

Jan. 7, 1930.

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1,742,916

TELEPHONE EXCHANGE SYSTEM

Filed June 20, 1928

8 Sheets-Sheet 1

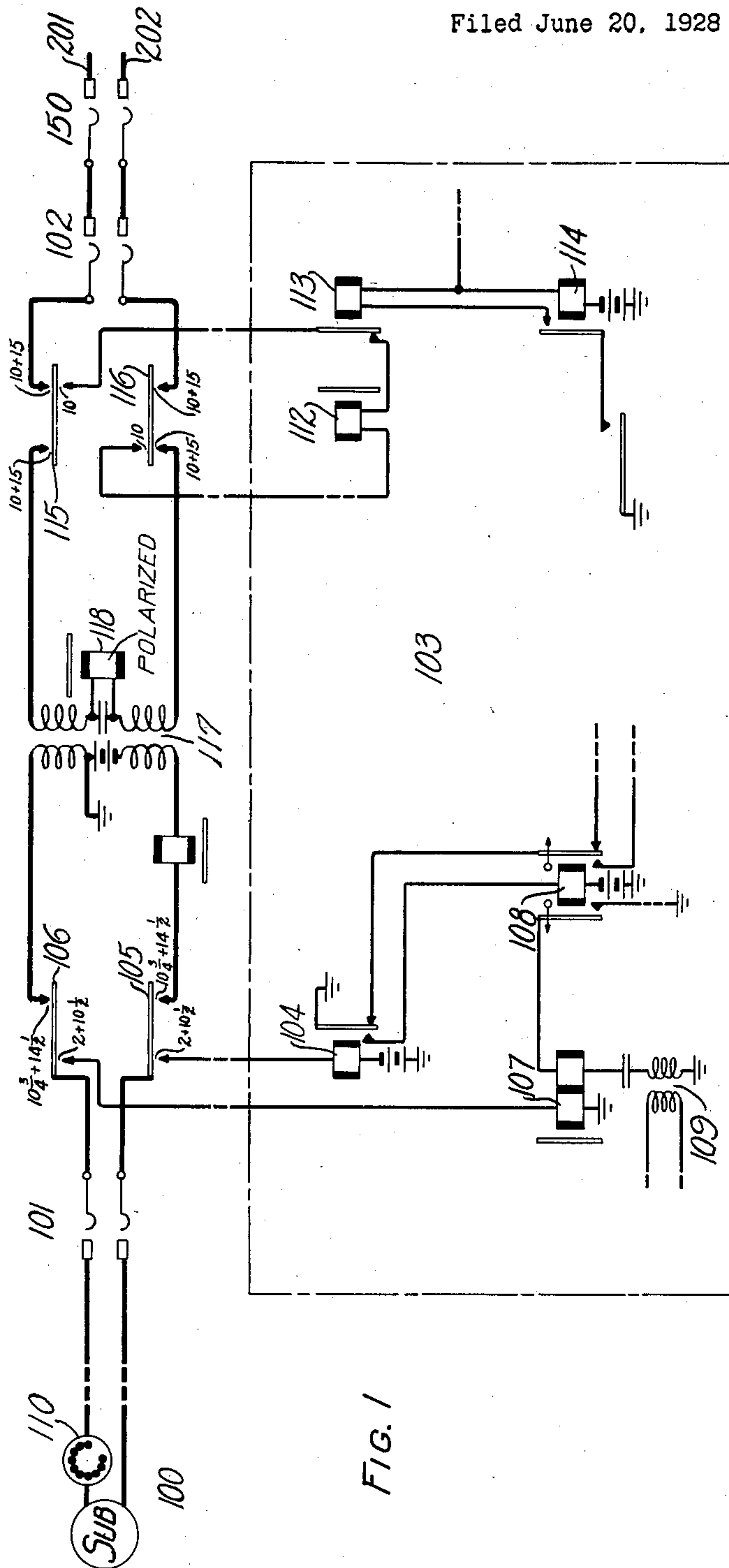


FIG. 1

FIG. 1	FIG. 2	FIG. 3
	FIG. 4	
	FIG. 5	
	FIG. 6	FIG. 7

FIG. 9

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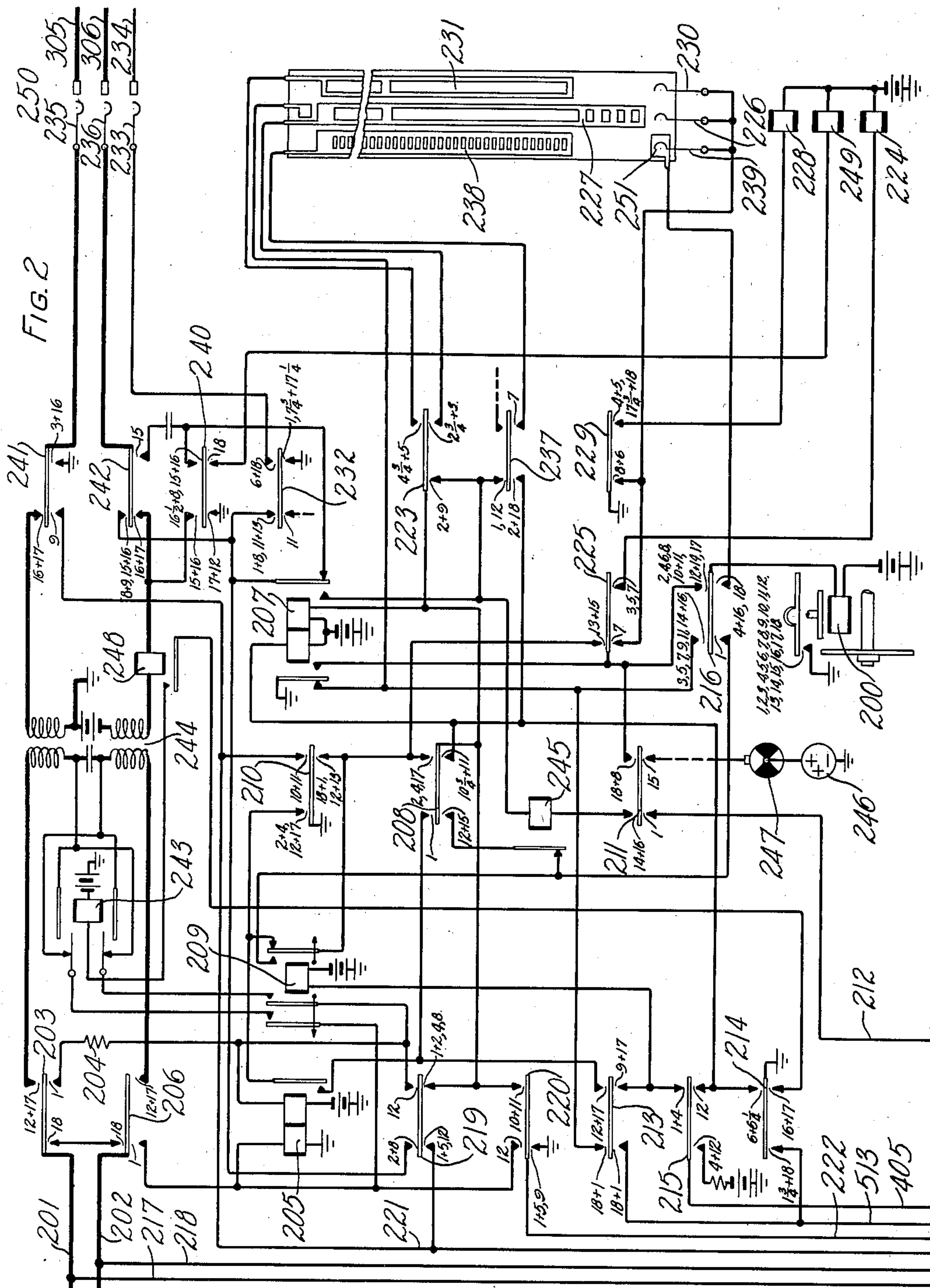
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8 Sheets-Sheet 2



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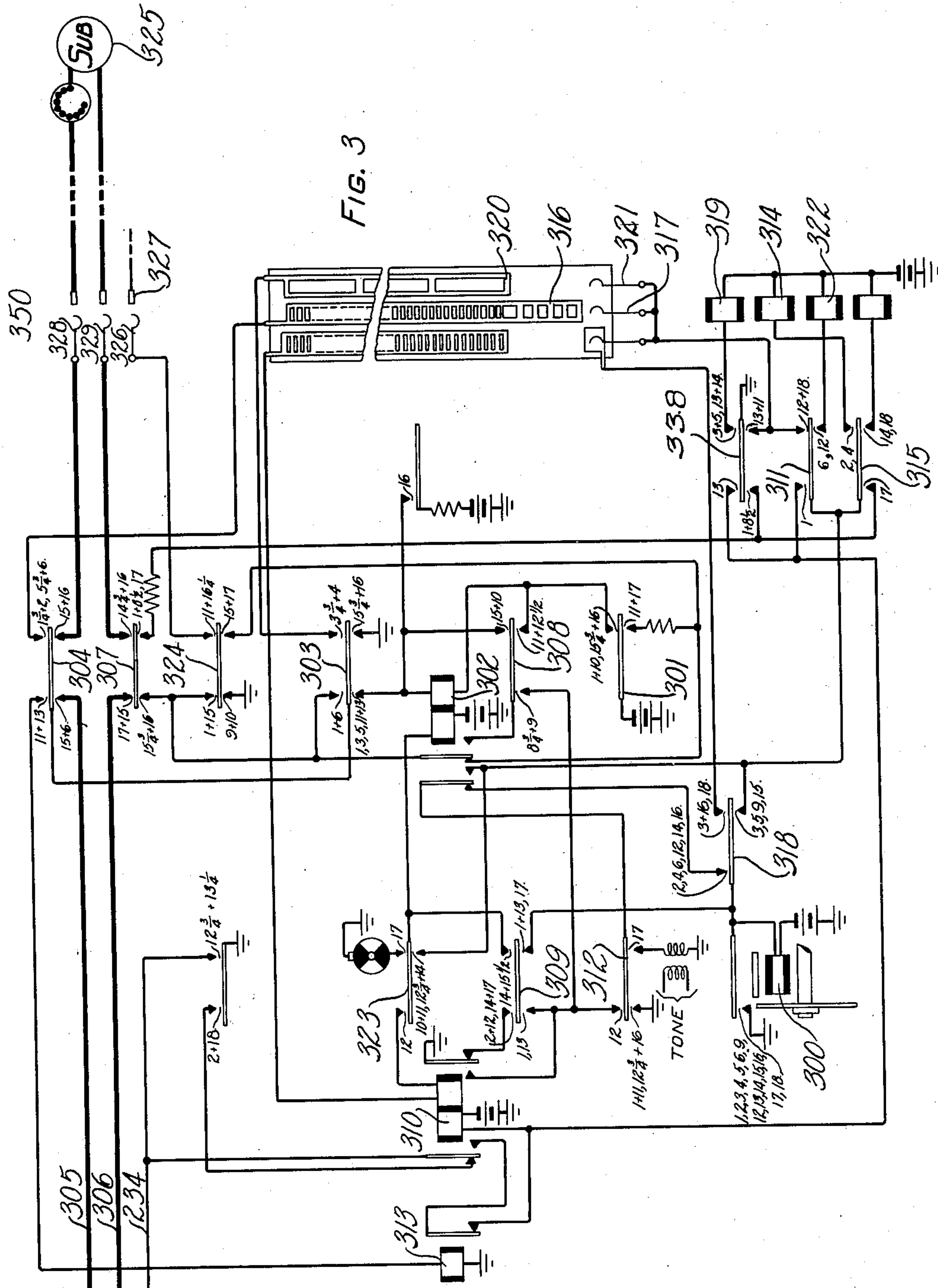
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TELEPHONE EXCHANGE SYSTEM

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8 Sheets-Sheet 3



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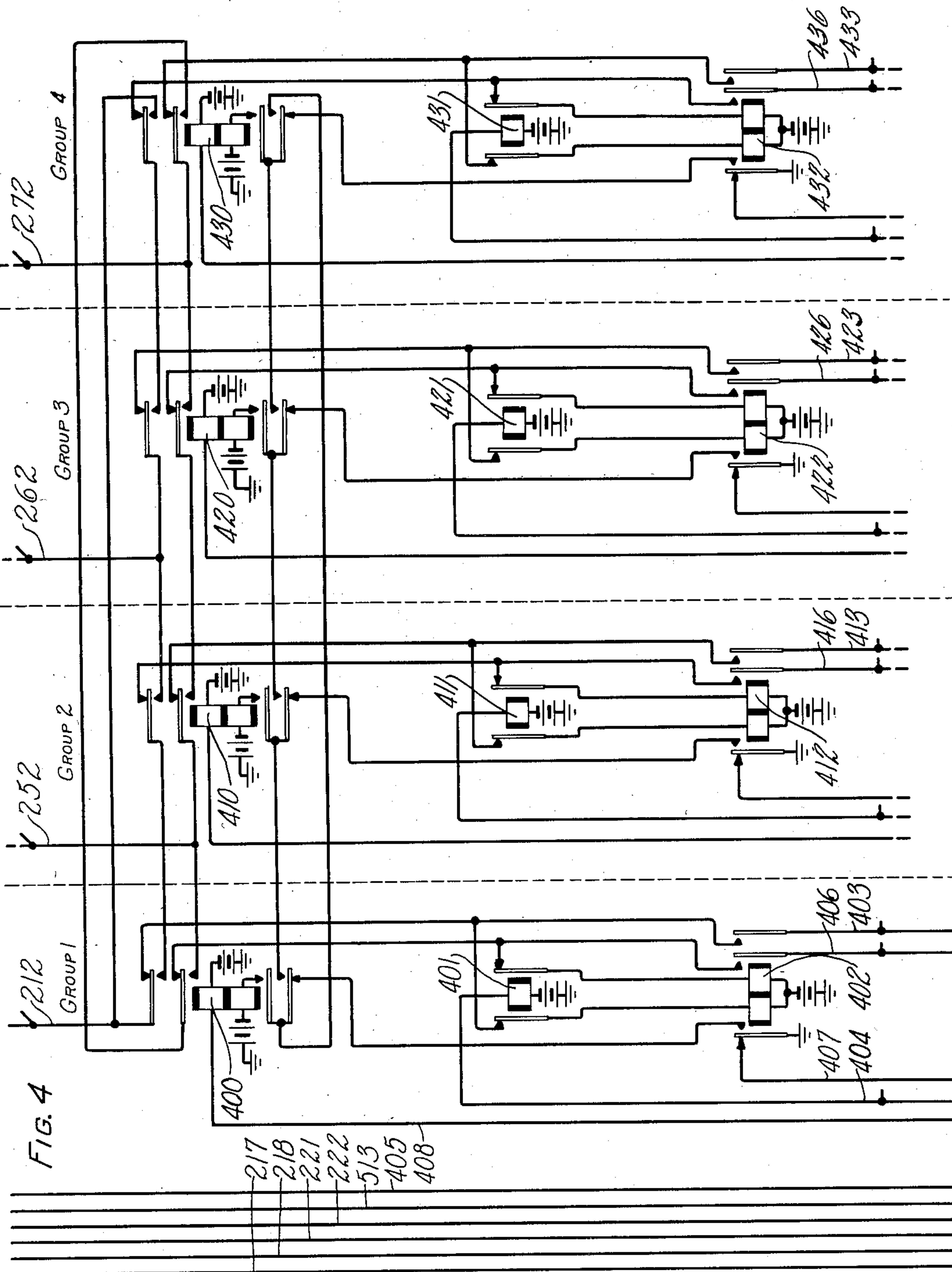
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TELEPHONE EXCHANGE SYSTEM

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8 Sheets-Sheet 4



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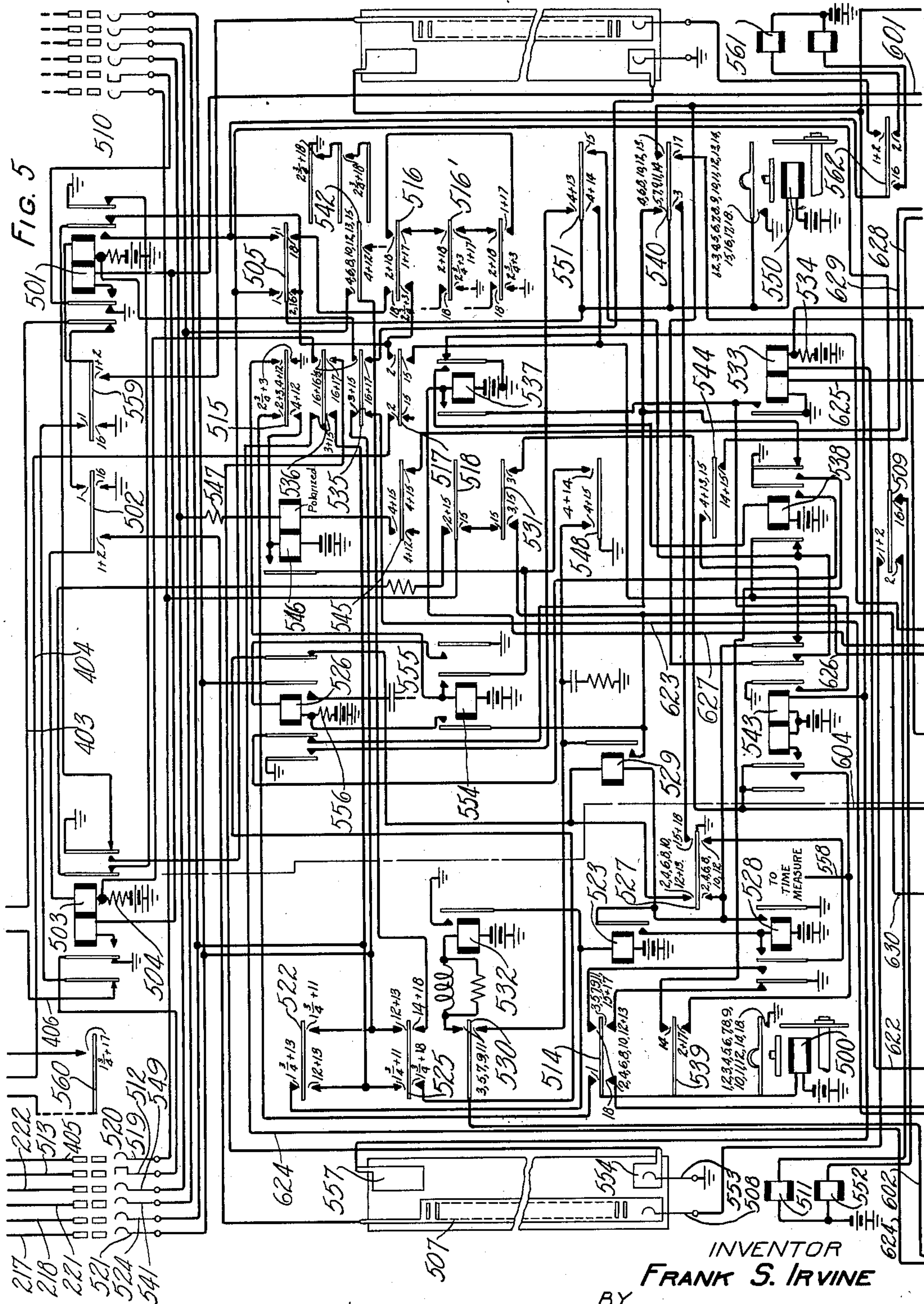
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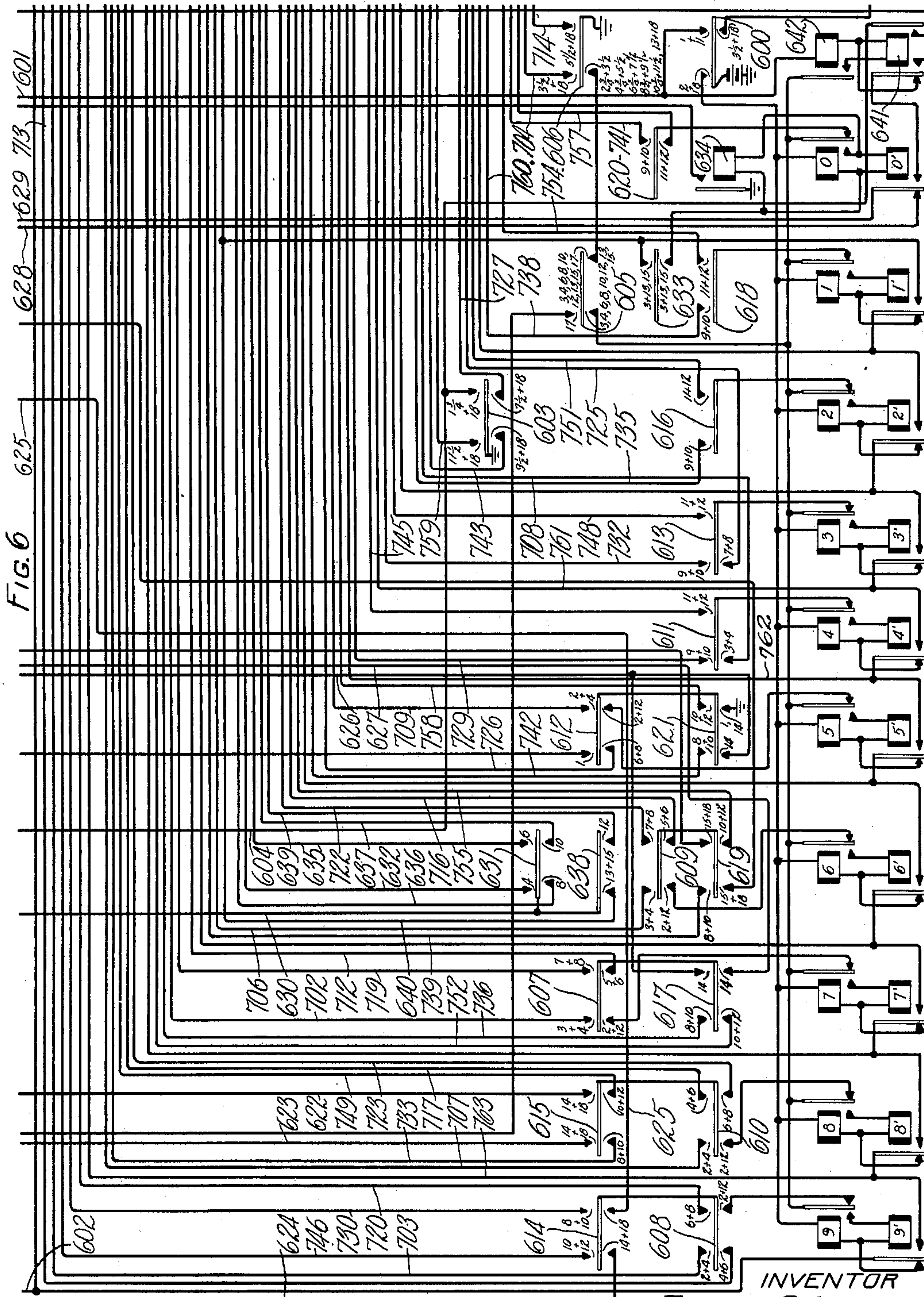
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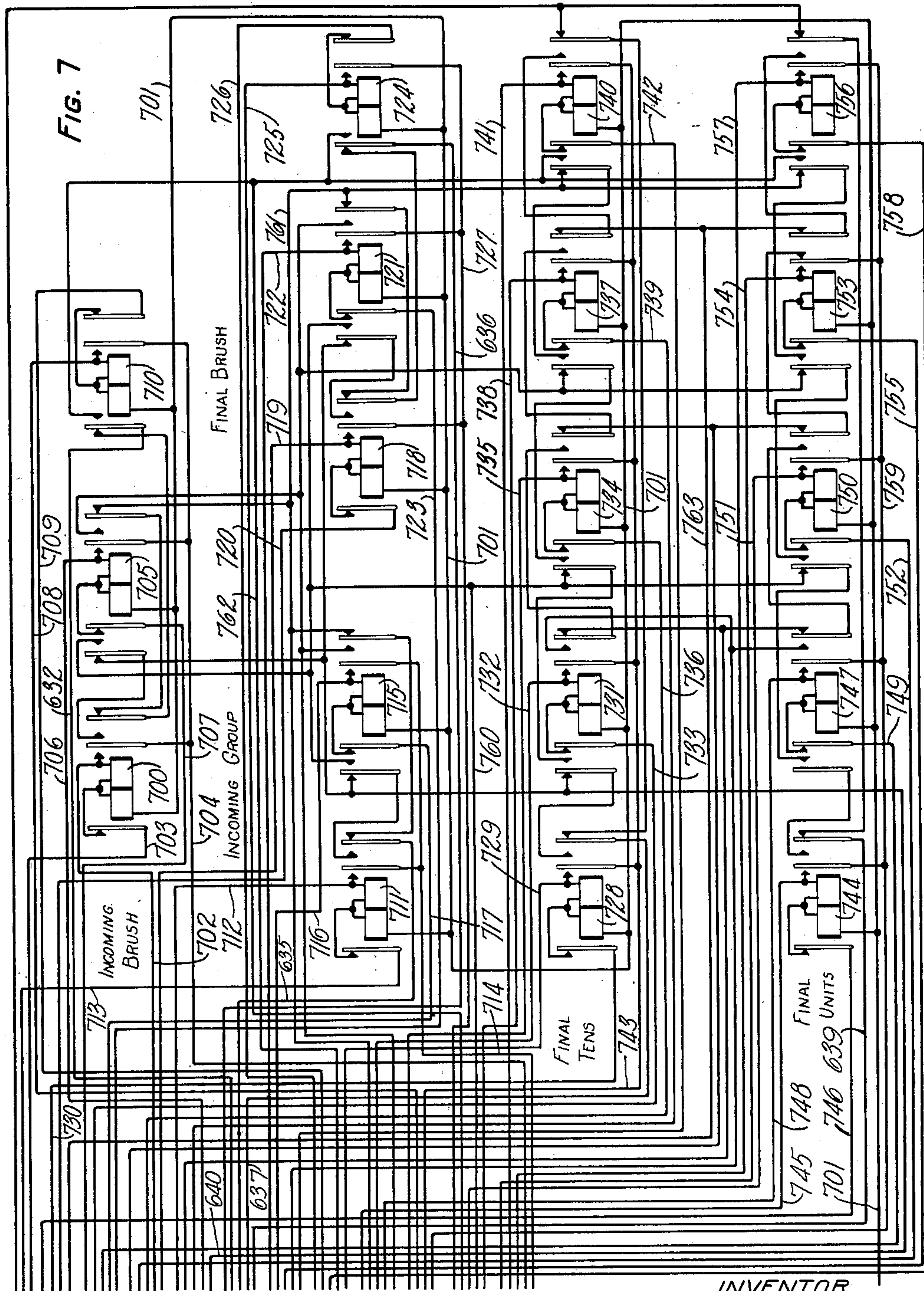
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8 Sheets-Sheet 7



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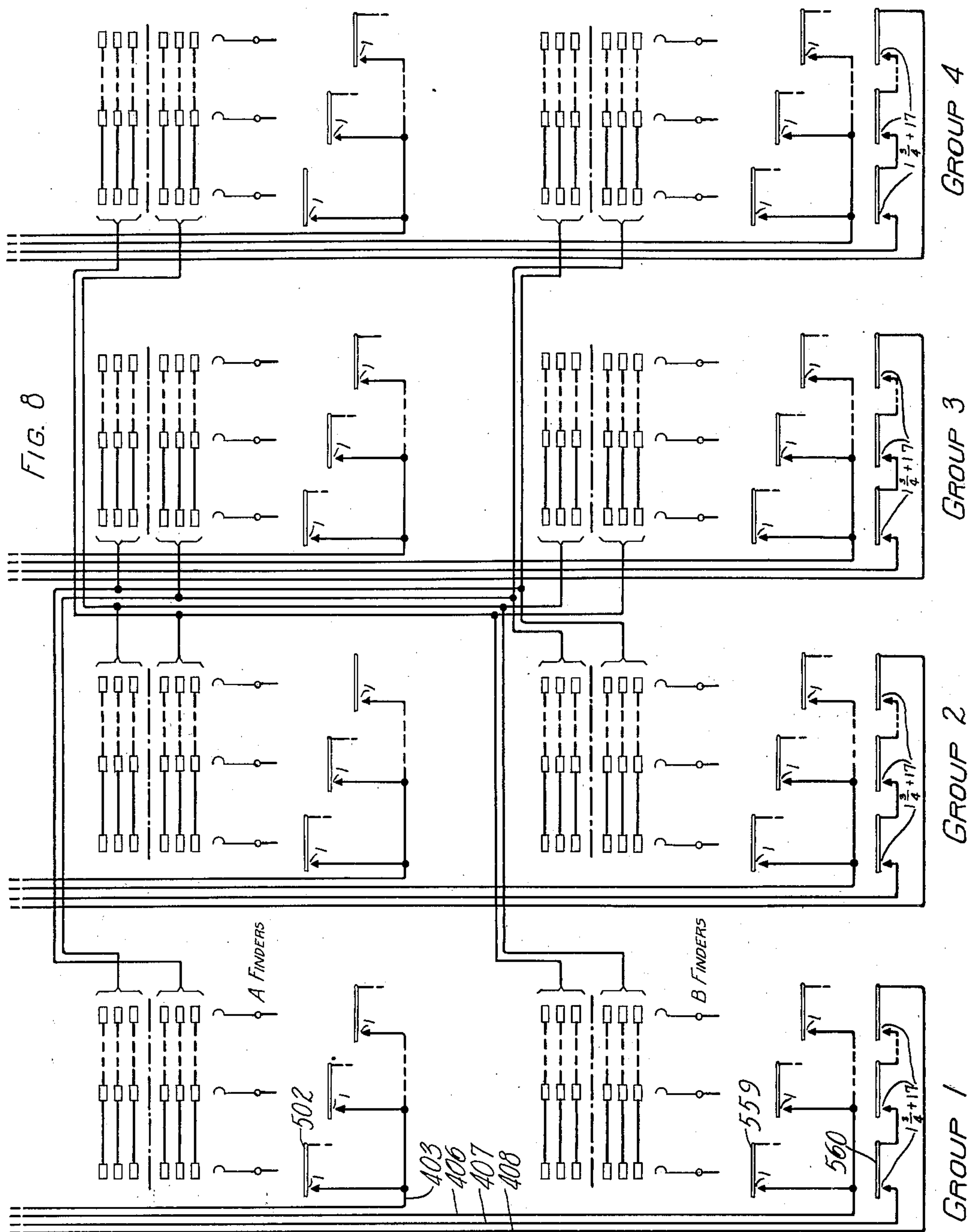
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UNITED STATES PATENT OFFICE

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TELEPHONE-EXCHANGE SYSTEM

Application filed June 20, 1928. Serial No. 286,813.

This invention relates to a telephone exchange system employing automatic selector switches and more particularly to a system employing a repeating sender associable with the incoming ends of interoffice trunks, to which the numerical portion of a wanted line number is transferred from the subscriber's sender and which in turn controls the setting of the selector switches at the terminating office. The invention has for its object the more accurate control of selector switches over long interoffice trunks and the simplification of apparatus for repeating control impulses from one sender to another.

In large machine switching telephone exchanges it often occurs that certain offices of such exchanges are located at the outskirts of such areas and that therefore long interoffice trunks are necessary to interconnect certain offices which may be quite widely separated. Under these conditions the revertive control of panel type selectors over such long trunks is not always reliable since the fixed speed at which the selectors at the terminating office operate on local connections may be faster than can be accurately controlled from a sender in an originating office, especially where a long length of interoffice cable intervenes. Heretofore, it has been the practice to establish such connections through a tandem switching office, the digits registered on the sender in an originating office being first transferred to a sender in the tandem office, which latter sender then controls the setting of the selectors in the terminating office. Unless the exchange area is very large and comprises a large number of offices, such tandem offices are not warranted from an economical standpoint and direct trunking between offices of the area is desirable.

A tandem trunking system of the type above described is illustrated in the patent to W. L. Dodge, No. 1,531,080, issued March 24, 1925. In this system the office and line designations registered on the registers of the sender in the originating office are transferred to the registers of the tandem sender by the so-called relay call indicator pulse method. That is, for each digit registered in the first sender a special code of impulses

of negative and positive polarity is transmitted to the tandem sender which is arranged to receive and register such codes on relay registers in much the same manner as impulses are transmitted to and registered in the well known call indicators. For local calls of a full mechanical nature the originating sender functions in the well known manner to control selector switches by impulses sent to the sender revertively by the selectors. Since such tandem senders must perform substantially all of the functions of the senders in the originating office, they must of necessity be as complicated in structure and function as such originating senders.

In accordance with the present invention calls from originating offices may be trunked directly to terminating offices without extension through a tandem office. This is accomplished through the provision of a group of small repeating or so-called "spill senders" in each office accessible in common to all interoffice incoming trunks. Each of these senders comprises a means for sending trains of revertive impulses back to the originating sender in the same manner that impulses are revertively sent from a selector switch commutator to satisfy the originating sender in accordance with the line designation digits registered on the registers thereof. The registers of the repeating sender are set in accordance with the impulses of each train so sent and therefore assume settings equivalent to the settings of the registers of the sender in the originating office. Counting relays are also provided which count the impulses so transmitted and assist in the setting of the registers and also in the usual manner count the impulses later transmitted from the selectors of the terminating office to control the setting of such selectors in accordance with the setting of the sender registers.

Each sender is also provided with means comprising an additional or 11th pair of counting relays which function in case the sender is not properly controlled from the originating sender during the revertive transmission of impulses back to the originating sender and transmits an excessive number of impulses, to set up an overflow condition in

the sender whereby the sender is released from the interoffice trunk with which it is at the time associated and another equivalent sender is taken for use. Provision is also made for enabling the sender and any selector switches which have been set thereby to be restored in the event that the calling subscriber abandons a call at any time before the connection to the desired line has become established.

Provision is also made for enabling idle, preselected senders to be very quickly associated with any calling trunk of a large group of interoffice trunks. For this purpose the group of interoffice trunks is divided into four sub-groups and the senders are similarly divided into four sub-groups. Each sender has individual thereto a pair of trunk finding switches each having access to 100 trunks whereby each sender has access to all of the trunks of a trunk group. Normally all of the senders of one sub-group have access to a sub-group of trunks through one of the trunk finders individual thereto, one sender of each sub-group being normally pre-allotted for use. For starting a pre-allotted sender-trunk-finder to hunt for a calling trunk in the sub-group which it normally serves, each sub-group of trunks has individual thereto a common start circuit. In the event that all senders in the sub-group normally assigned for connection with the trunks of a sub-group are busy at the time another call is initiated in such sub-group of trunks, the start circuit for such sub-group of trunks is extended for starting a pre-allotted sender in the next sub-group of senders. This start circuit may be similarly extended to all of the sub-groups of senders so that any idle sender in any of the sub-groups may be employed. The banks of the trunk finders are divided into two sections each and the trunks are all so multiplied between the sections of the banks of all trunk finders associated with the four sub-groups of senders that they appear as first choice trunks in the banks of the finders associated with two successive sub-groups of senders and as second choice trunks in the banks of the finders associated with the next two successive sub-groups of senders.

The apparatus of the repeating sender is thus very simple and since it controls the transfer of registrations to its registers revertively in the same manner as selectors control their own settings, it is not necessary to employ special call indicator code apparatus in originating senders for this purpose but the same apparatus employed in the originating senders for setting selector switches may be employed. Further, since there is no fixed speed of impulsing established such as is present in pulsing revertively from selector switches, the speed of impulsing from the repeating sender to the originating sender may be made such as is more suitable for pulsing

over longer interoffice cables than could be used for controlling selectors directly from the originating sender. This speed of impulsing may, however, be greater than would be attainable by the use of the aforementioned relay call indicator method.

Considering the present invention in a general manner, calls to a terminating office of an exchange area are extended in the well known manner by means of selector switches under the control of a register sender in an originating office in which the calling line terminates. When a call is incoming to an incoming selector in which an interoffice trunk terminates a start circuit is closed to start a pair of trunk finders individual to an allotted repeating or spill sender of a group serving the group of trunks in which the seized trunk is located, in search of the selected trunk. When one of the trunk finders finds the calling trunk a circuit is extended from the sender, over the interoffice trunk, to the sender in the originating office. Series of impulses are thereupon sent back over such established circuit from the spill sender to the originating sender in simulation of the usual action of commutators of incoming and final selector switches. In response to these series of impulses the registers of the originating sender are satisfied and incoming brush, and group, and final brush, tens and units registers of the spill sender are set into correspondence with the similar registers of the originating sender. A fundamental switch controlling circuit is then established between the spill sender and incoming and final selectors of the terminating office and such selectors are controlled from the spill sender in much the same manner as they would be controlled from the originating sender in accordance with the prior art. As soon as the originating sender has completed the transference of its registrations to the spill sender, the district selector is advanced into the talking position and such sender is dismissed. When the spill sender has completed its control of the incoming and final selectors it is also dismissed.

The invention has been disclosed by way of illustration in the accompanying drawings in which Fig. 1 shows diagrammatically a calling line terminating in an automatic dial switching office having a line finder, district selector, office selector and common sender; Fig. 2 shows an incoming selector of a terminating office of the exchange; Fig. 3 shows a final selector of such terminating office and one subscriber's line terminating therein; Fig. 4 shows the start circuits of four sub-groups of incoming interoffice trunks; Figs. 5, 6 and 7, taken together, show one spill sender of the terminating office, Fig. 5 showing the A and B trunk finders and control circuits individual to one sender, Fig. 6 showing the counting relays of the sender, and Fig. 7 showing the relay registers of the sender; Fig. 130

8 shows diagrammatically the multiplying of the four sub-groups of trunks before the banks of the A and B trunk finders of the four sub-groups of senders; and Fig. 9 shows the manner in which the figures of the drawing should be assembled to completely disclose the invention.

The apparatus of the originating office disclosed in Fig. 1 may be of the type fully disclosed in the patent to F. A. Stearn No. 1,505,171, granted August 19, 1924.

The trunk finders 510 and 520 of the spill sender, shown in Fig. 5, may be of the well known panel type with the exception that each finder is provided with but a single set of brushes and no tripping mechanism is provided. Two sequence switches are provided for controlling the spill sender. One of these sequence switches has a driving magnet 500 shown in Fig. 5. All the cams shown at the left of the dot and dash line of Fig. 5 and all of the cams shown in Fig. 6 with the exception of cams 605, 631, 633 and 638 are operated by magnet 500. The other sequence switch whose magnet is shown at 550 of Fig. 5 controls all of the cams shown at the right of the dot and dash line of Fig. 5 and cams 605, 631, 633 and 638 of Fig. 6.

Extension of connection to spill sender

It is believed that the invention may be best understood from a detailed consideration of the manner in which a call may be established from the line of subscriber 100 in Fig. 1 to the line of subscriber 325 in Fig. 3. For this purpose it will be assumed that the number of subscriber 325 is CORTlandt 3983. When the calling subscriber removes his receiver from the switchhook his line becomes extended by means of the line finder 101 to the district selector 102 and through link mechanism not shown to an idle sender diagrammatically illustrated by the rectangle 103. The line finder 101, district selector 102, sender 103 and link mechanism may be of the type disclosed in the patent to W. H. Matthies No. 1,567,072 granted December 29, 1925. A sender of the type disclosed at 103 is shown in detail in the patent to O. H. Kopp No. 1,589,402, granted June 22, 1926.

Upon the extension of the calling line to the sender a pulsing circuit is established extending from battery, winding of pulsing relay 104, the left contact of cam 105, the ring brush of line finder 101 and the line terminal with which it is in engagement over the subscriber's line loop, returning over the tip brush of line finder 101, the left contact of cam 106 to ground through the left winding of coil 107. Relay 104 energizes in this circuit, closing an obvious circuit for relay 108 which in turn establishes a tone circuit from the source 109 through the right winding of relay 107, the left contact of relay 108 to ground. A tone is thereby induced into the

pulsing circuit and is heard by the calling subscriber apprising him that he may commence to dial the office and numerical designations of the wanted line. In the manner fully set forth in the aforementioned patent to Kopp, in response to the manipulation of dial 110, the office code and numerical registers of the sender are set to record the number of the wanted line. As soon as the office code has been registered and the proper translation has been made in the sender, the sender proceeds in the well known manner to control the setting of the district selector 102 to extend the calling line to the terminals of an idle office selector 150. The control of this selector is exercised through the operation of the sender stepping relay 112 in conjunction with the usual train of counting relays, the last pair of which 113 and 114 are disclosed, and with the translator of the sender, not shown. As soon as the district selector has found an idle office selector such as 150 the district sequence switch advances to position 10 in which position a controlling or fundamental circuit is extended from the sender to the office selector which may be traced in part from the tip brush of the district selector 102, the right contacts of cam 115, the back contact of counting relay 113, the winding of stepping relay 112, the upper left and lower right contacts of cam 116 to the ring brush of the district selector. The office selector 150 which is of the well known type is then set from the translator of the sender to complete the extension of the calling line to the office in which the wanted line 325 terminates.

Upon the seizure of conductors 201 and 202 of an idle trunk terminating in the incoming selector 250, the previously traced fundamental circuit is extended from the tip brush of the selector 102, over the tip brush of selector 150, conductor 201, the lower right contact of cam 203, resistance 204, to battery through the right winding of relay 205 and from the ring brush of the district selector 102, over the ring brush of office selector 150, conductor 202, the lower left contact of cam 206, to ground through the left winding of relay 205. Relays 112 and 205 energize in this circuit, relay 112 preparing the sender for controlling the transfer of the incoming brush registration from the sender 103 to the sender of Figs. 5, 6 and 7. With sequence switch 200 in position 1, relay 205 upon energizing establishes a circuit for control relay 207, extending from battery, right winding of relay 207, upper left contact of cam 208, front contact of relay 205, right back contact of relay 209, to ground at the lower contact of cam 210.

Relay 207 energizes in this circuit and closes a start circuit for associating an idle sender with the trunk circuit 201, 202. This circuit extends from ground at the left front contact of relay 207, the upper right and

lower left contacts of cam 211, start conductor 212, the upper back contact of relay 400, the left back contact of relay 401 to battery through the left winding of relay 402, provided there is an idle sender in the sub-group of senders normally assigned for serving the trunks in which trunk 201, 202 is located. Relay 402 upon energizing extends the start conductor 212 over the upper back contact of relay 400, the outer right front contact of relay 402 to conductor 403, the outer left back contact of relay 501, the upper contact of cam 502, to battery through the right winding of relay 503 and resistance 504. Relay 503 upon energizing closes a circuit for advancing sequence switch 550 out of position 1 into position 2 extending from battery, winding of sequence switch magnet 550, the upper left contact of cam 505 to ground at the right front contact of relay 503. With sequence switch 550 in position 2 relay 503 is locked from battery through resistance 504 and the right winding of relay 503, the lower left contact of cam 502, segment 507 of the commutator of switch 520, brush 508 normally in engagement therewith, the upper contact of cam 509 to ground at the right front contact of relay 503. A circuit is also established for the up-drive magnet of switch 520 as follows: Battery, winding of up-drive magnet 511, the lower left contact of cam 509 to ground at the right front contact of relay 503. In response to the energization of magnet 511, the brushes of switch 520 are advanced to the first set of terminals connected to the first trunk of the group to which this trunk finder has access. It will be assumed that this trunk is in a non-calling condition and that the control relay thereof corresponding to relay 207 is deenergized. When the brushes of switch 520 are centered on the first set of terminals, the locking circuit of relay 503 is opened at the commutator strip 507 as the brush 508 is then resting on an insulating segment thereof, but relay 503 is maintained energized over a locking circuit extending from battery at the upper right contact of cam 600, conductor 601, the left winding and inner left front contact of relay 503, bridging type test brush 512 and the terminal upon which it is resting, over a conductor similar to conductor 513 thence over the left contacts of a cam similar to cam 213 to ground at the back contact of the control relay of that trunk similar to relay 207. Had such trunk been engaged in the establishment of a connection and its sequence switch been advanced beyond position 1, then the conductor 513 would be grounded at the lower left contact of a cam similar to cam 214 and relay 503 would remain locked. With relay 503 thus locked the circuit of the up-drive magnet 511 is maintained to advance the brushes of switch 520 to the next set of terminals.

It will be assumed that the next set of ter-

minals is connected as shown to the trunk 201, 202 and that the test conductor 513 is therefore open both at the back contact of relay 207 and at the contact of cam 214. Relay 503 thereupon releases, opening the circuit of magnet 511, stopping the brushes of the switch 520 upon the terminals of this trunk and closing a circuit extending from ground at the outer right back contact of relay 503 over the inner right back contact of relay 501, the lower left contact of cam 505 to battery through the magnet of sequence switch 550 advancing such sequence switch into position 3. Relay 503 upon releasing also connects ground over its inner left contact to test brush 512 to maintain busy potential upon the terminal upon which it is resting thereby preventing the brushes of another trunk finder associated with another sender finder from connecting therewith.

Relay 503 at its outer right back contact also establishes a circuit from ground over the inner right back contact of relay 501, the upper contacts of cam 517, conductor 404 to battery through the winding of relay 401. Relay 401 upon operating opens the start circuits through the windings of relay 402 to prevent the starting of another pre-allotted trunk finder until after the started trunk finder has found the calling trunk. With sequence switch 550 in position 3 a circuit is closed to advance sequence switch 500 out of position 1 into position 2 extending from battery through the winding of magnet 500, upper left contact of cam 514 to ground over the upper left and lower right contacts of cam 515. A circuit is also established from ground at the outer right back contact of relay 503, the inner right back contact of relay 501, the lower contact of cam 516, the upper contacts of cam 516' of a sender similar to the one disclosed whose sequence switch corresponding to 550 is standing in position 18 awaiting allotment, thence to the lower right contact of a cam similar to 505 to battery through the magnet of such sequence switch advancing such sequence switch into position 1 in readiness for serving the next incoming call.

At its inner right back contact relay 503 establishes a circuit extending from ground at the outer right back contact of relay 501, inner right back contact of relay 503, upper left contact of cam 518, brush 519, and the terminal upon which it is resting, conductor 405, upper contact of cam 215, winding of relay 209 to battery. Relay 209 energizes opening at its right back contact the circuit of relay 207 which in turn deenergizes, opening the circuit through relay 402, and at its right front contact closes a circuit for advancing sequence switch 200 out of position 1 into position 2. This circuit may be traced from battery through the winding of magnet 200, lower left contact of cam 216, right

front contact of relay 209, to ground at the lower contact of cam 210. With sequence switch 200 in position 2, ground is placed on conductor 513 at the lower left contact of cam 214 to mark the incoming selector and associated trunk as busy before all sender trunk finding switches having access thereto. When sequence switch 200 left position 1 the windings of relay 205 became disconnected from the tip and ring conductors 201 and 202 of the trunk and relays 112 and 205 became deenergized. The fundamental circuit is now extended from trunk conductor 201 over conductor 217, brush 521, the lower right and upper left contacts of cam 522 to battery through the winding of control relay 523 and from trunk conductor 202 over conductor 218, brush 524, the left contacts of cam 525, the right back contact of relay 526 to ground at the upper left contact of cam 527. Relays 523 and 112 energize over the fundamental circuit. Relay 523 upon energizing closes a circuit for relay 528 from battery through the winding of relay 528, the front contact of relay 523 to ground at the lower left contact of cam 527. Relay 528 locks over its inner left front contact to ground at the lower right contact of cam 527, closing a holding circuit for itself directly to ground over its right front contact and the front contact of relay 523 to prevent its deenergization after sequence switch 500 leaves position 2, and closing a circuit over its left front contact, upper right front contact of cam 514 through the winding of sequence switch 500 for advancing sequence switch 500 into position 3. With sequence switch 500 in position 3 the shunt which normally exists around relay 529 is removed at the left contacts of cam 527 and relay 529 energizes over the fundamental circuit.

Setting the sender registers

Two circuits are now effective in parallel with each other, the first extending from battery over the left contact of cam 600 through the winding of the No. 9 counting relay of the train of counting relays disclosed at the bottom of Fig. 6, over the back contact of the No. 9' counting relay, conductor 602, the bottom contact of cam 530, the front contact of relay 529, the lower contacts of cam 531, conductor 604 to ground at the upper right contacts of cam 603. The second circuit extends from ground on conductor 604 over both contacts of cam 530 to battery through the winding of relay 532. Relay 532 and the No. 9 counting relay energize, the No. 9 counting relay locking through the winding of the No. 9' counting relay, the front contact of the No. 9 counting relay, the lower contacts of cam 605 to ground at the lower contacts of cam 606. The No. 9' counting relay, however, does not energize in this locking circuit since

at this time both of its terminals are connected to ground. Relay 532 upon energizing closes an obvious holding circuit for relay 523 in shunt of relay 529 and also in shunt of the sender stepping relay 112. Both of these relays thereupon deenergize, the stepping relay 112 causing upon its energization and deenergization the operation of a pair of counting relays of the sender 103 in the well known manner. Upon the deenergization of relay 529 ground is removed from one terminal of the No. 9' counting relay and this relay energizes in the locking circuit of the No. 9 counting relay. Thus a pair of counting relays in both the sender 103 and in the spill sender shown in Figs. 5, 6 and 7 have been operated and locked.

Upon the deenergization of relay 529, the energizing circuit of relay 532 is opened and the shunt again removed from the windings of relays 529 and 112 and these relays again energize, the relay 112 operating another counting relay of the next pair in the train of sender 103 and relay 529 again closing the circuit for operating relay 532 and in parallel therewith the No. 8 counting relay, over a circuit extending from conductor 602 through the front contact of the No. 9' counting relay, the back contact of the No. 8' counting relay through the winding of the No. 8 counting relay to battery over the circuit previously traced. Relay 532 and the No. 8 counting relay energize, the No. 8 counting relay locking through the winding of the No. 8' counting relay and relay 532 again shunting the stepping relay 112 and the relay 529. This cycle of operations continues until the originating sender 103 is satisfied as to its incoming brush selection registration whereupon the fundamental circuit is opened at the sender 103 and relay 523 deenergizes.

Relay 523 upon deenergizing opens the holding circuit of relay 528, which latter relay deenergizes closing a circuit from battery through the magnet winding of sequence switch 500, the lower right contact of cam 514 for advancing sequence switch 500 into position 4. It has been assumed that the number of the wanted subscriber 325 is 3983. Thus, two pairs of counting relays, No. 9 and No. 9' and No. 8 and No. 8' have been operated and locked to cause a registration of the fact that it will be necessary to trip the second set of brushes in the incoming selector 250. The manner in which this registration is set up on the incoming brush register relays of Fig. 7 will now be described.

When sequence switch 500 passes into position 3½, a circuit is extended from battery over the lower contact of cam 600, conductor 701, both windings of register relay 700, conductor 702, the left contacts of cam 607, the back contact of No. 7 counting relay, the lower contacts of cam 605 to ground at the lower contact of cam 606. Until the No. 9

counting relay energizes, a shunt around the right winding of relay 700 exists which may be traced from the junction of the two windings of relay 700 over the left back contact of relay 700, conductor 703, the upper left and lower right contacts of the cam 608 to the back contact of the No. 9 counting relay to ground at the lower contact of cam 606. As soon as the No. 9 counting relay energizes relay 700 energizes.

A circuit is also established for relay 705 extending from battery over the lower contact of cam 600, conductor 701, both windings of relay 705, conductor 706, the left contacts of cam 609, the back contact of the No. 6 counting relay, the lower contacts of cam 605 to ground at the lower contact of cam 606. Until the No. 8 counting relay energizes there is a shunt around the right winding of relay 705 which may be traced from the junction of the two windings of relay 705 over the inner left back contact of relay 705 and conductor 707, the left contacts of cam 610, the back contact of the No. 8 counting relay to ground at the lower contact of cam 606. This shunt is opened at the back contact of the No. 8 counting relay when that relay is energized and relay 705 thereupon energizes.

A circuit is also established for relay 710 extending from battery, conductor 701, through both windings of relay 710, conductor 708, lower contact of cam 611, back contact of the No. 4 counting relay to ground as traced at the lower contact of cam 606. This relay, however, does not energize since its right winding is shunted over its outer right back contact, conductor 709, the right contacts of cam 612, the back contact of the No. 5 counting relay to ground at the lower contact of cam 606 and, since the No. 5 counting relay has not been energized this relay 710 cannot operate. Thus, in response to the operation of the counting relays two incoming brush selection register relays 700 and 705 have been operated and when sequence switch 500 advances into position 4 locking circuits are established therefor. The locking circuit of relay 700 may be traced from battery, conductor 701, through both windings and the inner right contact of relay 700, conductor 704 to ground at the upper left contact of cam 606. The locking circuit for relay 705 may be traced from battery on the conductor 701 through both windings and the inner right contact of relay 705, conductor 704 to ground at the upper left contact of cam 606.

It will be recalled that upon the termination of the transference of the incoming brush registration from the sender 103 to the spill sender that sequence switch 500 advanced into position 4. The fundamental circuit is now reestablished from battery through the winding of relay 523 thence as traced to the winding of relay 112 at the

sender 103, returning over the right back contact of relay 526 to ground at the upper left contact of cam 527. Relay 529 is at this time shunted at the left contacts of cam 527. Relay 523 upon energizing over the fundamental circuit again operates relay 528 which locks as before described and closes a circuit from ground over its outer left front contact and the upper contact of cam 514 for advancing sequence switch 500 into position 5. Relay 528 remains locked over the contact of relay 523 and its own right contact after sequence switch 500 leaves position 4. The operated counting relays No. 9, No. 9', No. 8 and No. 8' are at this time released as their locking circuits were opened at the lower contacts of cam 606 when sequence switch 500 passed out of position 3½. With sequence switch 500 in position 5, the shunt around the winding of relay 529 is removed and this relay energizes over the fundamental circuit closing the previously traced parallel circuits through the winding of relay 532 and the winding of the No. 9 counting relay.

In the manner previously described relays 523, 529 and 112 cooperate to successively operate and lock pairs of counting relays in the spill sender and in the sender 103 until sufficient counting relays in the sender 103 have been operated to satisfy the incoming group registration therein, when the fundamental circuit will be opened through the operation of relay 113, releasing relays 523, 529 and 112. The release of relay 523 in the manner previously described opens the holding circuit of relay 528 which releases and causes the advance of sequence switch 500 into position 6. Since it has been assumed that the subscriber's line number is 3983, it will be necessary to select a group of final selectors terminating in the fourth group of the second brush group of the incoming selector and therefore, four pairs of counting relays, No. 9, No. 9', No. 8, No. 8', No. 7, No. 7' and No. 6, No. 6' will be operated during the transference of the incoming group registration in the manner previously described.

As the sequence switch 500 passes into position 5, the following circuits will be established for operating relays of the incoming group register: The first circuit extends from battery at the lower contact of cam 600 over conductor 701 through both windings of relay 711, conductor 712, the lower contacts of cam 607, the back contact of counting relay No. 7, the lower contacts of cam 605 to ground at the lower contact of cam 606. Until the No. 9 counting relay energizes the right winding of relay 711 is shunted over a circuit from the junction point between the windings thereof over the left contact of relay 711, conductor 713, the lower contacts of cam 608, back contact of the No. 9 counting relay to ground at the lower contact of cam 606. As soon as the No. 9 counting relay en-

ergizes this shunt is opened and relay 711 operates. A second circuit is also closed from the battery, conductor 701, through both windings of relay 715, conductor 716, the lower contacts of cam 609, the back contact of the No. 6 counting relay to ground at the lower contact of cam 606. Until the No. 8 counting relay energizes, relay 715 is shunted in a circuit from the junction point between the windings of relay 715, the inner left back contact of relay 715, conductor 717, the upper right and lower left contacts of cam 610, the back contact of the No. 8 counting relay to ground at the lower contact of cam 606. As soon as the No. 8 counting relay energizes this shunt is opened and relay 715 operates. When the No. 7 counting relay operates the operating circuit of relay 711 is opened at the back contact of the No. 7 counting relay and relay 711 deenergizes. As soon as the No. 6 counting relay operates the circuit of the relay 715 is opened at the back contact of the No. 7 counting relay. Thus, when the sequence switch advances out of position 5 into position 6 at the end of the transference of the incoming group registration, no relays of the incoming group register remain operated.

As sequence switch 500 leaves position 5½ the locking circuits for the operated counting relays are opened at the lower contact of cam 606, and as the sequence switch arrives in position 6 relay 523 is again operated over the fundamental circuit in series with relay 112 of the sender 103. In the manner previously described relay 528 operates and locks upon the operation of relay 523, advancing sequence switch 500 into position 7 and thereby including relay 529 in the fundamental circuit. Counting relays of the spill sender and of the sender 103 are thereupon operated and locked in the manner previously described until the sender 103 is satisfied as to its final brush registration when relay 113 operates, opening the fundamental circuit at the sender 103. Thereupon relays 112, 523 and 529 are deenergized, relay 523 unlocking relay 528 which in turn deenergizes advancing sequence switch 500 into position 8. Since it has been assumed that the subscriber's number is 3983 the terminals of the wanted line will appear in the fifth brush group of the final selector and therefore five pairs of counting relays from No. 9, No. 9' to No. 5, No. 5' inclusive will have been operated.

Prior to the advance of sequence switch 500 out of position 7 a circuit will be effective from battery on conductor 701 through both windings of final brush register relay 718, conductor 719, the upper right and lower left contacts of cam 607, the back contact of the No. 7 counting relay, the lower contacts of cam 605 to ground at the lower contact of cam 606. Until the No. 9 counting relay operates a shunt exists around the right winding of relay 718, extending from the

junction point between its windings over the left contact of relay 718, conductor 720, the right contacts of cam 608, the back contact of the No. 9 counting relay to battery. As soon as the No. 9 counting relay operates this shunt is opened and relay 718 operates. A circuit is also closed from battery on conductor 701, through both windings of relay 721, conductor 722, the upper right and lower left contacts of cam 609, the back contact of the No. 6 counting relay, thence to ground at the lower contact of cam 606. Until the No. 8 counting relay operates a shunt exists around the right winding of relay 721 extending from the junction point between its windings over the inner left back contact of relay 721, conductor 723, the lower contacts of cam 610, the back contact of the No. 8 counting relay to ground at the lower contact of cam 606. As soon as the No. 8 counting relay operates this shunt is opened and register relay 721 operates. A circuit is also established from battery on conductor 701, through both windings of relay 724, conductor 725, the lower contact of cam 613, the back contact of the No. 3 counting relay to ground at the lower contact of cam 606, and a shunt around the right winding of relay 724 exists from the junction of its two windings over its right back contact, conductor 726, the lower contacts of cam 612, the back contact of the No. 5 counting relay to ground at the lower contact of cam 606. This shunt is removed when the No. 5 counting relay energizes and relay 724 thereupon operates.

As soon as the No. 7 counting relay energizes the operating circuit of relay 718 is opened at the back contact of this counting relay and relay 718 releases. The operation of the No. 6 counting relay also opens the operating circuit of relay 721 at the back contact of the No. 6 counting relay and relay 721 releases. Thus at the end of the transference of the final brush registration from the sender 103, relay 724 is the only final brush register relay operated. This relay locks over its right front contact, conductor 727 to ground at the lower right contact of cam 603 as soon as sequence switch 500 advances into position 7½.

When sequence switch 500 leaves position 7½ the locking circuits for the operated counting relays are opened at the lower contact of cam 606 and as the sequence switch arrives in position 8 relay 523 is again operated over the fundamental circuit in series with relay 112 of the sender 103. In the manner previously described relay 528 operates and locks upon the operation of relay 523, advancing sequence switch 500 into position 9 and thereby including relay 529 in the fundamental circuit. Counting relays of the spill sender and of the sender 103 are thereupon operated and locked in the manner previously described until the sender 103 is satisfied

as to its final tens registration when relay 113 operates opening the fundamental circuit at the sender 103. Thereupon relays 112, 523 and 529 deenergize, relay 523 unlocking relay 528 which in turn deenergizes, advancing sequence switch 500 into position 10. Since it has been assumed that the wanted line terminates in the ninth group of the fifth brush group of the final selector, all of the pairs of counting relays from No. 9, No. 9' to No. 1, No. 1' will have been operated.

Prior to the advance of sequence switch 500 out of position 9 a circuit will be effective from battery on conductor 701, through both windings of relay 728, conductor 729, the upper left contact of cam 611, the back contact of the No. 4 counting relay to ground at the lower contact of cam 606. Until the No. 9 counting relay operates a shunt exists around the right winding of relay 728 extending from the junction between its windings, the left back contact of relay 728, conductor 730, the upper right contact of cam 614, the lower right contact of cam 608, the back contact of the No. 9 counting relay to ground at the lower contact of cam 606. As soon as the No. 9 counting relay operates this shunt is opened and relay 728 energizes. A circuit is also closed from battery on conductor 701, through both windings of relay 731, conductor 732, the upper left contact of cam 613, the back contact of the No. 3 counting relay to ground at the lower contact of cam 606. Until the No. 8 counting relay operates a shunt exists around the right winding of relay 731, extending from the junction between its windings over its inner left back contact, conductor 733, the lower left contact of cam 615, the lower left contact of cam 610, the back contact of the No. 8 counting relay to ground at the lower contact of cam 606. As soon as the No. 8 counting relay operates this shunt is opened thereby and relay 731 operates.

A circuit is also established from battery on conductor 701, through both windings of relay 734, conductor 735, the left contact of cam 616, the back contact of the No. 2 counting relay to ground at the lower contact of cam 606. Until the No. 7 counting relay operates a shunt exists around the right winding of relay 734, extending from the junction between the windings thereof, over the inner left back contact of relay 734, conductor 736, the upper left contact of cam 617, the lower left contact of cam 607, the back contact of the No. 7 counting relay to ground at the back contact of cam 606. As soon as the No. 7 counting relay operates this shunt is opened and relay 734 operates. A circuit may also be traced from battery on conductor 701, through both windings of relay 737, over conductor 738, over the left contact of cam 618, the back contact of the No. 1 counting relay to ground at the lower contact of cam 606. Until the No. 6 counting relay operates a

shunt exists around the right winding of relay 737, extending from the junction between the windings thereof, over the inner left back contact of relay 737, conductor 739, the upper left contact of cam 619, the lower left contact of cam 609, the back contact of the No. 6 counting relay to ground at the lower contact of cam 606. As soon as the No. 6 counting relay operates this shunt is opened and relay 737 energizes. Still another circuit may be traced from battery on the conductor 701, over both windings of relay 740, conductor 741, the upper contact of cam 620, the back contact of the No. 0 counting relay to ground at the lower contact of cam 606. Until the No. 5 counting relay operates the right winding of relay 740 is shunted in a circuit extending from the junction point between the windings thereof, over the inner left back contact thereof, conductor 742, the upper left contact of cam 621, the lower right contact of cam 612, the back contact of the No. 5 counting relay to ground at the lower contact of cam 606. As soon as the No. 5 counting relay operates this shunt is removed and relay 740 operates.

When the No. 4, No. 3, No. 2 and No. 1 counting relays operate, previously traced operating circuits for relays 728, 731, 734 and 737 are opened at the back contacts of such counting relays and therefore at the time sequence switch 500 advances out of position 9 into position 10 only one register relay 740 of the final tens register remains operated. This relay locks from battery on conductor 701, through both of its windings and its inner right front contact, conductor 743, to ground at the lower left contact of cam 603 as soon as sequence switch 500 reaches position 9½. Upon leaving position 9½ the locking circuits for all operated counting relays are opened at the lower contact of cam 606 in readiness for the registration of final units impulses.

With sequence switch 500 in position 10 relay 523 is again operated over the fundamental circuit in series with relay 112 of the sender 103. In the manner previously described relay 528 operates and locks upon the operation of relay 523, advancing sequence switch 500 into position 11 thereby including relay 529 in the fundamental circuit. Counting relays of the spill sender and of the sender 103 are thereupon operated and locked in the manner previously described until the sender 103 is satisfied as to its final units registration when relay 113 operates opening the fundamental circuit at the sender 103. Thereupon relays 112, 523 and 529 deenergize, relay 523 unlocking relay 528 which in turn deenergizes, advancing sequence switch 500 into position 12. Since it has been assumed that the units digit of the wanted line is three and the line therefore terminates in the fourth set of terminals of

the ninth tens group, the No. 9, No. 9', No. 8, No. 8', No. 7, No. 7', No. 6 and No. 6' counting relays will have been operated.

Prior to the advance of sequence switch 500 out of position 11 a circuit will be effective from battery on conductor 701, through both windings of relay 744, conductor 745, the right contact of cam 611, the back contact of the No. 4 counting relay to ground at the lower contact of cam 606. Until the No. 9 counting relay operates a shunt exists around the right winding of relay 744, extending from the junction between its windings, the left back contact of relay 744, conductor 746, the upper left contact of cam 614, the lower right contact of cam 608, the back contact of the No. 9 counting relay to ground at the lower contact of cam 606. As soon as the No. 9 counting relay operates this shunt is opened and relay 744 energizes. A circuit is also closed from battery on conductor 701, through both windings of relay 747, conductor 748, the right contact of cam 613, the back contact of the No. 3 counting relay to ground at the lower contact of cam 606. Until the No. 8 counting relay operates a shunt exists around the right winding of relay 747, extending from the junction between its windings, over its inner left back contact, conductor 749, the lower right contact of cam 615, the lower left contact of cam 610, the back contact of the No. 8 counting relay to ground at the lower contact of cam 606. As soon as the No. 8 counting relay operates this shunt is opened thereby and relay 747 operates.

A circuit is also established from battery on conductor 701, through both windings of relay 750, conductor 751, the right contact of cam 616, the back contact of the No. 2 counting relay to ground at the lower contact of cam 606. Until the No. 7 counting relay operates a shunt exists around the right winding of relay 750, extending from the junction between the windings thereof, over its inner left back contact, conductor 752, the lower left contact of cam 617, the lower left contact of contact 607, the back contact of the No. 7 counting relay to ground at the lower contact of cam 606. As soon as the No. 7 counting relay operates this shunt is opened and relay 750 operates. A circuit may also be traced from battery on conductor 701, through both windings of relay 753, conductor 754, the right contact of cam 618, the back contact of the No. 1 counting relay to ground at the lower contacts of cam 606. Until the No. 6 counting relay operates a shunt exists around the right winding of relay 753, extending from the junction of the windings thereof, over its inner left back contact, conductor 755, the lower right contact of cam 619, the lower left contact of cam 609, the back contact of the No. 6 counting relay to ground at the lower contact of cam

606. As soon as the No. 6 counting relay operates this shunt is opened and relay 753 energizes. Still another circuit may be traced from battery on conductor 701, over both windings of relay 756, conductor 757, the lower contact of cam 620, the back contact of the No. 0 counting relay to ground at the lower contact of cam 606. Until the No. 5 counting relay operates the right winding of relay 756 is shunted in a circuit extending from the junction between the windings thereof, over its inner left back contact, conductor 758, the upper right contact of cam 621, the lower right contact of cam 612, the back contact of the No. 5 counting relay to ground at the lower contact of cam 606. Since it has been assumed that the No. 5 counting relay is not energized this shunt is not opened, and relay 756 does not energize. When therefore sequence switch 500 advances out of position 11 into position 12 only register relays 744, 747, 750 and 753 of the final units register remain operated. These relays then lock as soon as sequence switch 500 reaches position 11½ from battery on conductor 701, over both windings of these relays, the inner right front contact of each, conductor 759 to ground at the upper left contact of cam 603. Upon leaving position 11½ the locking circuits of all operated counting relays are opened at the lower contact of cam 606 and these relays deenergize.

With sequence switch 500 in position 12 the fundamental circuit through the windings of relays 523 and 112 is again closed but the winding of relay 523 is at this time connected over the left contacts of cam 522 to conductor 521, thence to the ring conductor 202 of the trunk and ground is connected over the upper left contact of cam 527, the right back contact of relay 526, the lower left and upper right contacts of cam 525, to tip conductor 201 of the trunk. This reversal of current advances the sender in the well known manner for making talking selection at the district selector whereupon the district selector advances into the talking position and the sender 103 is dismissed. Relay 523 also energizes over the fundamental circuit in turn operating relay 528 which locks and in turn advances sequence switch 500, through position 13 into position 14. As soon as sequence switch 500 leaves position 13 relays 523 and 528 deenergize.

With sequence switch 500 in position 14 and sequence switch 550 in position 3 as soon as the district selector 102 advances into the talking position a circuit is established from battery through resistance 534, the right winding of relay 533, conductor 622, the upper contacts of cam 615, conductor 623, the left contacts of cam 535, brush 521 of trunk finder 520, conductor 217, trunk conductor 201, tip brushes of office selector 150 and district selector 102, the upper contacts

of cam 115, the upper right winding of repeating coil 117, the winding of relay 118 the lower right winding of repeating coil 117, the lower contacts of cam 116, the ring brushes of selectors 102 and 150, trunk conductor 202, conductor 218, brush 524 of trunk finder 520, the left contacts of cam 536, conductor 624, the lower contacts of cam 614, conductor 625 to ground through the left winding of relay 533. Relay 533 energizes in this circuit but relay 118 being polarized does not. Relay 533 upon energizing closes a circuit from ground on its front contact over conductor 626, the right contacts of cam 617, conductor 627, to battery through the winding of relay 537. Relay 537 energizes closing at its left front contact a locking circuit for itself extending to ground at the front contact of relay 533 and over conductor 626 to ground at the lower contacts of cam 621. At its right front contact relay 537 closes an obvious operating circuit for relay 538 which upon energizing closes a circuit extending from ground over its outer right front contact, the upper contact of cam 539 to battery through the winding of sequence switch magnet 500 advancing this sequence switch out of position 14 into position 18.

30 *Incoming brush selection*

Upon reaching position 15 a circuit is closed from ground at the upper right contact of cam 527 over the lower left contact of cam 540 to battery through the winding of magnet 550 advancing sequence switch 550 into position 4. With sequence switch 200 in position 2 a fundamental switch controlling circuit may be traced from the incoming selector of Fig. 2 to the spill sender, extending from battery through the right winding of relay 207, the lower contacts of cam 219, conductor 221, brush 541 of the trunk finder, the left contact of cam 542, the lower contacts of cam 525, the right back contact of relay 526, the winding of relay 529, the outer right back contact of relay 543, the contacts of cam 544, conductor 628, the back contact of the No. 0' counting relay, conductor 629, the contacts of cam 545, the right winding of polarized overflow relay 546, resistance 547, brush 549, conductor 222, to ground at the lower contact of cam 220. Relays 207 and 529 energize in this circuit but relay 546 being polarized does not operate.

Relay 207 upon energizing closes a circuit for advancing sequence switch 200 into position 3 extending from battery through the magnet winding of sequence switch 200, the upper right contact of cam 216 to ground at the left front contact of relay 207. Relay 207 also closes a locking circuit for itself extending from battery through its right winding, the left contact of cam 223, the right front contact of relay 207, the left contacts of cam

219 to conductor 221 of the fundamental circuit for holding itself energized over the fundamental circuit after sequence switch 200 leaves position 2. With sequence switch 200 in position 3, a circuit is established for the up-drive magnet 224 extending from battery through this magnet, the right contact of cam 225 to ground at the left front contact of relay 207 for advancing the switch shaft in its brush selection movement. As the switch shaft approaches the first brush selection position a circuit is closed in shunt of the sender stepping relay 529 which may be traced from ground at the left contact of cam 229, commutator brush 226, a conducting segment of commutator strip 227, the lower contacts of cam 223, to battery through the right winding of relay 207 and to conductor 221 of the fundamental circuit over the right front contact of relay 207 and the left contacts of cam 219. Relay 207 is held energized over this circuit but the sender stepping relay deenergizes.

It will be recalled that relays 700 and 705 of the incoming brush register of the spill sender have been operated and therefore upon the initial energization of stepping relay 529 over the fundamental circuit just traced a circuit is established from ground at the left contact of cam 548, the contact of relay 529, conductor 630, the upper left contact of cam 631, conductor 632, the left back contact of relay 710, the outer right front contact of relay 700, the outer left front contact of relay 705, conductor 760, the back contact of the No. 1' counting relay, the winding of the No. 1 counting relay to battery at the left contact of cam 600. The No. 1 counting relay energizes in this circuit locking through the winding of the No. 1' counting relay through the right front contact of the No. 1 counting relay over the lower contacts of cam 605 to ground at the lower contact of cam 606. The No. 1' counting relay being shunted at this time over the front contact of the stepping relay 529 does not operate. When, however, the stepping relay 529 deenergizes at the time the incoming selector reaches its first brush tripping position, the No. 1' counting relay energizes and extends conductor 760 over its front contact, the contacts of cam 633, the winding of the No. 0 counting relay to battery at the left contact of cam 600.

As the switch shaft of the incoming selector 250 advances, the brush 226 engages the next insulating segment of commutator strip 227, and the shunt about stepping relay 529 is removed and relay 529 again energizes completing the circuit of the No. 0 counting relay. This counting relay now locks through the winding of the No. 0' counting relay and the winding of relay 634 in parallel over the front contact of the No. 0 counting relay to ground at the lower contact of cam 606. Relay 634 and the No. 0' counting relay do not energize in this circuit until the switch shaft

of the incoming selector approaches the next brush selection position when the shunt previously traced is closed permitting stepping relay 529 to again deenergize. As soon as relay 634 energizes a circuit is closed from its front contact over the upper right contact of cam 540 through the magnet winding of sequence switch 550 advancing such sequence switch into position 5. In position 5 a circuit is closed through magnet 550, the upper left contact of cam 540, the left back contact of relay 526, to ground at the inner right front contact of relay 538, for advancing sequence switch 550 into position 6. The No. 0' counting relay upon energizing opens the fundamental circuit at its back contact thereby releasing stepping relay 529 and relay 207. As the sequence switch 550 advances out of position 4 the locking circuits of the operated counting relays are opened at the lower contacts of cam 605.

Incoming group selection

At the incoming selector relay 207 is held energized over the circuit previously traced to ground over the brush 226 until the switch shaft has been positioned to enable the second set of brushes to be tripped, when the brush 226 will engage an insulating segment of commutator strip 227. Relay 207 upon deenergizing opens the circuit of the up-drive magnet 224 and closes a circuit extending from battery through the winding of sequence switch magnet 200, the upper left contact of cam 216, to ground at the left back contact of relay 207 for advancing sequence switch 200 out of position 3 into position 3. In position 4 a circuit is closed for the trip magnet 228 extending from battery through magnet 228 to ground at the right contact of cam 229. Also in position 4 the fundamental circuit previously traced is again closed and relays 207 and 529 energize thereover. Relay 207 upon energizing again closes the previously traced circuit for advancing sequence switch 200 out of position 4 into position 5, locking itself to the fundamental circuit in the manner previously described. With sequence switch 200 in position 5 the circuit of the up-drive magnet 224 is again closed over the front contact of relay 207 for advancing the switch shaft in its group selection movement.

During the initial portion of the group selection movement of the switch shaft the second set of brushes is tripped in the well-known manner. As the switch shaft approaches its first group selection position the brush 230 engages the first conducting segment of commutator strip 231 closing a circuit for relay 207 extending from ground at the left contact of cam 229, brush 230, commutator strip 231, the upper contact of cam 223 to battery through the right winding of relay 207. This circuit being in shunt of the

sender stepping relay 529, the latter relay deenergizes.

At the sender upon the reestablishment of the fundamental circuit for controlling incoming group selection relay 529 energizes and since it has been assumed that no incoming group register relays are at the time energized a circuit is established from ground at the front contact of relay 529 over conductor 630, the upper right contact of cam 631, now in position 6, conductor 635, the right back contact of relay 711, the right back contact of relay 715, conductor 761, the back contact of the No. 3' counting relay to battery through the winding of the No. 3 counting relay and the left contact of cam 600. The No. 3 counting relay energizes and locks through the winding of the No. 3' counting relay and its own front contact to ground at the lower contact of cam 606, but the No. 3' counting relay being shunted does not energize until the stepping relay 529 deenergizes as above described. As the switch shaft of the incoming selector advances the shunt about relay 529 is intermittently established and broken until the counting relays including No. 0 and No. 0' relays and relay 634 become energized in the manner previously described. At that time the brush shaft of the incoming selector will have been positioned at the bottom of the fourth or upper brush group accessible to the tripped set of brushes.

Upon the energization of relay 634 the sequence switch 550 is again advanced out of position 6 into position 8 over the circuits previously traced, unlocking the operated counting relays, and the fundamental circuit is opened at the back contact of the No. 0' counting relay. As soon after the opening of the fundamental circuit as the commutator brush 230 engages an insulating portion of strip 231 relay 207 releases opening the circuit of the up-drive magnet 224 and advancing sequence switch 200 into position 6. In position 6 a circuit is established from ground at the upper contact of cam 214 to battery through the left winding of relay 207, whereupon relay 207 energizes. At its left front contact relay 207 closes the previously traced circuit for advancing sequence switch 200 into position 7. As the sequence switch leaves position 6 1/4 the energizing circuit of relay 207 is opened at cam 214, but relay 207 remains locked up over its right winding, the left contact of cam 223, the right front contact of relay 207, the upper contacts of cam 232, sleeve brush 233 to ground on the sleeve terminal of the first trunk of the selected group, if the trunk upon which the brushes 233, 235, and 236 are standing is busy. In that event, relay 207 establishes a circuit over the right contact of cam 225, to battery through the winding of up-drive magnet 224. The switch shaft is thereupon advanced in a trunk hunting movement until the brushes are

positioned on the terminals of an idle trunk when the holding circuit for relay 207 over the test brush 233 will be opened. Until the brush set is so centered on the idle trunk terminals, relay 207 is held energized over its left winding, the lower contacts of cam 237, commutator strip 238, brush 239, to ground over the lower left contact of cam 225 and the left front contact of relay 207. When the brushes are properly centered relay 207 de-energizes opening the circuit of the up-drive magnet 224 and advancing sequence switch 200 into position 8.

Until the sequence switch 200 reaches position 8 ground is placed on the sleeve terminal of the selected trunk over brush 233, the upper contacts of cam 232, the right back contact of relay 207, the upper right and lower left contacts of cam 240 to ground. As soon as sequence switch 200 reaches position 7 $\frac{3}{4}$ direct ground is connected to brush 233 over the right contacts of cam 232. In position 8 a circuit is established from battery, through the right winding of relay 207, the lower right and upper left contacts of cam 219 to ground over the upper left and lower right contacts of cam 232. Relay 207 energizes and closes the previously traced circuit for advancing sequence switch 200 into the selection beyond position 9. After the sequence switch 200 leaves position 8, relay 207 remains energized over a holding circuit extending from battery through its right winding, the left contact of cam 223, right front contact of relay 207, the upper contact of cam 242, brush 236, conductor 306, the upper left and lower right contacts of cam 307 to ground at the lower left contact of cam 338.

Final brush selection

A fundamental switch controlling circuit is now established from the final selector 250 to the sender which may be traced from battery, upper contact of cam 301, right winding of relay 302, lower left contact of cam 303, lower left contact of cam 304, conductor 305, brush 235, lower left contact of cam 241, thence as previously traced over conductor 221, through the winding of sender stepping relay 529, returning over conductor 222 to ground at the lower contact of cam 220. Relays 302 and 529 energize in this circuit. Relay 302 upon energizing locks in a circuit from battery over the upper contact of cam 301, its right winding, the upper contact of cam 308, the inner left front contact of relay 302, the upper left contact of cam 303, thence over the fundamental circuit, and closes a circuit extending from battery through the left winding of relay 310, the left contact of cam 311, the outer left front contact of relay 302 to ground at the lower left contact of cam 312. Relay 310 energizes and locks through its left winding, the back con-

tact of relay 313, the left front contact of relay 310, to ground on sleeve conductor 234 and at its right front contact establishes a circuit from ground over the lower contacts of cam 309 to battery through the magnet winding of sequence switch 300 for advancing the sequence switch into position 2. With sequence switch 300 in position 2 and relay 302 energized a circuit is closed for the high speed up-drive magnet 314 which may be traced from battery through the magnet 314, the upper contact of cam 315, the outer left front contact of relay 302 to ground at the lower left contact of cam 312. Magnet 314 upon energizing causes the switch shaft to be moved upwardly in its brush selection movement.

During the upward movement of the switch shaft an intermittent ground is connected to the fundamental circuit for intermittently shunting the stepping relay 529 of the sender over a circuit which may be traced from trunk conductor 305, the lower left and upper right contacts of cam 304, commutator strip 316, brush 317, to ground at the lower right contact of cam 338. On the initial closure of the fundamental circuit relay 529 energizes and since it has been assumed that relay 724 of the final brush register of the sender is at the time energized a circuit is established from ground at the left contact of cam 548, contact of relay 529, conductor 630, the lower left contact of cam 631, conductor 636, the left front contact of relay 724, conductor 762, the back contact of the No. 4' counting relay to battery through the winding of the No. 4 counting relay and the left contact of cam 600. The No. 4 counting relay locks over a circuit through the winding of the No. 4' counting relay and its own front contact in the manner previously described, the No. 4' counting relay operating in this locking circuit upon the first deenergization of relay 529. In response to the intermittent shunting of relay 529 as the final selector brush shaft advances, successive counting relays are operated until the No. 0' relay and relay 634 operate at which time the brush shaft of the final selector will have advanced to position its fourth set of brushes for subsequent tripping.

Relay 634 upon energizing closes the previously traced circuits for advancing the sequence switch 550 out of position 8 into position 10, the operated counting relays being released when such sequence switch leaves position 8. The No. 0' counting relay upon operating opens the fundamental circuit previously traced through the windings of relays 302 and 529. Until the selector switch shaft reaches a position in which the fourth brush set may be tripped, relay 302 is held energized over the previously traced shunt path extending to ground over the commutator brush 317. Relay 302 thereupon deen-

energizes opening the circuit of the up-drive magnet 314 and at its outer left back contact closes a circuit extending from battery through the winding of sequence switch magnet 300, the left contact of cam 318, the outer left back contact of relay 302 to ground at the lower left contact of cam 312 for advancing sequence switch 300 into position 3. In position 3 a circuit is established for the trip magnet 319 over the upper right contact of cam 338.

When sequence switch 300 reaches position 3, the energizing circuit of relay 302 is again established over the fundamental circuit previously described and relay 302 and stepping relay 529 energize. Relay 302 upon energizing again closes the previously traced circuit for driving sequence switch 300 out of position 3 into position 4. With sequence switch 300 in position 4 the previously traced circuit for the up-drive magnet 314 is again established. Relay 302 also establishes the previously traced locking circuit for itself extending through its inner left front contact for maintaining itself energized over the fundamental circuit after sequence switch 300 leaves position 3. Upon the energization of the high speed up-drive magnet 314, the switch shaft is driven upwardly in its group or tens selecting movement and during the initial portion of this movement the fifth set of brushes is tripped. During the remainder of the group selecting movement the tripped set of brushes travels upwardly in contact with the terminals of the bank with which it is associated. During this movement an intermittent ground is connected to the fundamental circuit in shunt of the sender stepping relay 529, from conductor 305 over the lower left contact of cam 304, upper right contact of cam 303, commutator strip 320, brush 321 to ground at the lower right contact of cam 338. Relay 302 is held energized over this shunt path.

The stepping relay 529 of the sender upon energizing over the fundamental circuit, with sequence switch 550 in position 10, closes a circuit for the No. 8 counting relay extending from ground at the left contact of cam 548 through the contact of relay 529, conductor 630, the lower right contact of cam 631, conductor 637, the right back contact of register relay 728, the outer right front contact of relay 740, the outer right back contact of relay 739, conductor 763, the back contact of the No. 8' counting relay, the winding of the No. 8 counting relay to battery at the left contact of cam 600. In the manner previously described the counting relays energize in succession until the No. 0' counting relay and relay 634 energize in parallel. The energization of relay 634 closes the previously traced circuit for advancing sequence switch 550 out of position 10 into position 12. The energization of the No. 0' counting relay opens the

fundamental circuit, releasing stepping relay 529. In the advance of sequence switch 550 out of position 10 the operated counting relays are released.

As soon as the selector brushes become positioned in the proper relation to the bottom of the selected group and the shunt path previously traced over commutator strip 320 is opened, relay 302 deenergizes opening the circuit of the up-drive magnet 314 and closing the previously traced circuit for advancing sequence switch 300 out of position 4 into position 5. In position 5 the fundamental circuit extending through the windings of relays 302 and 529 is again established and relay 302 upon energizing closes the previously traced locking circuit for itself and closes the circuit for driving sequence switch 300 out of position 5 into position 6. Upon reaching position 6 a circuit is established for the low speed up-drive magnet 322, which may be traced from battery, winding of magnet 322, the lower contact of cam 311, the outer left front contact of relay 302 to ground at the lower left contact of cam 312. The low speed magnet 322 causes the upward movement of the selector shaft in its units selection movement. During this movement of the switch shaft an intermittent shunt is connected from conductor 305 over the lower left and upper right contacts of cam 304, commutator strip 316, brush 317 to ground at the lower right contact of cam 338 around the winding of the sender stepping relay 529. Relay 302 is held energized over this shunt.

The stepping relay 529 upon energizing over the fundamental circuit with sequence switch 550 in position 12, closes a circuit for the No. 3 counting relay which may be traced from ground at the upper left contact of cam 548, the contact of relay 529, conductor 630, the right contact of cam 638, conductor 639, the outer right front contact of units register relay 744 to the outer left front contact of relay 747, the outer left front contact of relay 750, the outer left front contact of relay 753, the outer left back contact of relay 756, conductor 761, the back contact of the No. 3' counting relay, the winding of the No. 3 counting relay to battery at the left contact of cam 600. In the manner previously described the counting relays energize in succession until the No. 0' counting relay and relay 634 energize in parallel. The energization of relay 634 closes the previously traced circuit for advancing sequence switch 550 out of position 12 into position 13. As the sequence switch leaves position 12 the locking circuits of the operated counting relays are opened at the lower contacts of cam 605. The energization of the No. 0' counting relay opens the fundamental circuit, releasing stepping relay 529.

As soon as the selector brushes are properly

centered on the terminals of the wanted line, the shunt path over commutator strip 316 is opened and relay 302 releases, opening the circuit of up-drive magnet 322 and closing the previously traced circuit for driving sequence switch 300 out of position 6 into position 9. The brushes of the final selector 350 have now been positioned upon the terminals of the desired line and sequence switch 300 upon reaching position 9 closes a circuit for energizing relay 302, which may be traced from battery through the upper contact of cam 301, the right winding of relay 302, the upper right and lower left contacts of cam 308 to ground at the right front contact of relay 310. Relay 302 upon energizing closes a locking circuit for itself extending from battery through its right winding, the upper right contact of cam 308, the inner left front contact of relay 302, thence to ground over the left contacts of cam 324. This locking circuit will be maintained through position 10 of sequence switch 300. Relay 302 also closes a circuit as previously traced for driving sequence switch 300 out of position 9 and the sequence switch will continue to advance into position 12. Upon reaching position 10 a new holding circuit is established for relay 302, extending from battery through its left winding, the lower contact of cam 323, the outer left front contact of relay 302 to ground at the lower left contact of cam 312. Upon reaching position 11 sequence switch 300 establishes a new holding circuit for relay 302 from ground through the winding of relay 313, the upper left contact of cam 314, the lower left contact of cam 303, the right winding of cam 302, the lower right contact of cam 308, the inner left front contact of relay 302, the upper contacts of cam 324, test brush 326 to battery on the test terminal 327 if the called line is busy.

In the present case it will be assumed that the line is idle and that ground potential is encountered on the test terminal 327. Therefore when the test circuit therefrom is completed through the right winding of relay 302 and the winding of relay 313, both terminals of relay 302 will be connected to ground and relay 302 will become deenergized when the sequence switch 300 leaves position 11, and relay 313 will not energize. When, therefore, relay 302 deenergizes it closes a circuit for driving sequence switch 300 out of position 12 into position 13, this circuit extending from battery through the winding of magnet 300, the upper left contact of cam 318, the outer left back contact of relay 302, the upper contact of cam 312 to ground at the right front contact of relay 310. Upon reaching position 13 a circuit is established over the lower contacts of cam 309 and the right front contact of relay 310 for driving sequence switch 300 out of position 13 into position 14, and in position 14 a circuit is

established as previously traced through the winding of magnet 300, the outer left back contact of relay 302 to ground at the lower left contact of cam 312 for driving sequence switch 300 into the talking position 15. In this position trunk conductors 305 and 306 are connected respectively, to brushes 328 and 329 over the lower contacts of cam 304 and the upper contacts of cam 307. When sequence switch 300 left position 8½ the circuit previously traced extending over the ring conductor 306 and through the right winding of relay 207 of the incoming selector is opened at the lower left contact of cam 338 and relay 207 deenergizes closing a circuit for driving sequence switch 200 out of position 9 into position 10. This circuit may be traced from battery through the winding of magnet 200, the upper left contact of cam 216 to ground at the left back contact of relay 207. With sequence switch 200 in position 10 and sender sequence switch 550 in position 13 relay 207 is again connected to the fundamental circuit extending to the sender, which may be traced from battery through the right winding of relay 207, the right contact of cam 220, conductor 222, brush 549, resistance 547, right winding of polarized overflow relay 546, contacts of cam 545, conductor 629, the back contact of the No. 0' counting relay, conductor 628, contacts of cam 544, the outer right back contact of relay 543, winding of stepping relay 529, the right back contact of relay 526, the lower contacts of cam 525, the left contact of cam 542, brush 541, conductor 221, the upper right contact of cam 210 to ground. Relay 207 energizes in this circuit closing a circuit over its left front contact and the upper right contact of cam 216 for driving sequence switch 200 out of position 10 into position 12.

At the sender since the direction of current flowing in the fundamental circuit has been reversed at the incoming selector, both the stepping relay 529 and the overflow relay 546 energize. Relay 546 upon energizing locks from battery through its left winding and left contact to ground at the upper right contact of cam 548 but is without function at this time. Relay 529 upon energizing closes a circuit from ground at the left contact of cam 548, contact of relay 529, conductor 630, the left contact of cam 638, conductor 640, the contacts of cam 633, the winding of the No. 0 counting relay to battery at the left contact of cam 600. The No. 0 counting relay locks through the windings of the No. 0' counting relay and relay 634 in parallel. As soon as sequence switch 200 of the incoming selector 250 leaves position 11 the fundamental circuit is opened and relay 529 deenergizes, thus permitting the No. 0' counting relay and relay 634 to energize. Relay 634 upon energizing advances sequence switch 550 into position 14, thereby unlock-

ing the operated counting relays. Sequence switch 550 is then further advanced into position 15 over a circuit extending from battery through its magnet winding, the upper left contact of cam 540, the left back contact of relay 526, to ground at the inner right front contact of relay 538. The locking circuit of overflow relay 546 is now opened and that relay releases.

With sequence switch 550 in position 15 and sequence switch 200 in position 12 a circuit is closed from battery through the right winding of relay 205, the upper right and lower left contacts of cam 219, conductor 221, brush 541, the left contact of cam 542, the lower contacts of cam 525, the right back contact of relay 526, the winding of relay 529, the outer right back contact of relay 543, the contacts of cam 544, conductor 628, the back contact of the No. 0 counting relay, conductor 629, contacts of cam 545, the right winding of relay 546, resistance 547, brush 549, conductor 222, the upper left contact of cam 220 to ground through the left winding of relay 205. Relays 205 and 529 energize in this circuit. Relay 205 upon energizing closes a circuit for relay 209 extending from battery through the winding of relay 209, right contacts of cam 213, contact of relay 205 to ground at the left contact of cam 210. Relay 209 upon energizing connects the windings of relay 205 over the left contacts of relay 209, the normal contacts of relay 243, the left windings of repeating coil 244 and contacts of cams 203 and 206 to trunk conductors 201 and 202 and thence through the winding of relay 118 at the district selector. Relay 205 is held energized over this circuit but the current flowing is not in the proper direction to operate the polarized relay 118.

Relay 209 also closes a circuit extending from battery through the right winding of relay 207, the lower left contact of cam 208, the back contact of relay 245, the right front contact of relay 209 to ground at the lower contact of cam 210. Relay 207 energizes, closing the previously traced circuit over its left front contact for advancing sequence switch 200 out of position 12 into position 15. After sequence switch 200 leaves position 13 relay 207 is maintained energized over the circuit previously traced to the front contact of relay 209 thence over the upper contact of cam 225 to ground at the left front contact of relay 207. A circuit is now established for applying ringing current to the called line which may be traced from the source of ringing current 246, interrupter 247, the lower right and upper left contacts of cam 211, winding of relay 245, right front contact of relay 207, upper contact of cam 242, brush 236, conductor 306, over the upper contacts of cam 307, brush 329, through the call bell at the called line substation, returning over

brush 328, the lower contacts of cam 304, conductor 305, brush 235 to ground at the right contact of cam 241. A ringing tone is also transmitted to the calling line from the right front contact of relay 207, over the upper left and lower right contacts of cam 242, the upper contacts of cam 240, winding of relay 248, the lower right winding of induction coil 244 to battery and ground and thence by induction to the calling line. When the called subscriber responds, relay 245 energizes over the circuit just traced opening the circuit of relay 207 which deenergizes in turn opening the ringing circuit. At its left back contact relay 207 closes the previously traced circuit for advancing sequence switch 200 out of position 15 into the talking position 17.

In position 17 the called subscriber is supplied with talking battery over a circuit extending from brush 235, the upper contact of cam 241, the right windings of repeating coil 244 and battery interposed therebetween, the winding of supervisory relay 248, the lower left contact of cam 242, brush 236, thence as traced over the called line loop. Relay 248 energizes in this circuit closing a circuit for reversing relay 243 extending from battery through the winding of that relay, the contact of relay 248 to ground at the lower right contact of cam 214. Relay 243 upon energizing reverses the connection of battery and ground through the windings of relay 205 to the trunk conductors 201 and 202 whereupon the polarized relay 118 of the district energizes for supervisory or call charging purposes. The calling subscriber receives talking battery from the district selector 102 in the well known manner. A talking connection has now been established between the calling line 100 and the called line 325.

It will be recalled that sequence switch 500 of the sender is in position 15 and that at the time relay 205 of the incoming selector energized over the fundamental circuit extending to the sender, relay 529 also energized. Relay 529 upon energizing closed a circuit extending from ground at the left contact of cam 548, contact of relay 529, conductor 630, left contact of cam 638, conductor 640, contacts of cam 633, winding of the No. 0 counting relay to battery at the left contact of cam 600. The No. 0 counting relay energizes in this circuit as soon as sequence switch 200 advances beyond position 12. Until sequence switch 200 so advances the No. 0 counting relay is shunted over a circuit extending from the winding of the No. 0 relay, the contacts of cam 633, conductor 640, the left contact of cam 638, conductor 630, the left contacts of cam 531, the lower contact of cam 518, brush 519, conductor 405 to battery at the left contact of cam 215. As soon as the sequence switch 200 of the incoming selector advanced out of position 12 the fundamental

circuit between the windings of relay 205 and relay 529 was opened, releasing relay 529, whereupon the No. 0' counting relay and relay 634 energize in the locking circuit of the No. 0 counting relay. Relay 634 now establishes a circuit for advancing sequence switch 550 into position 16, which may be traced from battery, through the winding of magnet 550, the right contact of cam 551, the inner right back contact of relay 543 to ground at the front contact of relay 634. When sequence switch 550 leaves position 15 the locking circuit of the operated counting relays is opened and these relays release.

In position 16 a circuit is established from battery, through the right winding of relay 503 to ground at the lower right contact of cam 502 and relay 503 energizes, closing at its right front contact a circuit extending from ground over the lower right contact of cam 509 to battery through the winding of down drive magnet 552 of the trunk finder 520. When the finder brush shaft reaches normal, brush 553 engages the normal commutator segment 554 establishing a circuit from ground over brush 553, a segment 554, right contacts of cam 536, resistance 504 to battery in shunt of the winding of the relay 503, whereupon relay 503 quickly releases to open the circuit of down drive magnet 552 thereby arresting the movement of the switch shaft. Relay 503 upon releasing also closes a circuit extending from ground at its outer right back contact, over the inner right back contact of relay 501, the lower left contact of cam 505 to battery through the winding of sequence switch magnet 550, advancing sequence switch 550 to position 17. With sequence switch 500 in position 17 a circuit is established for advancing sequence switch 500 out of position 18 into normal position 1, extending from battery, winding of sequence switch magnet 500, the lower left contact of cam 514, the upper left and lower right contacts of cam 605 to ground at the lower contact of cam 606. As soon as sequence switch 500 leaves position 18 all operated register relays of the sender are released and a circuit is closed to advance sequence switch 550 into position 18 awaiting allotment. This circuit may be traced from battery, through the winding of magnet 550, the lower right contact of cam 540, the upper left contact of cam 612 to ground at the lower right contact of cam 621. The sender is now completely restored and in condition for serving another call.

Upon the termination of the conversation when the calling subscriber restores his receiver to the switchhook the district selector and office selector are restored in the well known manner and the circuit through the windings of relay 205 is opened. Relay 205 upon releasing opens the circuit of relay 209 which deenergizes and closes a circuit for re-

lay 207 extending from battery, through the right winding of relay 207, the upper right contact of cam 208, the right back contact of relay 209 to ground at the left contact of cam 210. Relay 207 upon energizing closes the previously traced circuit for advancing sequence switch 200 into position 18. In position 18 the circuit of relay 207 is opened and the circuit of down drive magnet 249 is established from battery through the winding of magnet 249 to ground at the lower contacts of cam 240 for driving the switch shaft into normal position. Upon reaching normal position a circuit for advancing sequence switch 200 into position 1 is closed from battery through the winding of sequence switch magnet 200, the lower right contact of cam 216, normal segment 251 of the switch commutator, brush 239 to ground at the left contact of cam 229. The incoming selector is now restored to normal. When sequence switch 200 leaves position 17 1/4 the holding circuit for relay 310 of the final selector is opened and the releasing of the final selector then proceeds in the well known manner.

Incoming to overflow

Should the incoming selector advance to the overflow position during its trunk hunting movement at which time the sequence switch 200 would be in position 7 and the sequence switch 500 of the sender in position 8, relay 207 will release when the selector brushes reach an overflow position because there would be no holding circuit therefor over the ring brush 236. Relay 207 upon releasing then advances sequence switch 200 into position 8 in a circuit over its left back contact and the upper left contact of cam 216. In position 8 relay 207 energizes over a circuit extending from battery through its right winding, the lower right and upper left contacts of cam 219 to ground over the upper left and lower right contacts of cam 232. Relay 207 upon energizing closes a circuit over its left front contact and the upper right contact of cam 216 for advancing sequence switch 200 into position 9. When sequence switch 200 leaves position 8, relay 207 deenergizes and at its left back contact closes the previously traced circuit for advancing sequence switch 200 into position 10. With sequence switch 200 in position 10 the fundamental circuit extending from the winding of relay 207 to the sender through the winding of overflow relay 546 and stepping relay 529 is closed in the manner previously described and since the current flowing in this circuit is in the proper direction to operate the polarized overflow relay 546 that relay operates with the stepping relay 529.

Relay 546 upon energizing closes a circuit extending from ground at the upper right contact of cam 548, front contact of relay 546, lower left and upper right contacts of

cam 515 to battery through the winding of relay 554 which latter relay locks over its inner right contact to ground at the upper right contact of cam 548 and at its outer right contact establishes an obvious circuit for relay 526. At the incoming selector relay 207 energizes over the fundamental circuit and in the manner previously described advances sequence switch 200 into position 12 thereby opening the previously traced fundamental circuit releasing relay 529 at the sender. With relay 529 released the shunt circuit about the winding of relay 526 which extended from battery through resistance 556, the left front contact of relay 554, the front contact of relay 529 to ground at the left contact of cam 548 is opened and relay 526 energizes. Relay 526 upon energizing opens the fundamental circuit at its right back contact to prevent relay 529 from re-energizing, at its right front contact connects a source of tone to brush 521, thence over conductors 217 and 201 whereby the calling subscriber receives a busy tone apprising him of the fact that the connection cannot be established, and at its left front contact closes a circuit from ground over the upper contact of cam 551 for advancing sequence switch 550 into position 14.

Relay 533 is at this time held energized over the previously traced circuit extending to the district selector and is thus under the control of the calling subscriber. Relay 533 also maintains relays 537 and 538 energized. When therefore the calling subscriber restores his receiver in response to the busy tone thereby releasing the district selector the circuit of relay 533 is opened in turn releasing relays 537 and 538. Relay 538 now closes a circuit for advancing sequence switch 550 into position 15 extending from battery, through the magnet 550, the upper left contact of cam 540 to ground at the outer right back contact of relay 538. Upon leaving position 14 the holding circuits of relays 546 and 554 are opened at cam 548 and these relays release, relay 554 in turn releasing relay 526. In position 15 a circuit is closed from battery, through the right winding of relay 205, the upper right and lower left contacts of cam 219, conductor 221, brush 541, left contact of cam 542, the lower contacts of cam 525, the right back contact of relay 526, winding of relay 529, the outer right back contact of relay 543, contacts of cam 544, conductor 628, the back contact of the No. 0' counting relay, conductor 629, contacts of cam 545, right winding of relay 546, brush 549, conductor 222, the upper left contact of cam 220 to ground through the left winding of relay 205. Relays 205 and 529 energize, relay 205 operating relay 209 in the manner previously described. Relay 529 upon energizing advances sequence switch 550 out of position 15 into position 16 from which point the sender

is restored in the manner previously described. The incoming selector is then restored through the operation of relay 209 in the manner previously described.

Trunk finder to overflow

Should the trunk finder 520 fail to find the calling trunk and advance its wipers in a hunting movement to the end of the terminal bank, sequence switch 550 being at that time in position 2 and sequence switch 500 being in position 1 a circuit is closed for relay 543 extending from battery, right winding of relay 543, overflow segment 557 of the switch commutator to ground on brush 553. Since no trunk has been found, relay 503 releases and advances sequence switch 550 out of position 2 into position 3 over a circuit extending from battery, winding of magnet 550, the lower left contact of cam 505, the inner right back contact of relay 501 to ground at the outer right back contact of relay 503. In position 3 the previously traced circuit is closed for advancing sequence switch 500 into position 2. In position 2 of sequence switch 500 a locking circuit for relay 543 is established through its left winding and inner left front contact, conductor 604 to ground over the upper right contact of cam 603 and this ground is also extended over the outer left contact of relay 543, the lower contact of cam 539 to battery through the magnet winding of sequence switch 500 for advancing said sequence switch into position 18. As soon as sequence switch 500 reaches position 15 a circuit is closed from ground at the upper right contact of cam 527, over the lower left contact of cam 540 to battery through the winding of magnet 550 for advancing sequence switch 550 into position 4 from which position it is advanced into position 15 over a circuit extending from battery through its magnet winding, the lower left contact of cam 551 to ground at the right front contact of relay 543. Since relay 538 is at this time deenergized, no connection having been established to a calling trunk, sequence switch 550 is advanced into position 16 over a circuit extending through its magnet winding, the right contact of cam 551, the left back contact of relay 538, to ground at the right front contact of relay 543. In position 16 the trunk finder is restored in the manner previously described following which sequence switch 550 advances as previously described into position 17 in turn advancing sequence switch 550 into normal position 1 and then advancing into position 18 awaiting allotment for a new call.

Overpulsing during setting of registers

If for any reason during the transfer of any digit registration from the sender 103 to the spill sender more than 10 impulses are sent, the No. 0' counting relay upon the re-

ceipt of the tenth impulse will extend the counting relay operating circuit over its front contact and the left back contact of relay 641, through the winding of relay 642, to battery at the upper right contact of cam 600. Relay 642 will operate on the next or superfluous impulse and lock through the winding of relay 641 over the lower contacts of cam 605 to ground at the lower contact of cam 606. At its right contact relay 641 closes a circuit from battery, through the right winding of relay 543, the right contact of relay 641 to ground at the upper right contact of cam 603. Relay 543 thereupon locks over its left winding and inner left front contact to ground at the upper right contact of cam 603 and in the manner previously described causes the restoration of the sender.

20 *Wipe-out on abandoned calls*

If the calling subscriber abandons a call during the time that the originating sender 103 is being set from the dial or during the period that the spill sender registers are being set from the originating sender, the originating sender is restored in the well known manner as fully disclosed in the patent to F. A. Stearn hereinbefore referred to and the connection established up to that time is released. If a spill sender has been seized, relay 523 thereof will in that case fail to further operate and sequence switch 500 will not advance further. The time alarm circuit 558 will therefore function and after a predetermined interval advance sequence switch 500 into position 18. In position 18 sequence switch 500 closes the previously traced circuit for advancing sequence switch 550 into position 4 for closing the fundamental circuit for starting the setting of the incoming selector.

If at the time the call is abandoned any of the sender registers have been set, selections at the incoming and final selectors will be controlled in accordance therewith, otherwise selections will be controlled in accordance with the unset condition of the register relays. Following the completion of the setting of the selectors, sequence switch 500 will advance into position 14 and sequence switch 200 of the incoming selector will advance into position 12. As previously described for a completed call sequence switch 550 is now advanced into position 15 over a circuit extending from battery, through the magnet 550, the upper left contact of cam 540, to ground at the outer right back contact of relay 538. With sequence switch 200 of the incoming selector in position 12 and sequence switch 550 in position 15 the circuit previously traced through the windings of relay 205 is closed, relay 205 thereupon energizing and causing the operation of relays 209 and 207. Relay 207 in turn advances sequence switch 200 out of po-

sition 12 into position 13. Since the calling subscriber has abandoned the connection and the district selector has released, relay 205 will not be held up over trunk conductors 201 and 202 as previously described, after sequence switch 200 leaves position 12 and therefore it will deenergize in turn releasing relays 209 and 207. A circuit is now established for advancing sequence switch 200 into position 15, extending from battery, through the magnet 200, the upper right contact of cam 216, the upper contact of cam 225, the back contact of relay 209 to ground at the left contact of cam 210. From position 15 the sequence switch 200 is advanced directly into position 17, over a circuit through its magnet winding, the upper left contact of cam 216, to ground at the left back contact of relay 207. Since sequence switch 200 has passed directly from position 12 into position 17 ringing current is not applied to any line upon which the brushes of the final selector may have been positioned. In position 17 the circuit previously traced over the back contact of relay 209 is again effective to advance sequence switch 200 into position 18. In position 18 the restoring circuit through the down drive magnet 249 is established and the incoming selector restores in the manner previously described. Following the restoration of the incoming selector the final selector is restored in the usual manner. The sender when sequence switch 550 is in position 15 proceeds to restore in the manner previously described.

If the calling subscriber abandons a call during the time that the spill sender is setting the incoming and final selectors at which time sequence switch 500 will be in position 18 and sequence switch 550 will be in some position between 4 and 12, relays 533, 537 and 538 will release. Selection control will then proceed as for a call that is to be completed until sequence switch 550 reaches position 15. The established connection will then be restored as just previously described.

Sender start circuits

The senders for serving all of the incoming selector trunks are divided into four subgroups. Each sender has two sets of trunk finders individual thereto, the sender shown in Figs. 5, 6 and 7 having two finders 510 and 520. The finder 520 will be termed the A finder and the finder 510 the B finder. Normally a subgroup of senders will be assigned for serving a subgroup of trunks and the A finder of such pre-allotted sender of the subgroup will be started. In the previous discussion it has been shown how the A finder of a pre-allotted sender is operated to connect such sender with a calling trunk and how the sequence switch 550 of another sender of the same subgroup is advanced out of position 18 in which it awaits allotment

into position 1 ready to serve the next incoming call in the subgroup of trunks.

In Fig. 4 the start circuits of four subgroups of trunks have been shown, each start circuit being set off by parallel dotted lines. The conductors extending from the start circuits to the upper margin of the figure, that is, conductors 212, 252, 262 and 272 extend in multiple to sequence switch cams similar to cam 211 of the incoming selectors in which the interoffice trunks terminate, and the five conductors extending from each start circuit to the lower margin of the figure extend in the same manner as conductors 403, 404, 406, 407 and 408 to senders of subgroups corresponding to the start circuits. The multiples from conductors such as 403, 404 and 406 extend to other senders in the same subgroups.

Referring to Fig. 8 three senders of each subgroup of senders have been diagrammatically illustrated, the brushes of the A and B finders and their corresponding banks of trunk terminals of each sender being shown in vertical alignment. It will be noted that the contact banks of both the A and B finders are divided into two sections. The trunks appearing in the lower section of the A finder banks of the first subgroup of senders are multiplied to the lower section of the B finder banks of the second subgroup, to the upper section of the A finder banks of the third subgroup, and to the upper section of the B finder banks of the fourth subgroup. Thus these trunks appear as first choice to the A finders of the first group, as first choice to the B finders of the second subgroup, as second choice to the A finders of the second subgroup, and as second choice to the B finders of the fourth subgroup. Thus each sender may have access to 200 trunks. Similarly the trunks appearing in the upper section of the A finder banks of the first subgroup of senders are multiplied to the upper section of the B finder banks of the second subgroup, to the lower section of the A finder banks of the third subgroup, and to the lower section of the B finder banks of the fourth subgroup. The other sections of the finder banks are similarly multiplied.

In the event that all senders in the subgroup assigned, for example, for serving the trunks in group 1, which terminate in the lower section of the A finder banks of the first subgroup of senders, are busy, then the sequence switches of all such senders will be in some position between $1\frac{3}{4}$ and 17 and a chain circuit will be established from battery, through the upper winding of relay 400 of the start circuit common to such subgroup of trunks, conductor 408, the contacts of cams 560 in series of all such sequence switches, conductor 407 to ground at the back contact of relay 402. If then another call comes in in the subgroup 1 of trunks, the starting con-

ductor 212 becomes connected over the upper front contact of relay 400, the upper back contact of relay 410 of the starting circuit for the second subgroup of trunks, the right back contact of relay 411 to battery, through the right winding of relay 412, relay 412, closing at its left front contact a locking circuit for relay 400, extending from battery, through the lower winding and lower front contacts of relay 400, lowermost back contact of relay 410, to ground at the left front contact of relay 412. This locking circuit is for the purpose of maintaining relay 400 energized until the calling trunk has been connected to a sender of the second subgroup of senders irrespective of whether an idle sender becomes available in the meantime in the first subgroup and the initial circuit of relay 400 becomes open.

Relay 412 also extends the start conductor 212 over the inner right contact of relay 412, over conductor 416 whence it is extended in a manner similar to conductor 406, over the outer left back contact of a relay similar to relay 503, the upper contact of a cam similar to cam 559, to battery through a relay similar to relay 501. The latter relay then closes a circuit for advancing the sequence switch 550 of the sender of the second subgroup of senders into position 1 over a circuit extending from ground at the outer right back contact of a relay similar to relay 503, the inner right front contact of a relay similar to relay 501, the upper right contact of a cam similar to cam 505. In position 2 of such sequence switch the up-drive magnet corresponding to magnet 561 is operated from battery, through such magnet, the lower right contact of a cam similar to cam 562, thence to ground at the right back contact of a relay similar to relay 503. The B finder of the allotted sender in the second subgroup of senders is thus started and since the first subgroup of trunks appears as first choice trunks in the bank to which the B finder has access a quick connection is made with the calling trunk.

Should there be no available sender in the second subgroup of senders and relay 410 be at the time energized, then the start conductor 212 would be extended over the upper front contacts of relays 400 and 410, the upper back contact of relay 420, the left back contact of relay 421 to battery through the left winding of relay 422, the starting conductor 212, then being extended over the outer right contact of relay 422 to conductor 423 for starting an A finder of the third subgroup senders. In a similar manner had there been no idle sender in the third subgroup and relay 420 been energized then conductor 212 would be extended as previously described over the upper front contact of relay 410, the upper front contact of relay 420, the upper back contact of relay 430, the right back contact of relay 431, to battery through

the right winding of relay 432, then being extended over the inner right front contact of relay 432 to conductor 436 for starting a B finder of the fourth subgroup of senders. In the event that there is no idle sender in the fourth subgroup the previously traced starting circuit is then extended over the upper front contact of relay 430, back to the starting circuit associated with the first subgroup of senders.

After a call has been transferred, for example, from the first subgroup of senders to the second subgroup through the operation of relay 400, and while the trunk finder of such second subgroup sender is hunting for the calling trunk, relay 411 will be maintained energized in a manner described in connection with relay 401, thus opening the circuits of relays 412. Relay 412 will open the locking circuit of relay 400 so that should a sender become available in the first subgroup, relay 400 will release permitting the start conductor 212 to be again extended for starting a sender in the first subgroup upon the next call incoming in the first subgroup of trunks.

For calls incoming in the second subgroup of trunks the common start conductor 252 is normally extended through the operation of relay 412 to the conductor 413, for starting the A finder of a pre-allotted sender in the second subgroup. For calls incoming in the third subgroup of trunks the common start conductor 262 is extended through the operation of relay 422 to conductor 423 for starting the A finder of a pre-allotted sender in the third subgroup of senders. Similarly when a call is incoming in the fourth group of trunks the start conductor 272 is extended to conductor 433 for starting the A finder of a pre-allotted sender in the fourth subgroup of trunks.

What is claimed is:

1. In a telephone exchange system, a sending device, registers associated therewith for registering the designation of a wanted line, selectively operable mechanism, means for controlling said mechanism comprising a plurality of registers and means for transferring said designation from the registers of said sending device from said controlling means, controlling means comprising means for revertingly transmitting trains of impulses to said sending device from said controlling means, means for counting the impulses in each train so transmitted and means for operating the registers of said controlling means in accordance with the operation of said counting means, said counting means also cooperating with the registers of said controlling means to determine the setting of said mechanism.

2. In a telephone exchange system, a sending device, registers associated therewith for registering the designation of a wanted line, selectively operable mechanism, means for controlling said mechanism including a plu-

ality of registers each comprising a group of relays and means for transferring said designation from the registers of said sending device to the registers of said controlling means, comprising means for revertingly transmitting trains of impulses to said sending device from said controlling means, counting relays operable from said transmitting means for counting the impulses in each train so transmitted, means for successively associating said relay registers with said counting relays and means for selectively operating the relays of each register under the control of said counting relays.

3. In a telephone exchange system, a first and a second connection controlling mechanism each having a plurality of registers for recording the designations of subscribers' lines, the registers of said second mechanism each comprising a group of relays, and means for transferring a line designation from the registers of said first mechanism to the registers of said second mechanism comprising means for transmitting trains of impulses from one said mechanism to the other, counting relays in said second mechanism successively operable to count the impulses in each train so transmitted, means for successively associating said relay registers with said counting relays, and means for successively operating the relays of each register and thereafter successively releasing them upon the successive operation of said counting relays.

4. In a telephone system, a connection controlling mechanism comprising a plurality of relay registers therein for recording line designations, a train of counting relays, means for successively operating relays of such train in accordance with trains of impulses, means for successively associating said train of counting relays with said registers, means responsive to the successive operation of certain relays of said train in response to each train of impulses to successively operate the relays of the associated register, and means responsive to the successive operation of further relays of said train in response to each train of impulses to successively release operated relays of the associated register.

5. In a telephone system, a connection controlling mechanism comprising a plurality of relay registers therein for recording line designations, a train of counting relays, means for successively operating relays of such train in accordance with trains of impulses, means for successively associating said train of counting relays with said registers, means responsive to the successive operation of certain relays of said train in response to each train of impulses to successively operate the relays of the associated register, and means responsive to the successive operation of further relays of said train in

response to each train of impulses to successively release operated relays of the associated register in the same order in which such register relays were operated.

5 6. In a telephone exchange system, a connection controlling mechanism comprising a train of counting relays, means for successively operating relays of such train in accordance with trains of impulses, a plurality
10 of relay registers for recording line designations, each register comprising a plurality of double wound relays, means for successively associating said train of counting relays with said registers, and shunt circuits
15 established around one winding of each relay of a register through back contacts of certain counting relays and operating circuits established through both windings of each relay of a register through back contacts of further
20 counting relays upon the connection of such register with said counting relay train, said shunt circuits of successive relays of a register being opened upon the successive operation of said certain counting relays and said
25 operating circuits being opened successively upon the successive operation of said further counting relays.

7. In a telephone exchange system, a connection controlling mechanism comprising a
30 train of counting relays, means for successively operating relays of such train in accordance with trains of impulses, a plurality of relay registering for recording line designations, each register comprising a plurality
35 of double wound relays, means for successively associating said train of counting relays with said registers, and shunt circuits established around one winding of each relay of a register through back contacts of successive
40 first relays of said train and operating circuits established through back contacts of successive later relays of said train upon the connection of such register with said counting relay train, said shunt circuits of successive
45 relays of a register being opened to operate said register relays upon the successive operation of said first counting relays and said operating circuits being opened to release said register relays upon the successive
50 operation of said later counting relays.

8. In a telephone exchange system, a first and a second connection controlling mechanism each having a plurality of registers for recording the designations of subscribers' lines, and means for transferring a line designation from the registers of said first mechanism to the registers of said second mechanism comprising means for transmitting
55 train of impulses from one said mechanism to the other, counting relays in said second mechanism successively operable to count the impulses of each train so transmitted, means for successively operating the registers of said second mechanism from said train of
60 common relays and means responsive to the

transmission of an excessive number of impulses in any train to release said second controlling mechanism and any connection which may have been established thereby.

9. In a telephone exchange system, a first
70 and a second connection controlling mechanism each having a plurality of registers for recording the designations of subscribers' lines and means for transferring a line designation from the registers of said first mechanism to the registers of said second mechanism comprising means for transmitting
75 trains of impulses from one said mechanism to the other, a train of counting relays in said second mechanism having more relays in said
80 train than the greatest number of impulses to be transmitted in any train to count the impulses of each train so transmitted, means for successively operating the registers of said second mechanism from said train of
85 counting relays and means responsive to the operation of the last relay of said train when an excessive number of impulses is transmitted in a train to release said second controlling mechanism and any connection which
90 may have been established thereby.

10. In a telephone exchange system, a first and a second office, interoffice trunks extending between said offices, selector switches in said second office for extending connections
95 from said trunks, a plurality of switch controlling mechanisms in said second office, a trunk finder individual to each mechanism for associating it with a calling trunk, a start circuit common to said trunks for causing the
100 trunk finder of an idle preselected mechanism to hunt for a calling trunk and means responsive to the failure of said finder to find the calling trunk to restore said finder and to start the finder of another idle mechanism
105 in search of said calling trunk.

11. In a telephone exchange system, a first and a second office, a group of interoffice trunks extending between said offices, said
110 group of trunks being subdivided into a plurality of subgroups, selector switches in said second office for extending connections from said trunks, a plurality of switch controlling mechanisms in said second office, said mechanisms being divided into the same number of
115 subgroups as said trunks, an A and a B trunk finder individual to each mechanism, means for pre-alloting the mechanism of each subgroup in succession for association with trunks, a start circuit individual to each subgroup of trunks and to each subgroup of mechanisms normally responsive to successive calls on the trunks of its subgroup to cause the successive operation of A finders to associate mechanisms of its subgroup with such
120 trunks, and means operative when no mechanisms are available in the subgroup normally assigned to a subgroup of trunks for causing the B finder of an allotted mechanism in the next subgroup of mechanisms to associate
130

such mechanism with such subgroup of trunks.

12. In a telephone exchange system, a first and a second office, a group of interoffice trunks extending between said offices, said group of trunks being divided into a plurality of subgroups, selector switches in said second office for extending connections from said trunks, a plurality of switch controlling mechanisms in said second office said mechanisms being divided into the same number of subgroups as said trunks, an A and a B trunk finder individual to each mechanism, means for pre-allotting the mechanisms of each subgroup in succession for association with trunks, a start circuit individual to each subgroup of trunks and to each subgroup of mechanisms normally responsive to successive calls on the trunks of its subgroup to cause the successive operation of A finders to associate mechanism of its subgroup with such trunks, and means in said start circuits operative when no mechanisms are available in the subgroup normally assigned to a subgroup of trunks for causing the B finder of an allotted mechanism in the next subgroup of mechanisms to associate such mechanism with such trunks and if no mechanism is available in such next subgroup for causing the A finder of an allotted mechanism in the next subgroup of mechanisms to associate said mechanism with such trunks.

13. In a telephone exchange system, a group of lines sub-divided into a plurality of subgroups, a group of dual line finders, each dual finder comprising an A and a B finder having access to such lines and similarly divided into corresponding subgroups, means for pre-allotting dual finders in each subgroup in succession for association with lines, a start circuit individual to each subgroup of lines and to each subgroup of dual finders normally responsive to successive calls on lines of its subgroup to cause the successive operation of A finders of its subgroup to hunt for lines, and means operative when no dual finders are available in the subgroup normally assigned to a subgroup of lines for causing the B finder of an allotted dual finder in the next subgroup to hunt for lines in such calling subgroup of lines.

14. In a telephone exchange system, a group of lines sub-divided into a plurality of subgroups, a group of dual line finders, each dual finder comprising an A and a B finder having access to such lines and similarly divided into corresponding subgroups, means for preallotting dual finders in each subgroup in succession for association with lines, a start circuit individual to each subgroup of lines and to each subgroup of dual finders, normally responsive to successive calls on lines of its subgroup to cause the successive operation of A finders of its subgroup to hunt for lines, and means operative

when no dual finders are available in the subgroup normally assigned to a subgroup of lines to cause the B finder of an allotted dual finder in the next subgroup to hunt for lines in such calling subgroup of lines and if no dual finder is available in such next subgroup for causing the A finders of the dual finders of the next subgroup to hunt for such lines.

15. In a telephone exchange system, a group of lines sub-divided into a plurality of subgroups, the lines of each subgroup being arranged in a fixed order, a plurality of pairs of contact banks each comprising two sections, multiple contact sets in said banks, said lines terminating in said contact sets, a group of paired line finders for cooperating with each pair of contact banks, one set of said line finders of each group cooperating with one bank of each pair and the other set of line finders of each group cooperating with the other bank of each pair, the various subgroups of lines being so arranged in the various sections of the pairs of banks that a subgroup which appears as first choice in a section of a first bank of a pair appears as first choice in the corresponding section of the second bank of the next pair, as second choice in the other section of the first bank of the next pair and as second choice in the other section of the second bank of the next pair and means operative upon the initiation of a call for putting into operation an idle one of said line finders which serves the bank in which the subgroup containing the contact set of the calling line first appears as first choice.

16. In a telephone exchange system, a group of lines sub-divided into a plurality of subgroups, the lines of each subgroup being arranged in a fixed order, a plurality of pairs of contact banks each comprising two sections, multiple contact sets in said banks, said lines terminating in said contact sets, a group of paired line finders for cooperation with each pair of contact banks, one set of line finders of each group cooperating with one bank of each pair and the other set of line finders of each group cooperating with the other bank of each pair, the various subgroups of lines being so arranged in the various sections of the pairs of banks that a subgroup which appears as first choice in a section of a first bank of a pair appears as first choice in the corresponding section of the second bank of the next pair, as second choice in the other section of the first bank of the next pair and as second choice in the other section of the second bank of the next pair, and means operative upon the initiation of a call for putting into operation an idle one of said line finders.

17. In a telephone exchange system, a group of lines sub-divided into a plurality of subgroups, the lines of each subgroup being arranged in a fixed order, a plurality of pairs of contact banks each comprising two

sections, multiple contact sets in said banks, said lines terminating in said contact sets, a group of paired line finders for cooperation with each pair of contact banks, one set of line finders of each group cooperating with one bank of each pair and the other set of line finders of each group cooperating with the other bank of each pair, the various subgroups of lines being so arranged in the various sections of the pairs of banks that a subgroup which appears as first choice in a section of a first bank of a pair appears as first choice in the corresponding section of the second bank of the next pair, as second choice in the other section of the first bank of the next pair and as second choice in the other section of the second bank of the next pair, means for allotting idle pairs of line finders of each group for service, and means operative upon the initiation of a call in a subgroup of lines for putting into operation the line finder of the allotted pair which serves the bank in which the subgroup containing the contact of the calling line first appears as first choice.

18. In a telephone exchange system, a group of lines sub-divided into a plurality of subgroups, the lines of each subgroup being arranged in a fixed order, a plurality of pairs of contact banks each comprising two sections, multiple contact sets in said banks, said lines terminating in said contact sets, a group of paired line finders for cooperation with each pair of contact banks, one set of line finders of each group cooperating with one bank of each pair and the other set of line finders of each group cooperating with the other bank of each pair, the various subgroups of lines being so arranged in the various sections of the pairs of banks that a subgroup which appears as first choice in a section of a first bank of a pair appears as first choice in the corresponding section of the second bank of the next pair, as second choice in the other section of the first bank of the next pair and as second choice in the other section of the second bank of the next pair, means for allotting idle pairs of line finders of each group for service, means operative upon the initiation of a call in a subgroup of lines for putting into operation the line finder of the allotted pair which serves the bank in which the subgroup containing the contact set of the calling line first appears as first choice, and means operative if there is no idle finder in such group to put into operation an idle finder of a subsequent group.

In witness whereof, I hereunto subscribe my name this 18th day of June, 1928.

FRANK S. IRVINE.