operated. When relay 323 is released as above described, a circuit is closed from ground at the front contact of relay 307, over the back contact of relay 323, inner upper front contact of relay 306 to the winding of relay 305 and battery. Relay 305 in operating connects the ring and tip conductors to ringing source 340 and ground, respectively. This impulse of ringing current operates relay 1001, which is connected in parallel with the windings of relay 1008 to battery and ground.

The windings of relay 1001 are connected differentially to each other. Therefore this relay will operate whenever ringing current is applied to either the primary or the secondary winding, but due to its differential arrangement, current which flows through both windings because of surges of current in the repeating coil will not operate it and false operation due to surge conditions is eliminated. Relay 1001 closes a circuit through the right winding of relay 1007, which operates and locks through its left winding, right back contact of relay 1017, the right back contact of relay 1011, right front contact of relay 1007, to ground over the lower right and upper left contacts of cam 929 and the outer right front contact of relay 1009. Relay 1007 in turn operates relay 905 which supplies ringing current and ground from conductors 941 and 936 to the called subscriber's line.

In the trunk circuit of Fig. 3, the release of relay 323 also opens the circuit of relay 310 which releases after an interval, opening the circuit of relay 313 which also releases after an interval, in turn releasing relay 307. Ringing current is, therefore, supplied to the incoming selector for a sufficient time to operate and lock relay 1007. If the A operator delays operating her ringing key until after the connection has been established and relays 310 and 313 are released, relay 307 remains operated only as long as the ringing key is held operated by the A operator. Under this condition, relay 305 responds directly to the ground at the front contact of relay 307 and connects ringing current to the incoming selector, it being assumed that the A operator holds her key closed long enough, to lock up relay 1007.

When the called subscriber answers, relay 1017 operates, releasing relays 1007 and 905 to terminate the ringing. Relays 904 and 915 operate in series with the called subscriber's line. Relay 904 is ineffective at this time, but relay 915 closes a circuit from battery through the winding of relay 902, upper contacts of cam 918, contact of relay 915, upper back contact of relay 902, right front contact of relay 1006, left front contact of relay 1010 to ground over the upper right contact of cam 922. Relay 1011 also operates under the control of relay 915 to substitute steady ringing current over conductor 933 for the intermittent ringing current for reringing. Relay 902 reverses the connection of battery and ground through the windings of relay 1008, to the inter-office trunk conductors, thereby oper-

ating polarized relay 312. Relay 312 in operating connects a shunt around the right-hand, high resistance, winding of relay 319 thereby permitting the supervisory relay of the A operator's cord to operate and extinguish the cord lamp.

When the call terminates and the called subscriber restores his receiver, relay 915 releases in turn releasing relay 902. Relay 902 restores the connection of battery and ground to the trunk, releasing relay 312 which opens the shunt around the right winding of relay 319, giving the A operator a disconnect signal. When the A operator removes the plug of cord 302 from jack 393, both relays 336 and 319 release, in turn releasing relay 314. Relay 314 in releasing opens the circuit of relay 306 which restores the circuit to normal. The release of relay 306 opens the circuit of relay 1008, in turn releasing relays 1006, 1009 and 1010. With these relays released, sequence switch 909 is advanced to position 16 where the return to normal is substantially the same for the incoming selector of Figs. 16 and 17.

Resetting keyset

Referring again to the position circuit, if the operator discovers she has operated a wrong key before she records the last digit, the sender may be reset by operating key 1316. This key releases relays 1334 and 1336 relighting lamp 1319 to indicate that the sender is not in condition to receive the number. The release of relay 1336 again connects battery to conductors 844 and 843. The connection of battery to conductors 843 and 844, which extend respectively to conductors 755 and 754 of the sender, operates relays 1210, 1216 and 1217 in the same manner as described at the seizure of the sender. The joint operation of relays 1210 and 1217 closes the circuit of relay 1220, which locks as before, through the windings of relays 1210 and 1217 in parallel to the battery supplied by the position circuit. With relay 1220 operated the locking circuits for all the operated register relays are opened, as well as the operating circuit extending through the windings of relays 1210 and 1217 and the circuit controlled by relay 1217. It also connects ground over its left front contact to the winding of relay 1411 to reoperate the transfer relays. When the transfer relays are all operated, battery is again connected to conductor 751 and thence to conductor 842 and the winding of relay 1333 which functions as previously described to prepare the position circuit for resetting the sender.

If the operator starts to set the numerical keys before lamp 1319 is extinguished to indicate that the sender is ready, a circuit is closed from battery over conductor 1350, over the right contact of the operated key through resistance 1335 over the back contact of relay 1334 or over the back contact of relay 1336 or over the front contacts of relays 1334 and 1333 to the lower winding of relay 1332 and ground. Relay 1332 locks in a circuit from battery on conductor 1350, upper winding and upper front contact of relay 1332, over key 1316 to ground. With relay 1332 operated, interrupter 1331 is connected over the front contact of relay 1332 to lamp 1319, causing that lamp to flash and warn the operator that she has started to operate her keyset prematurely. Relay 1332 also opens the circuit of relay 1333 so that the signal cannot be retired until the operator has released relay 1332 by the operation of key 1316.

Position disconnect

The position circuit is normally disconnected from the link circuit by the release of relay 1337 due to the advance of the link circuit. The release of relay 1337 in turn releases relays 1324, 1334, 1336, 1338 and 1317. However, if the position is held because of trouble in the link circuit, the position may also be released by operating position disconnect or reorder key 1315. If the link circuit, after seizing the position fails to operate relay 1337, a circuit is closed from ground through the winding of relay 1320, inner upper back contact of relay 1324, conductor 844, brush 804, inner right front contact of relay 817, upper contacts of cam 623, left winding of relay 827 to battery. Relay 1320 operates in this circuit but relay 827 does not. Relay 1320 closes a circuit from ground through interrupter 1327, lamp 1328, front contact of relay 1320, to battery at the lower front contact of relay 1326, causing lamp 1328 to flash. Since the order tones do not follow at once, the operator will operate key 1315. The operation of key 1315 closes a circuit from ground over key 1315, inner upper back contact of relay 1324 to conductor 844 in shunt of the winding of relay 1320, releasing relay 1320 and operating relay 827 to bring about the forced release of the link, if possible. The release of relay 1320 extinguishes lamp 1328. Relay 827 locks in a circuit from battery through its right winding and inner left front contact to ground over the lower left contact of cam 606. Relay 827 also extends this locking ground through the winding of relay 829 to battery. In addition it closes a circuit from battery through lamp 823 to ground at its middle right contact. It also closes a circuit from ground over its inner right contact, lower normal contact of jack 821, to conductor 745 which extends through the winding of relay 523 which controls the alarm circuit. Furthermore, it opens the locking circuit of relay 510. Relay 829 opens the circuit of relay 610 and also opens the circuit by which the position finder tests for an idle position.

Relay 829 closes a circuit from battery through the winding of relay 810, inner left contact of relay 829, to ground over the lower right contact of cam 602. Relay 810 locks over its outer left front contact to ground at the lower left contact of cam 606 and disconnects brushes 701 to 704 from the link equipment, thereby releasing trunk relays such as relays 220 and 221 which may be operated under the control of the link and preventing the operation of relay 1337. Since the wanted number has not been given to the B operator, the connection is maintained at the originating office and, with relay 510 released, another link may be assigned to handle the call. Relay 810 also closes a circuit from ground over its locking circuit and its inner left contact, middle normal contact of jack 823, upper left contact of cam 604 to battery through the winding of sequence switch magnet 600, advancing the sequence switch to position 5, where the sender finder hunts for an idle sender, after which the sequence switch is advanced to position 6. Relay 810 advances the sequence switch from position 6 to position 9 after which it advances to position 17 under the control of its local cam and restores to normal in the usual manner.

If relay 1337 is being held operated, in turn holding relays 1324 and 1333 operated, the operation of key 1315 closes a circuit from ground over the inner left operated contact of key 1315,

inner upper front contact of relay 1338, front contact of relay 1337 to conductor 845 and through the winding of relay 1337 to conductor 846. This ground shunts the left winding of relay 811 while maintaining the circuit through the right winding. Since relay 811 is differentially wound it now operates and closes an obvious circuit for relay 827 which functions as above described. However, sequence switch 600 is now in positions 4 to 6, since the finding of the position normally advances the sequence switch to position 4 and the advance from position 6 restores the position to normal. In these positions, therefore, the operation of relay 829 does not operate relay 810. It opens the circuit by which relays 814 and 817 are held operated and relay 814 opens the circuit of relay 1337 permitting the position circuit to restore to normal. In addition relay 829 closes a circuit from battery through the left winding of relay 820, right front contact of relay 829 to ground over the lower left contact of cam 607. Relay 820 locks in a circuit from battery through its left winding and the inner left front contact to this ground, independent of relay 829. Relay 820 opens the locking circuit of relay 822 and that relay releases. In addition, relay 820 transmits a reorder signal to the trunk circuit by closing a circuit from battery through resistance 821, inner right front contact of relay 820, inner right back contact of relay 810, brush 703, conductor 233, outer right front contact of relay 226, through the windings of relays 223 and 225 to ground. Relay 233 operates in this circuit and relay 225 also operates due to the low value of resistance 821.

Relay 225 in operating closes a locking circuit for itself from battery over its inner right front contact and right winding to ground at the outer right front contact of relay 213. Relay 225 in operating disconnects battery from the winding of relay 222 and that relay releases. It also disconnects battery from the operating circuit of relay 206 to prevent its premature operation and to disconnect relay 212 from the outgoing trunk conductors 241 and 242. In addition, it closes a circuit from battery through resistance 234 over the inner left front contact of relay 225 through the winding of relay 212, outer left front contact of relay 225 over interrupter 235 to ground thereby causing relay 212 to operate and release, these interruptions causing the cord supervisory lamp at the long distance office to flash. Relay 820 in operating also closes a circuit from battery through the winding of sequence switch magnet 600, upper left contact of cam 604, middle contact of jack 823, middle right front contact of relay 820 to ground, advancing sequence switch 600 to position 5 from which position the selection of a sender advances it to position 6, relay 820 advances it to position 9 and the local cam advances it to position 17. The restoration of the trunk finder and advance to position 18 take place in the usual manner. In a similar manner the connection of low resistance battery to conductor 333 operates relay 325, which locks under the control of relay 314 and closes a circuit from battery through resistance 339, inner right contact of relay 325, winding of relay 312, right back contact of relay 320, outer right contact of relay 325 to ground through interrupter 335, in which circuit relay 312 operates intermittently to transmit the reorder signal to the originating operator.

Key 1315 also opens the circuit of the operator's telephone 1340 and disconnects battery

from conductor 841 holding the position unavailable until the link has advanced. When the key is restored to normal and the link has removed the busy condition, the position circuit is again ready for service.

When the operator removes her headset from the position jack (not shown) she releases relay 1326 thereby removing battery and ground from the various position circuits. If, however, the position has just been seized by a link at this time, so that relay 1337 is operated, a circuit is closed from ground over the back contact of relay 1326, front contact of relay 1337, to conductors 845 and 846 to give the reorder signal to the originating operator as described above.

Abandoned calls

If the long distance operator abandons the call, the withdrawal of her plug from jack 203 is not immediately effective since relay 219 is held operated locally. If she abandons the call before passing the wanted number, the B operator receiving no response to the order tone and no response to her challenge will operate the position disconnect key 1315 which will function as above described. However, since the plug has been withdrawn from jack 203, when relay 212 operates under the control of interrupter 235, releasing relay 210, relay 219 is also released in turn releasing relays 214, 215 and 225 restoring the trunk circuit to normal. The link circuit is advanced and restored to normal as described.

If the call is abandoned after the number has been passed, the position, link, sender and selector circuits function in the usual manner until trunk closure is made and relay 212 operates. The operation of relay 212 releases relay 210 which connects the windings of relay 219 to the incoming trunk conductors. Since no connection is present at the toll office, relay 219 releases in turn releasing relays 214, 213. The release of relay 214 permits relays 215 and 218 to function in the manner described to complete the release of relay 206 and the trunk circuit. The release of relay 206 in turn releases the incoming selector.

In the case of the local trunk of Fig. 3 abandonment of the call by the A operator releases relays 319 and 336, in turn releasing relays 314 and 318. The release of relay 318 disconnects battery through resistance 339 from conductor 332 so that the trunk finder, if in motion, instead of stopping on the terminals leading to the trunk circuit advances to tell-tale position. As brush 710 nears the top of the commutator, it leaves strip 711 opening the locking circuit for relay 819 which releases. Immediately thereafter ground over brush 707 is connected to commutator segment 709, closing a circuit from battery through the winding of sequence switch magnet 600, upper left contact of cam 604, over commutator segment 709 and brush 707 to ground, advancing sequence switch 600 to position 5. In this position an idle sender is selected and the sequence switch advances to position 6 in the manner previously described. Sequence switch 600 is then advanced to position 9 over the same circuit which advanced it to position 5. It is then advanced from position 9 to position 17 over its local cam and restores to normal as previously described.

If the call is abandoned at a later time, relays 319, 336, 314 and 318 release as before. However, relays 321, 326, 327 and 323 are held operated under the control of the link circuit in order to permit the link circuit to give trunk closure to

the incoming selector circuit, which is necessary in order to restore it to normal. The release of relay 318 prevents the operation of relay 306, thus preventing a false connection between the trunk circuit and an incoming selector circuit if the trunk circuit is resealed very quickly.

If the sequence switch 600 is in position 3, when relay 318 releases, the disconnection of battery from conductor 332 releases relay 624 and opens the circuit of relay 822 which also releases. Relay 819 now operates in a circuit from battery through the winding of that relay, lower left and upper right contacts of cam 626, right contacts of cam 619, left back contact of relay 624, to ground over commutator strip 711 and brush 710. With relay 819 operated and relay 822 released, a circuit is closed from battery through the winding of relay 810, inner right front contact of relay 819, left back contact of relay 822, upper right contact of cam 609 to ground. Relay 810 operates in this circuit and locks in the circuit previously traced. Relay 810 functions as described to restore the link circuit to normal.

If the call is abandoned while sequence switch 600 is in positions 4 to 6, relay 822 is released as above and relay 819 operates in a circuit from battery through the winding of that relay, right back contact of relay 822, left back contact of relay 820, upper left contact of cam 607 to ground. Relay 819 operates relay 810 which functions as above described to bring about the release of the link circuit. If the call is abandoned with the link sequence switch in positions 7 to 18, the operations proceed as for a regular call.

Link time alarm

The link circuit is provided with a time alarm arrangement under the control of interrupters 824 and 825. With sequence switch 600 in positions 3, 6 and 8, ground is connected to interrupter 824 which has a comparatively slow period, while during positions 2, 4, 5, 7 and 9 to 16, inclusive, ground is connected to interrupter 825 which has a period of somewhat less than half that of interrupter 824. It may be noted that the right and left contacts of these interrupters are connected in parallel so that the effect of the operation of the interrupter is the same except for the speed at which it operates. The first closure of the left contact of either interrupter completes the circuit for relay 826 which locks in a circuit from battery through its right winding and inner right contact to ground at the upper left contact of cam 606, this locking circuit being closed irrespective of which interrupter is functioning and opened as the sequence switch passes from position to position. If relay 826 remains operated until the right contact of the same interrupter closes, a circuit is completed over the left contact of relay 826 through the left winding of relay 827 to battery. Relay 827 functions as described.

Holding link in case of trouble

If there is reason to believe that a particular link is involved in a trouble condition and it is desired to hold the link circuit until the real source of the trouble can be found, a plug may be inserted in jack 823. When trouble occurs, relays 826, 827 and 829 will operate as previously described. With sequence switch 600 in position 2 or 3, the operation of relay 829 will close the previously traced circuit for relay 810. Relay 810 will function to open the connection between

the brushes of the trunk finder and the link equipment so that the trunk circuit is released from this link and may summon another link. With sequence switch 600 in position 2, the disconnection of brush 702 prevents the operation of relay 624 which in turn prevents the release of relay 819 and holds open the normal circuit for advancing the sequence switch from position 2. Since relay 829 opens the position test circuit, it prevents the operation of relay 740 and the normal advance of the sequence from position 3. Plug 823 opens the middle contact of jack 823 and prevents relay 810 from advancing the sequence switch from positions 2 and 3. Therefore in positions 2 and 3, only the link circuit is held.

In position 4, relay 829 disconnects relay 740 from brush 801 and the position will be dismissed. However, the normal circuit for advancing sequence switch 600 is opened at both the jack 823 and relay 827. Relay 810 is not operated, but relay 820 is, connecting low resistance battery to conductor 233, releasing relay 220, which permits relay 226 to operate, extending the battery to relays 223 and 225. Relay 225 transmits the reorder signal to the originating office as previously described. Since sequence switch 600 can not advance from position 4, relays 227, 226 and 221 are held operated by the link circuit and both the trunk and link circuits are held.

In position 5 the link tests for an idle sender. If the sender selector is engaging an idle sender, relay 740 operates at once and advances the sequence switch to position 6. If the timing relays function, the operation of relay 827 opens the circuit of relay 818 to prevent further search and the trunk, link and position circuits are held.

If the time out occurs in position 6, relays 814 and 817 are released. Relay 741 is held by the sender, neither relay 819 nor relay 815 can operate and the sequence switch remains in position 6. Relay 820 is operated to give a reorder signal to the A operator. Relay 814 releases the position circuit but the link sender and trunk are held.

Position 7 is a pass-by position. If the timing relays function in position 8, since selections have not been completed, relay 819 is held operated and the normal circuit for advancing sequence switch from position 8 is open. The fundamental circuit is held closed, thus holding the incoming selector, trunk, link and sender.

Having left position 8, sequence switch 600 advances directly to position 17, dismissing the sender, the incoming selector and trunk circuits. In position 17 the operation of relay 827 and insertion of plug in jack 823 prevent the advance of the sequence switch and the link circuit is held alone.

Link out of service

If the link circuit should be taken out of service for any reason, a plug may be inserted in jack 331, but this produces no interruption during a call, but does open the circuit by which the sequence switch advances from position 17. If the plug is inserted with the sequence switch 600 in position 18 or 1, in which the link is awaiting assignment or seizure, a circuit is closed from battery through the winding of sequence switch magnet 600, lower left contact of cam 604, over the ring of jack 831, ring and sleeve of plug 832, sleeve of jack 831 to ground, advancing sequence switch 600 to position 2. Since relay 819 is not operated, it immediately advances sequence switch

600 to position 3. In this position, relay 819 is operated over the lower left and upper right contacts of cam 626, right contacts of cam 619, back contact of relay 624, to ground over commutator strip 711 and brush 710. With relay 819 operated, relay 810 is operated in a circuit through its winding over the inner right front contact of relay 819, left back contact of relay 822 to ground over the upper right contact of cam 609. Relay 810 closes a circuit from battery through the winding of sequence switch magnet 600 over the upper left contact of cam 604, inner left back contact of relay 827, inner left front contact of relay 810 to ground over the lower left contact of cam 606 advancing sequence switch 600 to position 5, where an idle sender is selected and the sequence switch advances to position 6. Relay 810 advances sequence switch 600 to position 9 as previously described, whence it is advanced to position 17 under the control of its local cam, and from which it can not advance due to the presence of plug 832 in jack 831. It may be noted that relay 819 released as soon as the sequence switch left position 3 and that the locking circuit for relay 810 is opened as soon as the sequence switch leaves position 16.

Overflow

If, during selection, the incoming selector of Figs. 16 and 17 finds all of the trunks in the selected group busy, the selector is driven to the overflow terminal, to the sleeve of which no ground is connected. Therefore, relay 1704 releases when this terminal is reached, in turn releasing the updrive magnet 1719 and advancing sequence switch 1600 to position 3. A circuit is thereupon closed from battery through the winding of sequence switch magnet 1600, upper left contact of cam 1624, commutator strip 1727, brush 1723, upper contacts of cam 1622 to ground, advancing sequence switch 1600 to position 9. In this position reverse battery is connected to the inter-office trunk in the manner previously described. Reverse battery is also supplied to the inter-office trunk if, in making any selection, the selector goes to the top of the bank, in which case a circuit is closed from battery through the winding of sequence switch magnet 1600, lower right contact of cam 1624, commutator segment 1729, brush 1723 and thence to ground as just traced.

The incoming selector of Figs. 9 and 10 operates in substantially the same manner in case the selector is driven to an overflow terminal or to the top of its bank. In addition, with sequence switch 900 in position 8, in which position final selections occur, a circuit is prepared from ground over the upper contacts of cam 917 to interrupter 939 to time the final selections. When the interrupter closes its right contact, this ground is extended through resistance 927, upper contacts of cam 928 to the lower right winding of repeating coil 903, winding of relay 915 and battery, causing the operation of that relay. Relay 915 closes an operating circuit for relay 904 extending from battery through the winding of relay 915, lower right winding of repeating coil 903, upper contacts of cam 928, resistance 927, front contact of relay 915, upper contacts of cam 919, upper right winding of repeating coil 903, winding of relay 904 to ground, which circuit becomes effective after interrupter 939 opens its right contact. If sequence switch 900 has not advanced out of position 8 before interrupter 939 closes its left contact, a circuit is closed from ground over the

left contact of interrupter 939, front contact of relay 904, right winding of relay 1004, resistance 1005 and battery. Relay 1004 advances sequence switch 900 to position 9 in the usual manner. When the sequence switch 900 leaves position 8, relays 904 and 915 release and the sequence switch remains in position 9 until the sender closes the fundamental circuit after which the circuit is restored to normal.

Premature reverse battery is also closed to the sender if the incoming selector is not in its normal position when the fundamental circuit is first established. This is apparent since it will take fewer than the normal number of selections to advance the incoming selector sequence switch to the reverse battery position.

Premature battery reversal

The fact that reverse battery connected to the interoffice trunk is premature, is indicated to the sender by the non-operation of relay 1526 which operates following the completion of final units selection. Polarized relay 1206 responds to reverse battery over the fundamental circuit as previously described and closes a circuit for relay 1203. Relay 1203 operates relay 1120 in cooperation with relay 1204 and provides a holding circuit for relays 1120, 1130 and 1140 which is effective when the reverse battery is removed. Relay 1140 opens the fundamental circuit to prevent the incoming selector from advancing falsely out of the trunk closure position. With relay 1130 operated, relay 1202 is operated, which in turn opens the holding circuit of relay 1206 causing that relay to release. A circuit is closed from battery through resistance 1530, lower back contact of relay 1527, inner left front contact of relay 1202 to conductor 752, thence over brush 722, left front contact of relay 815, right winding of relay 820, to ground over the upper contacts of cam 608. Relay 820 in operating connects battery through resistance 821 to brush 703 as previously described to give a reorder signal to the trunk circuit. Relay 820 also advances sequence switch 600 to position 9 whence it is advanced to position 17 over its local cam. When the sequence switch leaves position 16, relay 820 releases. As sequence switch 600 passes through positions 12½ to 15¼ the trunk closure previously described is completed in order to operate relay 1708 or 1008 and release the incoming selector. When the link sequence switch leaves position 8½, ground is disconnected from conductor 756, releasing relay 1207 and the other relays of the sender.

If the sender selector 720 is hunting for an idle sender and goes to the top of its bank without finding an idle sender, a circuit is closed from battery through resistance 630, winding of relay 739, upper right and lower left contacts of cam 629, commutator segment 744, brush 727 to ground, operating relay 739. Relay 739 closes a locking circuit for itself from battery through resistance 630, winding of relay 739, left contacts of cam 629 to ground at the inner lower contact of cam 729. Relay 739 also closes a circuit from battery through the winding of downdrive magnet 737, inner upper front contact of relay 739, left back contact of relay 610, right contacts of cam 615 to ground. When the selector reaches the bottom of its travel, a circuit is closed from battery through resistance 630 over the lower right and upper left contacts of cam 631, normal commutator segment 730, brush 729

to ground, shunting relay 739 and causing that relay to release in turn releasing the downdrive magnet 737 and bringing the selector to rest at the bottom of its bank. While relay 739 is operated it holds open the circuit if updrive magnet 736, the test circuit for testing for an idle sender the circuit of relay 818 and the circuit for advancing sequence switch 600 out of position 6. In addition a circuit is closed from battery through the winding of relay 742, middle lower front contact of relay 739, the lower left and upper right contacts of cam 622, commutator strip 731, brush 729 to ground. Relay 742 closes an obvious circuit for meter 743 which records the number of times that the selector has to be restored from the top of its bank. With relay 739 released the hunt for an idle sender is resumed.

Calls waiting alarm

Fig. 11 shows an arrangement for sounding an alarm when too many calls are delayed.

This arrangement is described and claimed in Patent 1,792,530, granted to R. E. Hersey, Feb. 11, 1931, and will not be described here.

What is claimed is:

1. In a telephone system, an operator's position, a second operator's equipment, switching equipment, a trunk circuit extending from said first operator's position to said switching equipment, means for connecting said second operator's equipment over said trunk circuit with said first operator's position to receive wanted line numbers, means operated by said second operator for controlling said switching equipment to complete a connection with a wanted line, means associated with said switching equipment for signaling said wanted line, and means under the control of said first operator to initiate the operation of said signaling means, said operator controlled means being operable before said connection has been completed.

2. In a telephone system, an operator's position, a second operator's equipment, switching equipment, a trunk circuit extending from said first operator's position to said switching equipment, means for connecting said second operator's equipment over said trunk circuit with said first operator's position to receive wanted line numbers, means operated by said second operator for controlling said switching equipment to complete a connection with a wanted line, means associated with said switching equipment for signaling said wanted line, and means under the control of said first operator to initiate the operation of said signaling means, said operator controlled means being operable whether or not said connection has been completed.

3. In a telephone system, an operator's position, a second operator's equipment, switching equipment, a trunk circuit extending from said first operator's position to said switching equipment, means for connecting said second operator's equipment over said trunk circuit with said first operator's position to receive wanted line numbers, means operated by said second operator for controlling said switching equipment to complete a connection with a wanted line, means associated with said switching equipment for signaling said wanted line, and means under control of said first operator to initiate the operation of said signaling means, said operator controlled means being independent of said switch controlling means.

4. In a telephone system, an operator's position, a second operator's equipment, switching equipment, a trunk circuit extending from said first operator's position to said switching equipment, means for connecting said second operator's equipment over said trunk circuit with said first operator's position to receive wanted line numbers, means operated by said second operator for controlling said switching equipment to complete a connection with a wanted line, means associated with said switching equipment for signaling said wanted line, a relay for initiating the operation of said signaling means operative in response to ringing current applied to said trunk at said first operator's position, said relay being operable whether or not said connection has been completed.

5. In a telephone system, an operator's position, a second operator's equipment, switching equipment, a trunk circuit extending from said first operator's position to said switching equipment, means for connecting said second operator's equipment over said trunk circuit with said first operator's position to receive wanted line numbers, means operated by said second operator for controlling said switching equipment to complete a connection with a wanted line, means associated with said switching equipment for signaling said wanted line, means for operating said signaling means, said means comprising a relay operative in response to ringing current applied to said trunk at said first operator's position, and means to render said relay ineffective until said second operator's equipment is disconnected from said trunk.

6. In a telephone system, an operator's position, a second operator's equipment, switching equipment, a trunk circuit extending from said first operator's position to said switching equipment, means for connecting said second operator's equipment over said trunk circuit with said first operator's position to receive wanted line numbers, means operated by said second operator for controlling said switching equipment to complete a connection with a wanted line, means associated with said switching equipment for signaling said wanted line, means for operating said signaling means, said means comprising a relay operative in response to ringing current applied to said trunk at said first operator's position, and means to render said relay ineffective until said connection has been completed.

7. In a telephone system, an operator's position, a second operator's equipment, switching equipment, a trunk circuit extending from said first operator's position to said switching equipment, means for connecting said second operator's equipment over said trunk circuit with said first operator's position to receive wanted line numbers, means operated by said second operator for controlling said switching equipment to complete a connection with a wanted line, means responsive to the completion of said connection for disconnecting said second operator's equipment from said trunk circuit, means associated with said switching equipment for signaling said wanted line, means for operating said signaling means, said means comprising a relay operative in response to ringing current applied to said trunk at said first operator's position, and means to render said relay ineffective until said second operator's equipment is disconnected from said trunk circuit.

8. In a telephone system, a two-conductor trunk circuit, a ring-up relay for operation over

said trunk circuit, two differentially arranged windings for said relay, and means for connecting one of said windings through a condenser between battery and one conductor of said trunk circuit and for connecting the other of said

5 windings through a condenser between ground and the other conductor of said trunk circuit.

9. In a telephone system, a two-conductor trunk circuit, a double wound trunk relay, means
10 for supplying battery and ground over the windings of said trunk relay to said trunk circuit to establish a direct current circuit, a double wound ring-up relay having a winding in series with a condenser in parallel with each winding of said
15 trunk relay, and means to apply ringing current to one of said trunk conductors to operate said ring-up relay, the windings of said ring-up relay being arranged differentially to render said relay unresponsive to variations of current in said direct current circuit.

10. In a telephone system, a trunk circuit terminating in an incoming selector, a register sender, a link circuit for connecting said trunk circuit with said register sender, means associated with
25 said link circuit for timing the operations of said circuits, means normally responsive to the complete operation of said timing means to transmit a signal to said trunk circuit and to restore said circuits to normal, and means to prevent the release of one or more of said circuits according
30 to the point in the operation of said circuits at which said timing means completes its operation.

11. In a telephone system, a trunk circuit terminating in an incoming selector, a register sender, a link circuit for connecting said trunk circuit with said register sender, means associated with
35 said link circuit for timing the operations of said circuit, means normally responsive to the complete operation of said timing means to transmit a signal to said trunk circuit and to restore said circuits to normal, and means to prevent the release of all of said circuits if said timing means completes its operation at a particular point in the operation of said link circuit.

12. In a telephone system, a trunk circuit terminating in an incoming selector, a register sender, a link circuit for connecting said trunk circuit with said register sender, means associated with
40 said link circuit for timing the operations of said circuit, means normally responsive to the complete operation of said timing means to transmit a signal to said trunk circuit and to restore said circuits to normal, means to prevent the release of one or more of said circuits according to the point in the operation of said circuits at which
45 said timing means completes its operation, and means effective at certain points in the operation of said link circuit to also disable said signaling means.

13. In a telephone system, a trunk circuit terminating in an incoming selector, a register sender, a link circuit for connecting said trunk circuit with said register sender, means associated with
50 said link circuit for timing the operations of said circuit, means normally responsive to the complete operation of said timing means to transmit a signal to said trunk circuit and to restore said circuits to normal, means to prevent the release of one or more of said circuits according
55 to the point in the operation of said circuits at which said timing means completes its operation, and means effective if only said link circuit is prevented from releasing to also prevent the transmission of said signal.

14. In a telephone system, a trunk circuit, a supervisory relay for said trunk circuit, means to connect said supervisory relay to said trunk circuit, means under the control of said supervisory relay to display a signal associated with
5 said trunk circuit, and means effective in case of trouble to disable said connecting means and to operate said supervisory relay intermittently to cause a characteristic operation of said signal.

15. In a telephone system, a trunk circuit, a
10 supervisory relay for said trunk circuit, means for connecting said supervisory relay to said trunk circuit, means under the control of said supervisory relay to display a signal associated with said trunk circuit, and means effective in
15 case of trouble to disable said connecting means and to connect said supervisory relay to battery and interrupted ground to cause a characteristic operation of said signal.

16. In a telephone system, an originating office, an intermediate office, a terminating office, a
20 trunk circuit connecting said originating office and said terminating office and passing through said intermediate office, a supervisory relay at said intermediate office, means for connecting
25 said relay in said trunk circuit, said relay normally responsive to the completion of a connection at said terminating office to cause the display of a signal at said originating office, and means for disabling said connecting means and for connecting said supervisory relay in circuit with battery and interrupted ground to cause a characteristic operation of said signal at said originating office.

17. In a telephone system, an originating office, a
35 intermediate office, a terminating office, a two-conductor trunk circuit connecting said originating office and said terminating office and passing through said intermediate office, a supervisory relay at said intermediate office, means for connecting
40 said relay to the two conductors of said trunk circuit, said relay normally responsive to the completion of the connection at said terminating office to cause the display of a signal at said originating office, and means for causing the substitution of interrupted battery and ground for
45 said trunk conductors to cause the intermittent operation of said supervisory relay and thereby a characteristic operation of said signal.

18. In a telephone system, an originating office, a
50 intermediate office, a terminating office, a switching apparatus at said terminating office, a trunk circuit connecting said originating office and said terminating office and passing through said intermediate office, control equipment at
55 said intermediate office for controlling said switching apparatus, a supervisory relay at said intermediate office, means for connecting said relay in said trunk circuit, said relay normally responsive to the completion of a connection at
60 said terminating office, to cause the display of a signal at said originating office, means in said control equipment for disabling said connecting means and for causing the connection of said supervisory relay in circuit with battery and interrupted ground to cause a characteristic operation of said signal at said originating office.

19. In a telephone system, an originating office, an intermediate office, a terminating office, a two-conductor trunk circuit connecting said originating
70 office and said terminating office and passing through said intermediate office, a supervisory relay at said intermediate office, means for connecting said relay to the two conductors of said trunk circuit, said relay normally responsive to
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the completion of a connection at said terminating office to cause the display of a signal at said originating office, and means in said control equipment for causing the substitution of interrupted battery and ground for said trunk conductors to cause the intermittent operation of said supervisory relay and thereby a characteristic operation of said signal.

20. In a telephone system, a trunk circuit terminating in an automatic selector at one office, a link circuit and a register sender at a second office, means to cause said link circuit to connect said sender with said trunk circuit at said second office, means in said sender to control the operation of said selector, a holding relay associated with said selector, means to connect said holding relay with said trunk circuit, means in said sender responsive to the completion of selections to initiate the release of said link circuit, means in said link circuit for causing said trunk circuit to prepare a holding circuit at said second office for said holding relay, and means in said link circuit for establishing a holding circuit for said holding relay prior to the completion of the holding circuit by the trunk circuit.

21. In a telephone system, a trunk circuit ter-

minating in an automatic selector at one office, a link circuit and a register sender at a second office, means to cause said link circuit to connect said sender with said trunk circuit at said second office, means in said sender to control the operation of said selector, a holding relay associated with said selector, means normally effective to connect said holding relay with said trunk circuit following the completion of selections, means to connect said holding relay with said trunk circuit prior to the completion of selections, means in said sender to transmit one signal to said link circuit when said holding relay is connected with said trunk before the completion of selections, means in said sender to transmit a different signal to said link circuit when said holding relay is connected with said trunk circuit after the completion of selections, means in said link circuit responsive to either signal to initiate the release of the link circuit and to establish a temporary holding circuit for said holding relay in said link circuit, and means responsive to said second signal only to cause the establishment of a holding circuit by said trunk circuit.

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