

June 24, 1930.

E. H. CLARK ET AL

1,767,960

AUTOMATIC TELEPHONE EXCHANGE

Filed Sept. 29, 1928

11 Sheets-Sheet 1

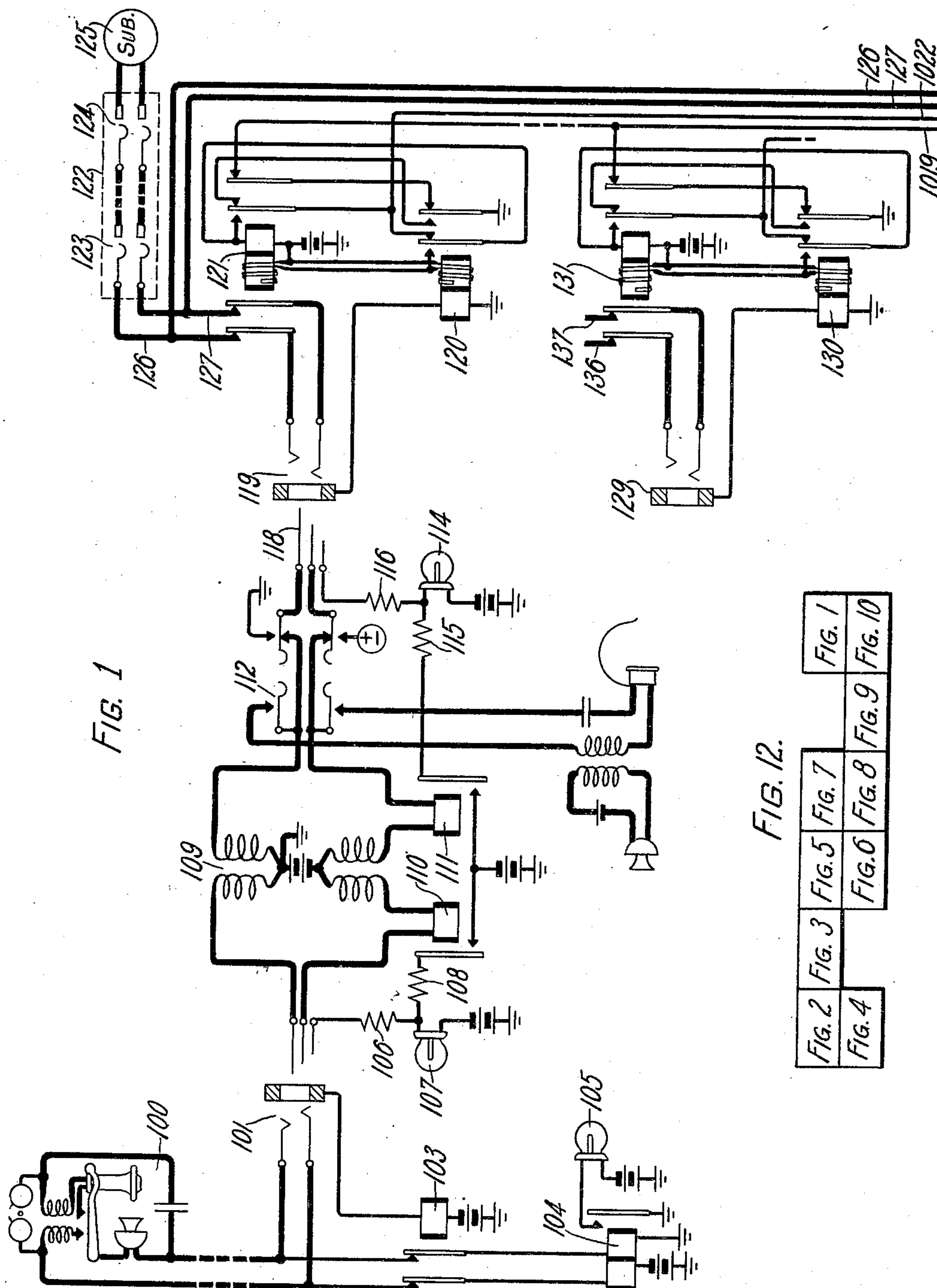


FIG. 1

FIG. 12.

|        |        |        |        |        |        |        |        |        |         |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| FIG. 1 | FIG. 2 | FIG. 3 | FIG. 4 | FIG. 5 | FIG. 6 | FIG. 7 | FIG. 8 | FIG. 9 | FIG. 10 |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|

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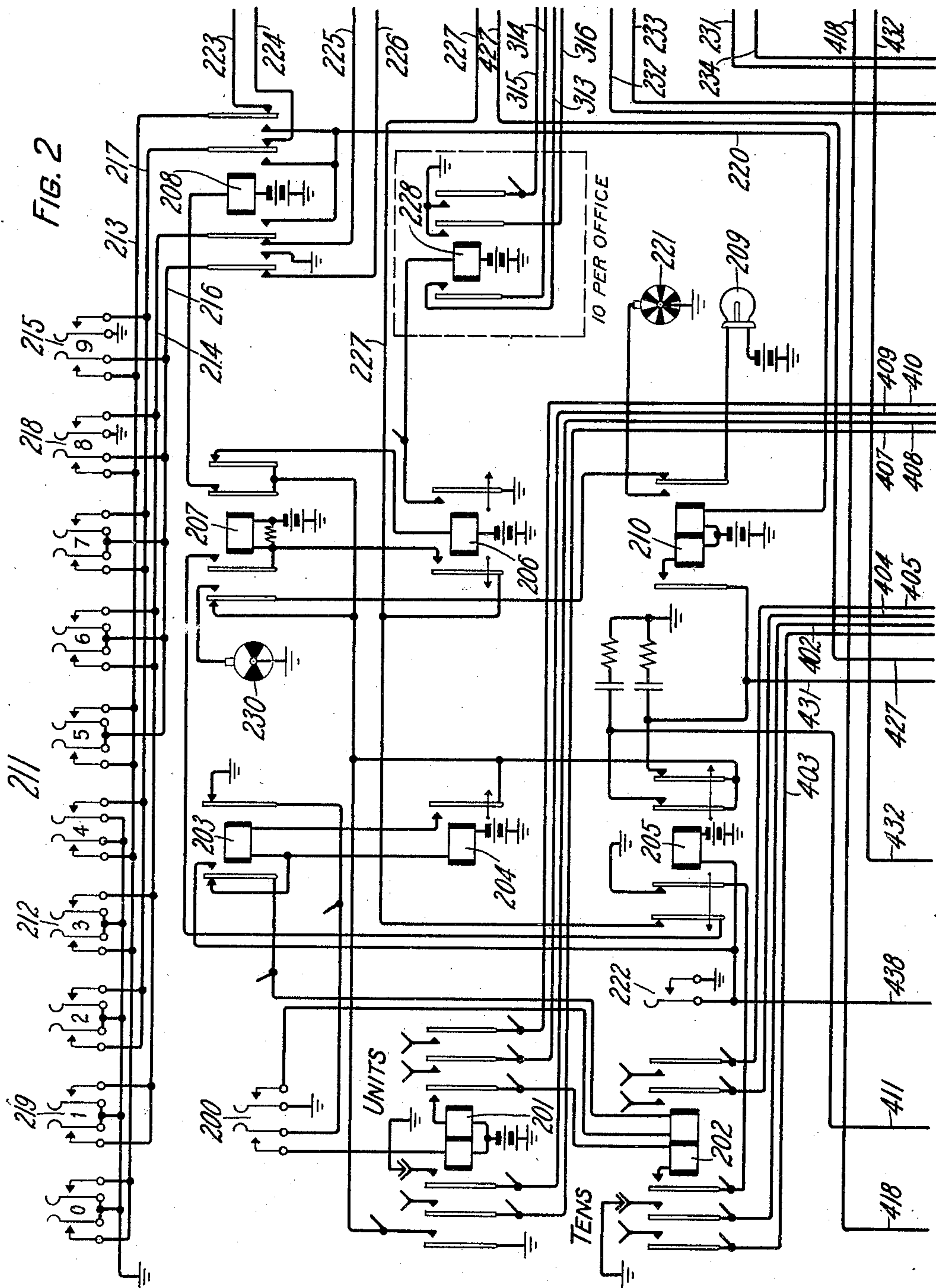
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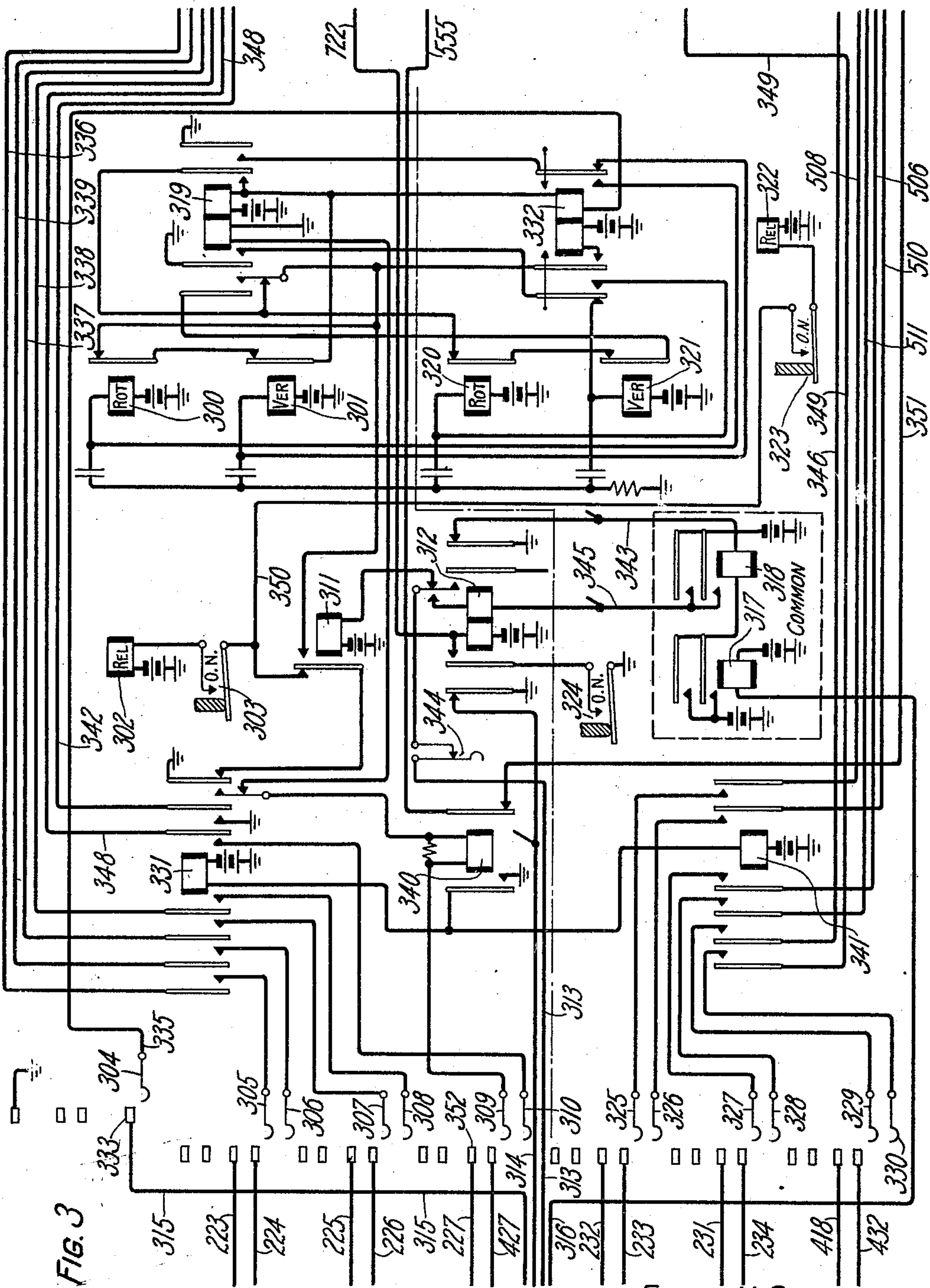
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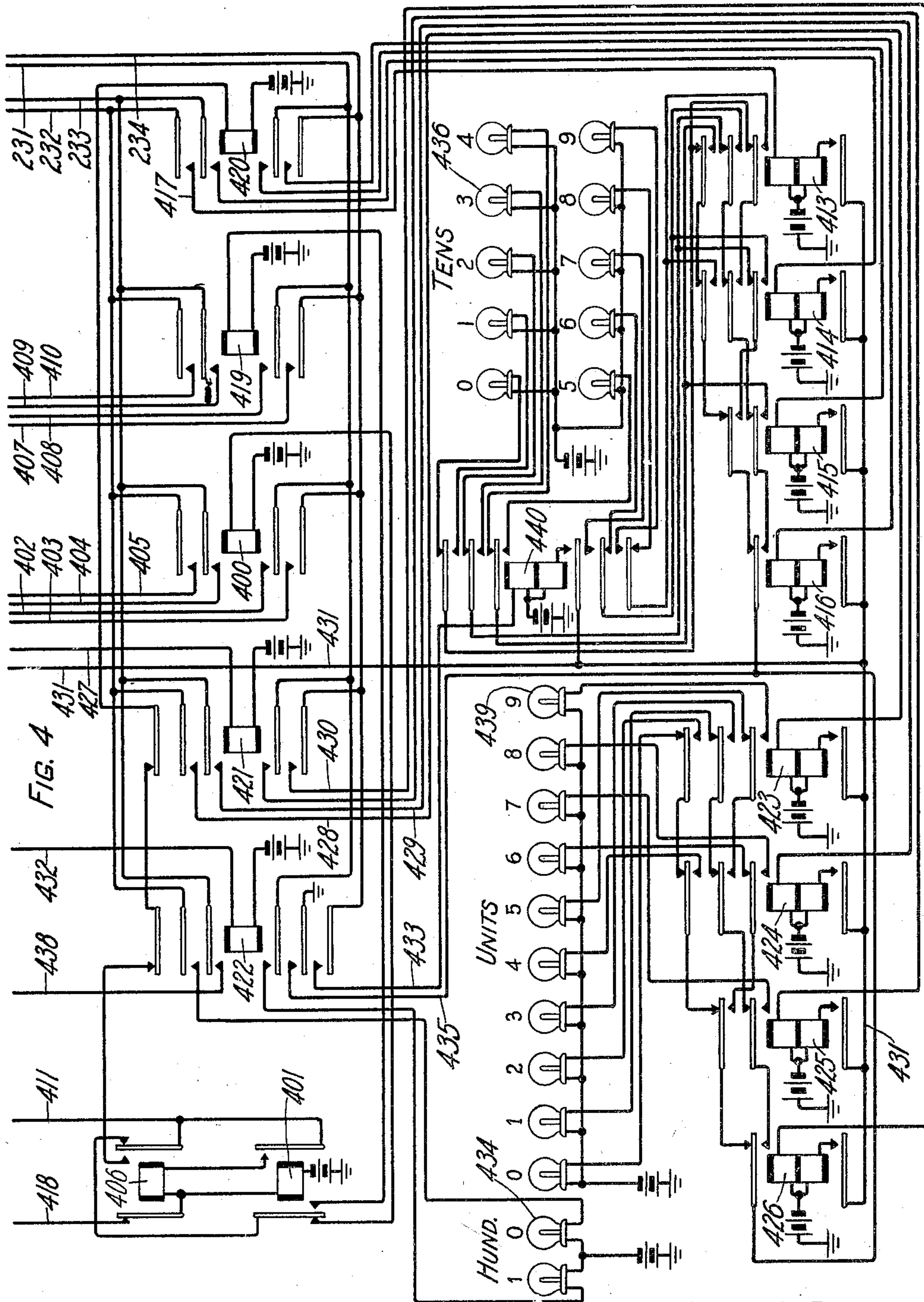
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11 Sheets-Sheet 4



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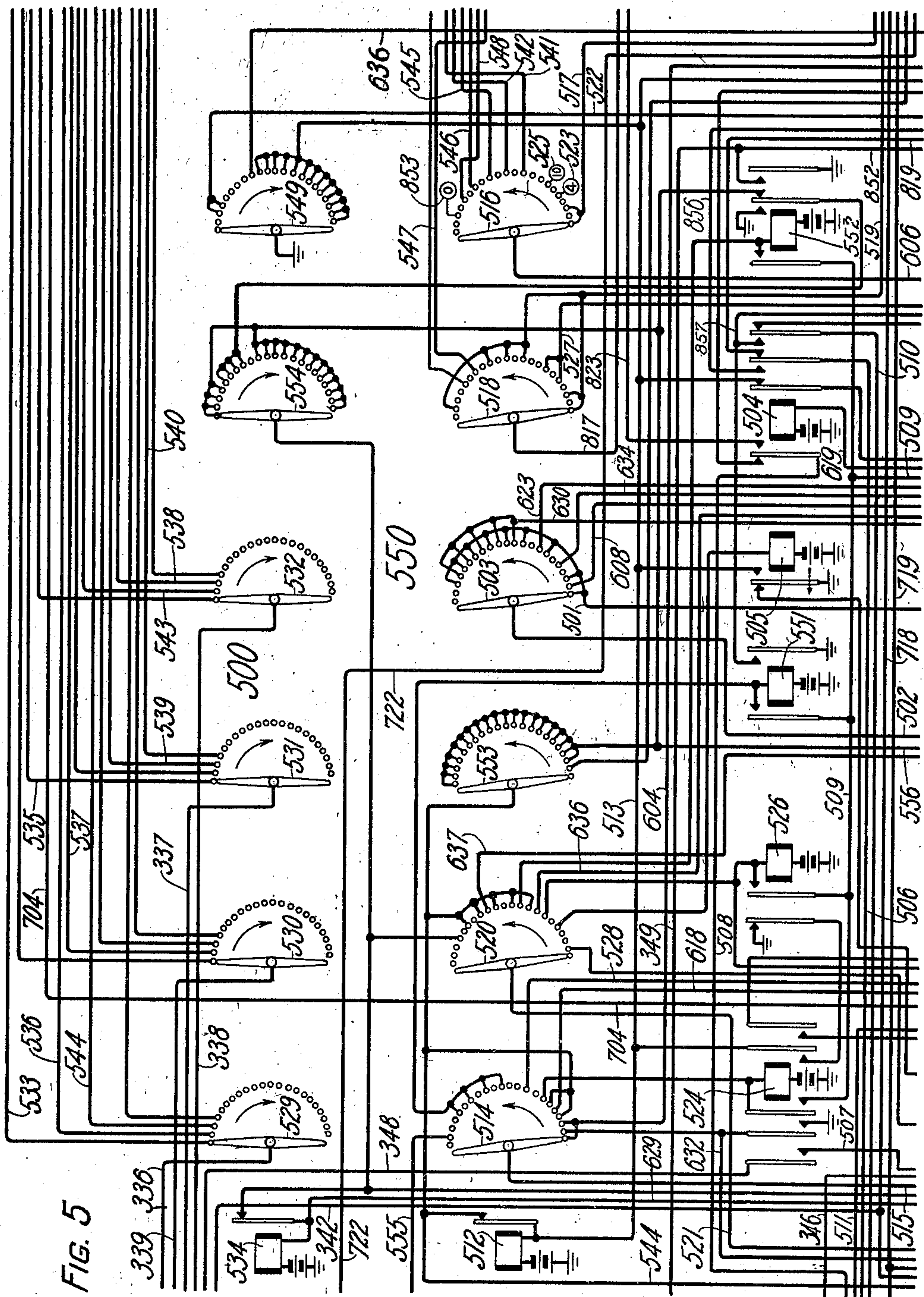
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AUTOMATIC TELEPHONE EXCHANGE

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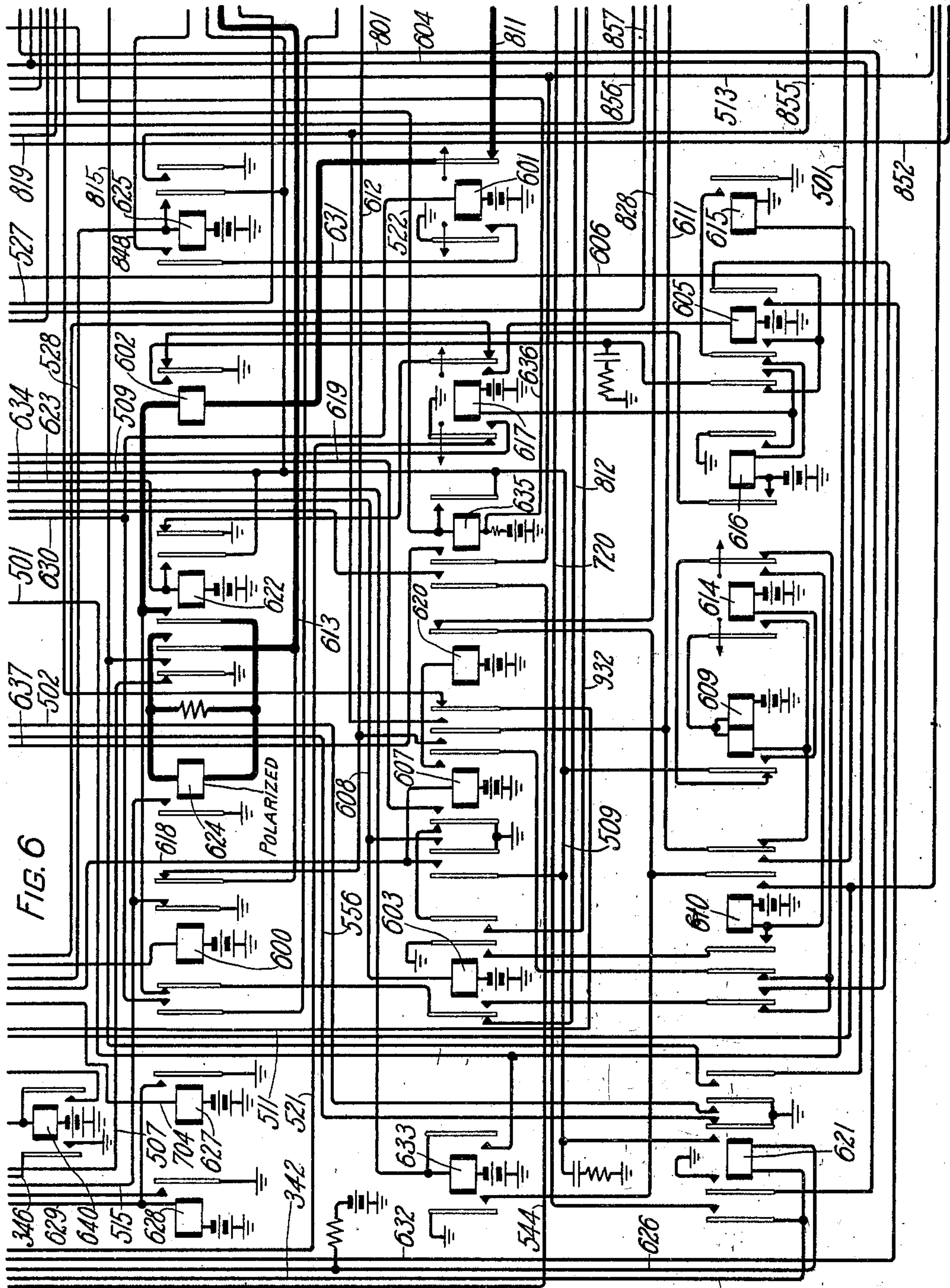
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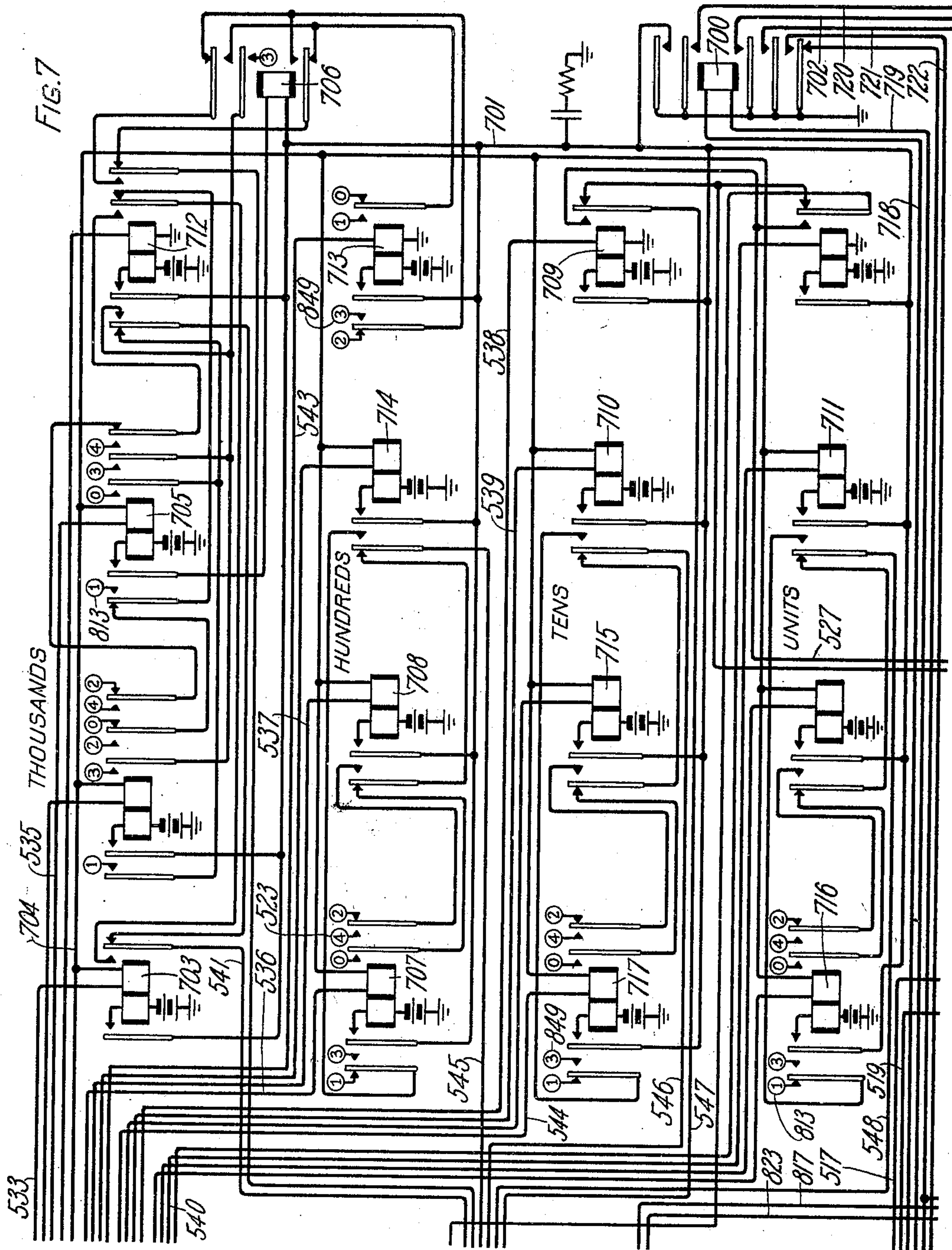
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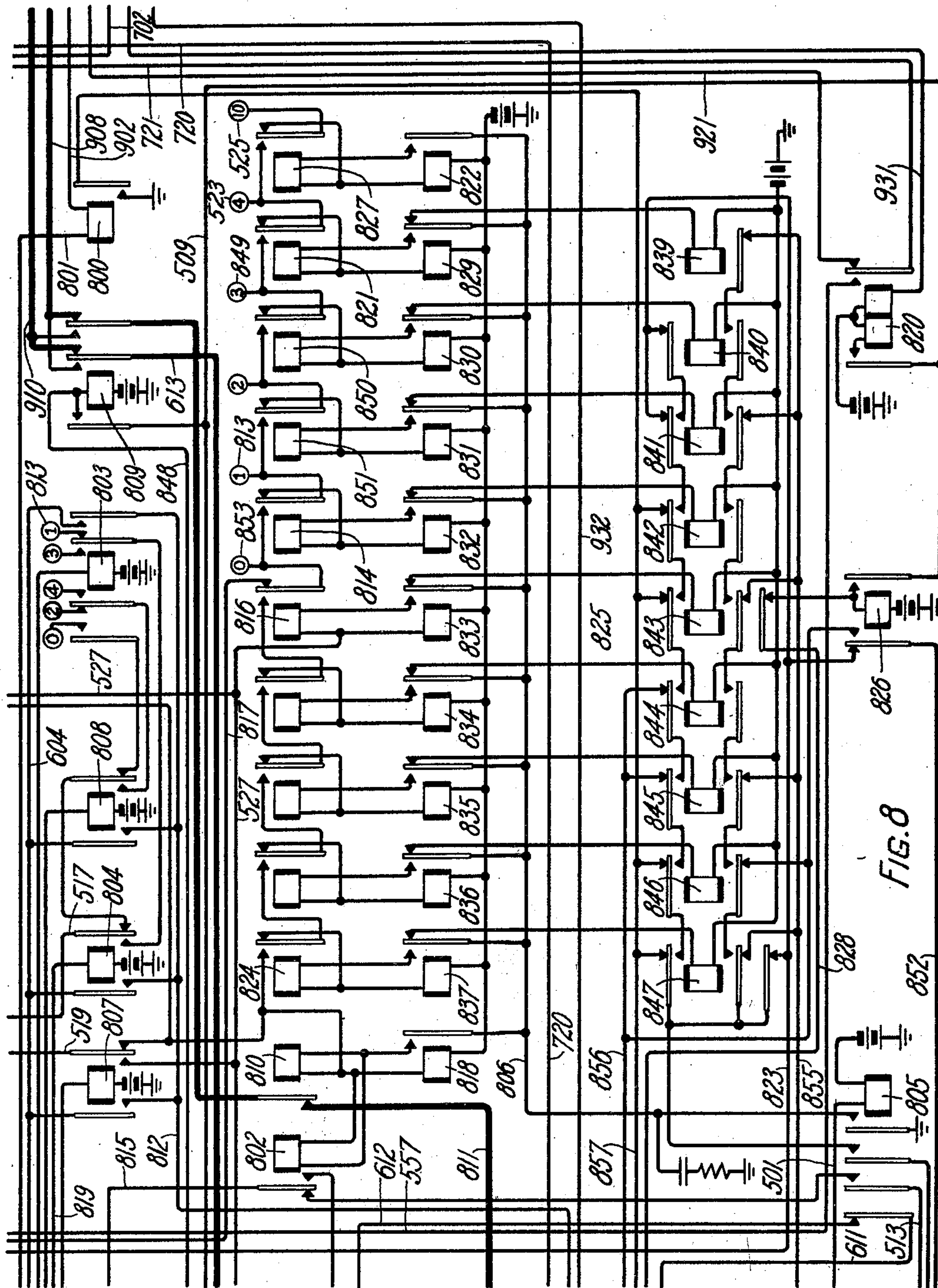
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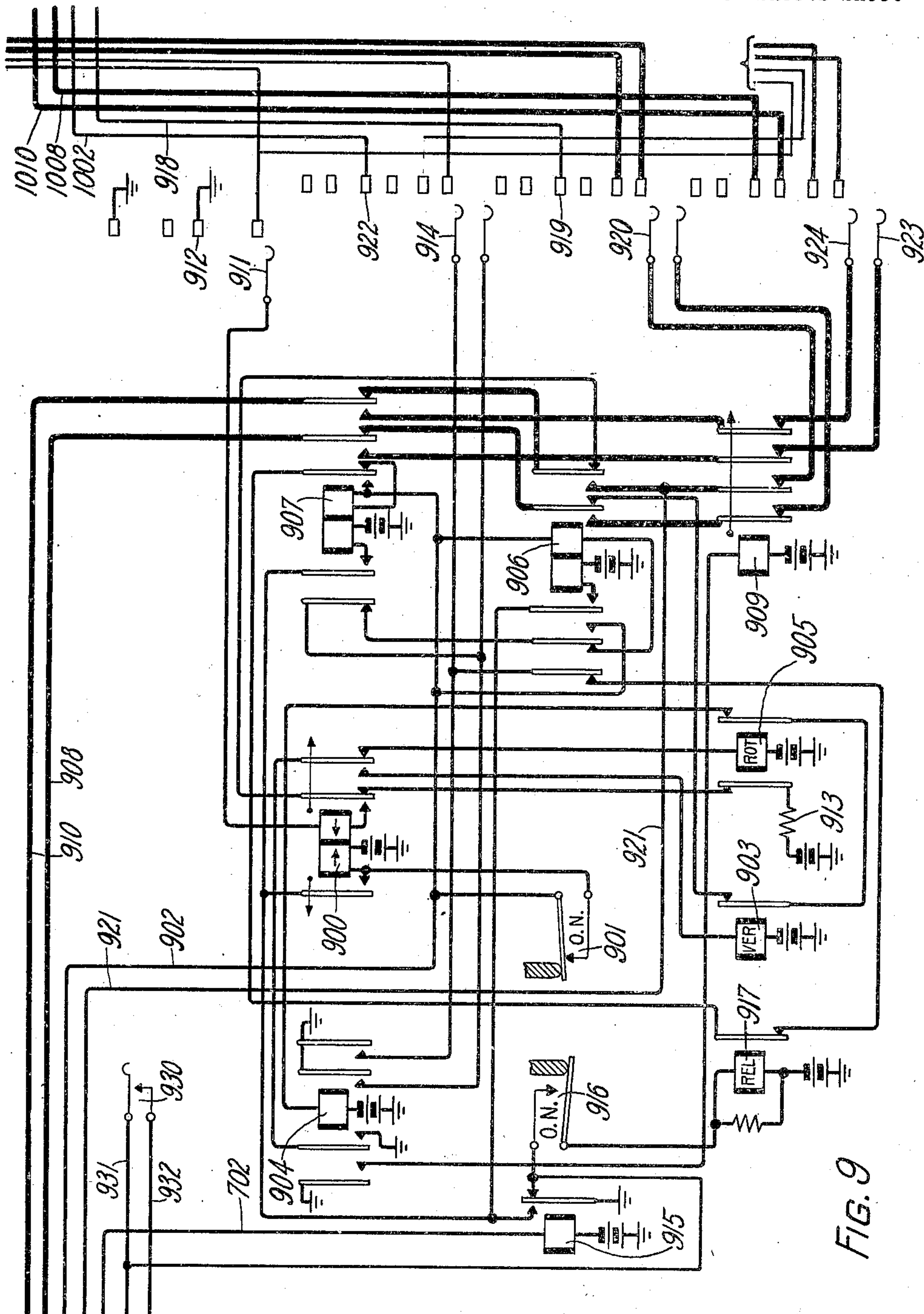
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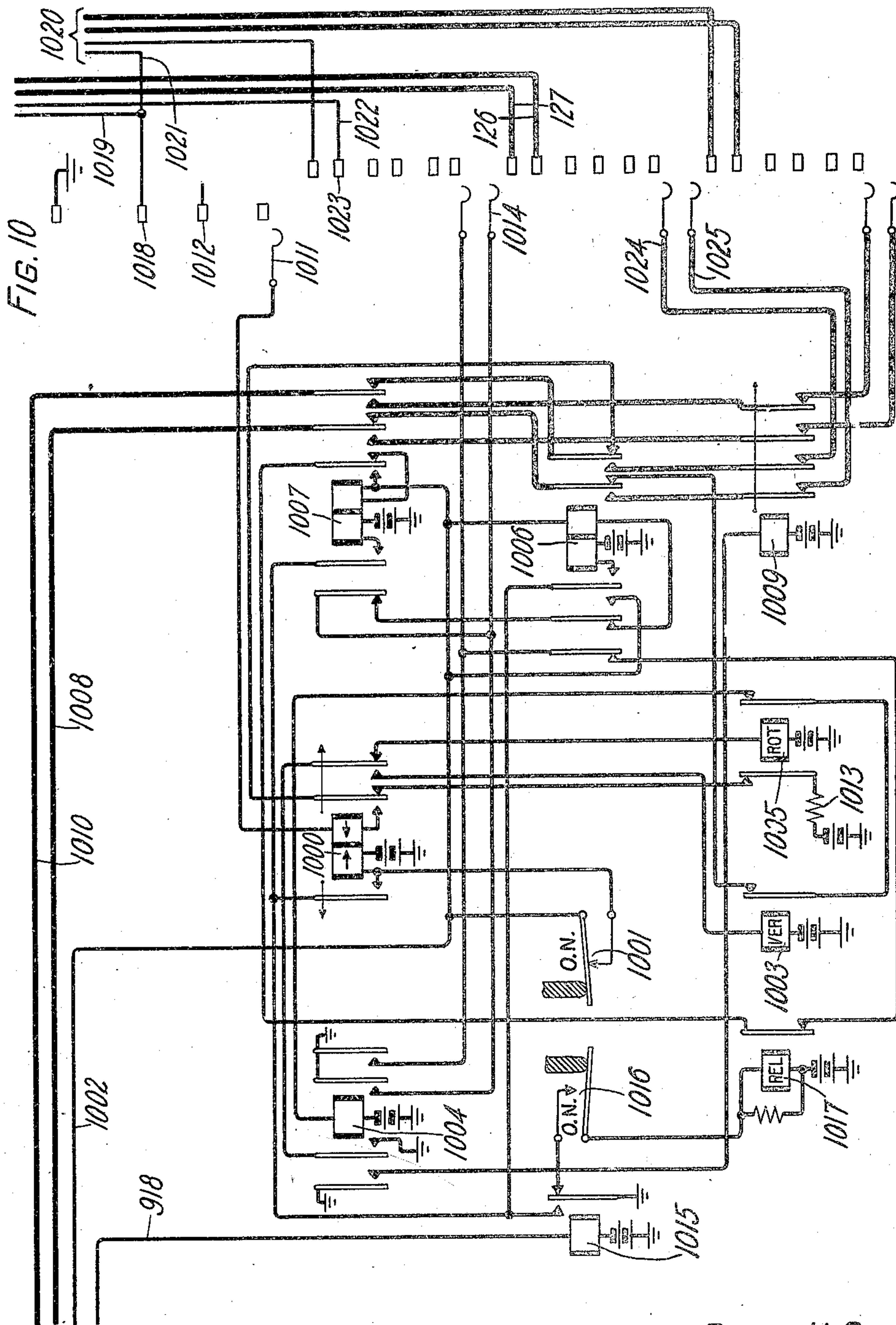
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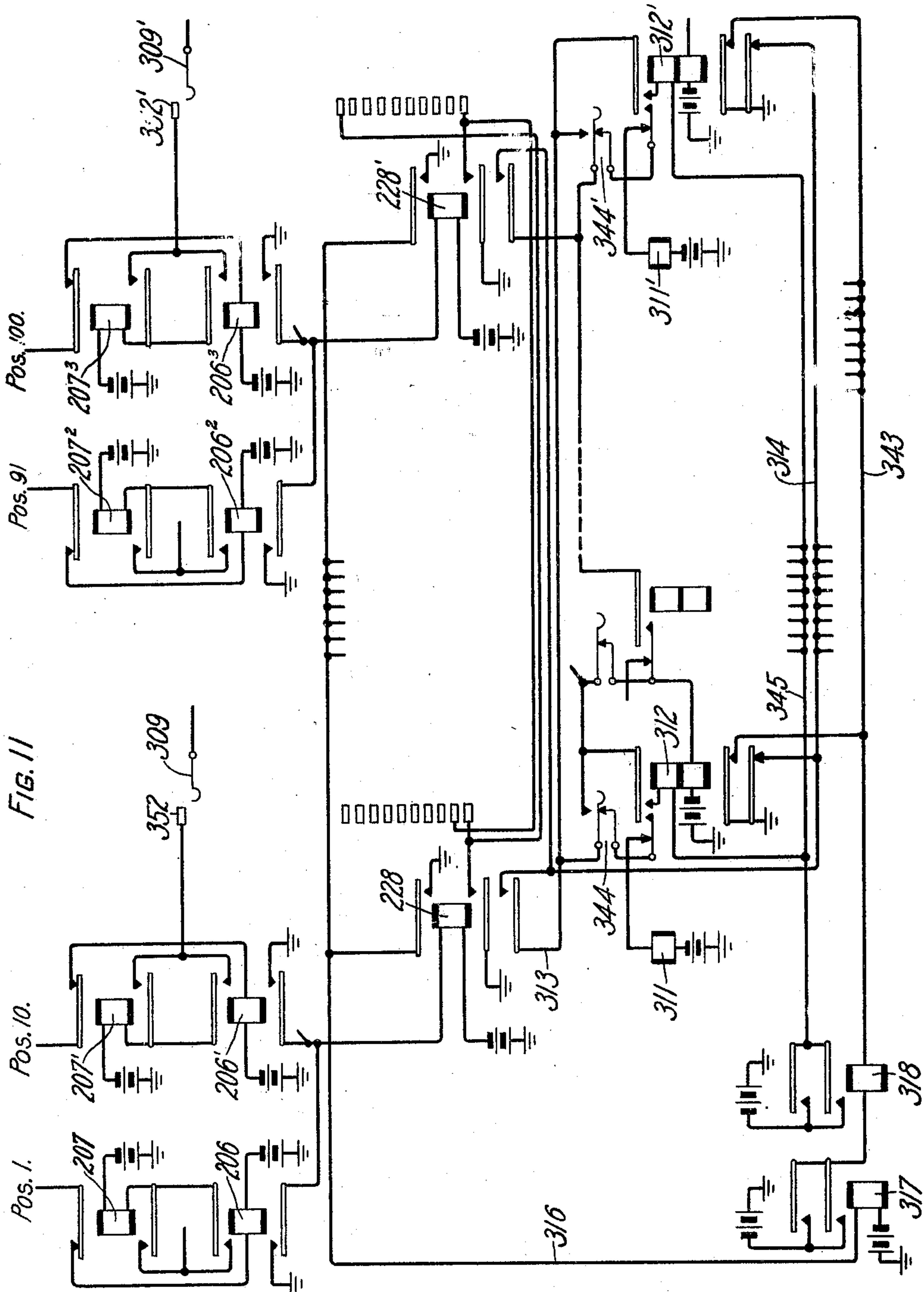
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AUTOMATIC TELEPHONE EXCHANGE

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11 Sheets-Sheet 11



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## UNITED STATES PATENT OFFICE

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## AUTOMATIC TELEPHONE EXCHANGE

Application filed September 29, 1928. Serial No. 309,175.

This invention relates to telephone exchange systems and particularly to those systems wherein mechanical switching apparatus is employed in the establishment of connections between subscribers' lines terminating in manual offices of the exchange area and subscribers' lines terminating in machine switching offices of the same area.

The invention has for its object the simplification of apparatus necessary for the establishment of such connections and the increased economy in the first cost and maintenance thereof.

In exchange areas which are being changed through the installation of machine switching apparatus to operate on a full mechanical basis rather than on a strictly manual basis, it is desirable that provision be made for the extension of calls originated in a manual office of the exchange to any of the outlying automatic offices through the control of the selector switches in the called automatic office, by mechanism located at the calling manual office. As the exchange area becomes more nearly full mechanical through the changing of a greater number of the manual offices to automatic offices, the need for such control equipment for the remaining manual offices becomes more essential. By this plan the operator who first answers the call is enabled to establish the interoffice connection which leads to a distant automatic office without assistance, the entire operation of the switches at the distant automatic office being governed by mechanism at the originating office controlled by the answering operator therein.

This has been accomplished satisfactorily in the past by circuits of the type shown, for example, in Patent 1,513,362, issued October 28, 1924 to L. M. Allen. The present invention was developed to attain the same results as have been heretofore attained in the employment of circuits of the type disclosed in this patent with simpler apparatus and with greater economy.

In accordance with the present invention, one embodiment of which has been disclosed herein, by way of example, each manual office is provided with a plurality of operators' positions, each of which has access to a plurality of groups of outgoing trunks, one group leading to each of the automatic offices of the exchange area. Each position is further equipped with a sender controlling key board, a set of office keys and office code register relays, and a set of relay registers and indicating lamps for trunk identification purposes. In order that an idle sender common to all operators' positions may be taken for use to extend a call and associated with the key board and registers of the operator's position concerned, each sender is provided with two step-by-step position finders individual thereto which mutually hunt for and associate a calling operator's position therewith. In order that the selected sender may become associated with an idle trunk to the desired automatic office, each sender is associated with a first selector switch individual thereto which in turn has access either directly or through second selector switches to all of the trunks in the different groups extending to the several automatic offices.

In the operation of the system, the operator who answers an incoming call at the originating manual office first depresses an office key at her position corresponding to the office in which the desired line terminates and thereby causes the position finder switch associated with an idle sender to hunt for her position and to associate her position apparatus with such sender, and causes the registration of the office code designation of the desired line on the office code register relays of her position. She may then depress keys in her keyboard to register on the numerical registers of the sender the numerical designation of the desired line. The tens designation of the office code is then transferred to a code register

in the sender and, assuming that both first and second selectors are to be used, the first selector switch is set under sender control in accordance therewith, and thereupon hunts for an idle second selector to further extend the connection from the sender to the desired interoffice trunk group. Thereafter the units designation of the office code is transferred to the code register of the sender which is now instrumental in setting the second selector switch whereby a group of trunks to the desired office is selected. The second selector is operated further in hunting movements to find a sub-group of trunks to the desired office and an idle link in the selected sub-group. Such selective movements being registered in the sender, which in turn controls the setting of the trunk number indicating relays of the position apparatus to indicate to the operator the number of the selected outgoing trunk.

If the trunk group to the desired office terminates in a terminal bank of the first selector, such first selector only is controlled by the sender to extend a connection from the sender to an idle trunk of such group of trunks.

The operator then plugs into the jack of the indicated trunk and her position apparatus is freed for another call. The sender then proceeds to operate the selector switches in the selected automatic office in accordance with the numerical designation registered on the registers thereof in the well known manner.

Referring to the drawings, Figs. 1 to 10, inclusive, arranged in accordance with the diagram of Fig. 12, disclose so much of a telephone system embodying the principles of this invention as is necessary to a comprehensive understanding thereof.

Fig. 1 shows one of a plurality of answering operators' positions of a manual office provided with cord circuits for extending subscribers' lines over inter-office trunks outgoing to distant dial switching offices. One of these outgoing trunks terminating in a dial switching office is illustrated in this figure.

Fig. 2 shows a set of numerical keys, one office key, a portion of the office code registers, and control relays of the operator's position shown in Fig. 1.

Fig. 3 shows a pair of position finder switches individual to the sender of Figs. 5, 6, 7 and 8 for associating the operator's position equipment of Figs. 2 and 4 with such sender.

Fig. 4 shows a trunk number indicating equipment individual to the operator's position of Fig. 1 for indicating to the operator the number of the inter-office trunk over which a connection to the desired dial switching office is to be extended and also shows a group of transfer relays.

Figs. 5, 6, 7 and 8 taken together show one

of a plurality of register senders available for the use of all operators' positions of one manual office. Fig. 5 shows two steering switches of the sender. Fig. 6 shows control relays. Fig. 7 shows relay registers for registering the numerical digits of wanted line numbers and Fig. 8 shows control and counting relays for setting the switches of the dial switching office under the control of the registers of Fig. 7, counting relays for controlling the setting of the trunk number indicating equipment of Fig. 4, and office code register relays.

Fig. 9 shows a first selector individual to the sender and Fig. 10 shows one of a plurality of second selectors for connecting a selected sender with an idle trunk extending to a desired dial switching office.

Fig. 11 shows diagrammatically the arrangement of start circuits for a plurality of pairs of position finders, such as the pair shown in Fig. 3.

Fig. 12 is a diagram showing how the various figures should be arranged with relation to each other.

The selector switches 123 and 124 diagrammatically illustrated in Fig. 1 and located in the distant dial switching office 122 are of the well-known power driven type, such as are shown in the patent to E. B. Craft and J. N. Reynolds No. 1,223,396, granted January 5, 1915. More particularly, they are of the specific type fully disclosed and described in the patent to F. A. Stearn and F. J. Scudder No. 1,395,977, granted November 1, 1921.

The steering switches 500 and 550 of Fig. 5 are of the rotary single motion step-by-step type driven by stepping magnets from terminal to terminal and so arranged that the brushes are moved forward to the next set of terminals upon the deenergization of the corresponding stepping magnet.

The selector switches of Figs. 9 and 10 and the position finder switches of Fig. 3 are of the step-by-step type having both a vertical and a rotary motion. Each switch is provided with a pair of brush sets and corresponding banks of terminals. More specifically, these switches are of the type disclosed in Patent No. 1,700,466, granted to W. W. Carpenter Jan. 29, 1929.

The operator's position equipment shown in Fig. 2 comprises a set of ten non-locking digit keys 211 upon which the operator may write up the numerical digits of wanted line numbers, a plurality of office keys only one of which 200 has been illustrated and two groups of office code relays, only one relay of each group having been disclosed. As many office keys are provided at each position as there are dial switching offices in the exchange area to which the manual office has access. Each such group of code register relays comprises eight relays, only the first of each group hav-

ing been disclosed, the register relays of one group register the tens code letter of an office designation, and the relays of the other group register the units code letter. By suitable interconnections with the office keys it is possible by the depression of a single key to register the first two letters of any office designation. For example, as will be hereinafter more fully described, the depression of key 200 registers the office code CA for the office CANal on the tens register relay 202 and on the units register relay 201.

It is believed that the invention will be best understood from a detailed explanation of the manner in which a connection may be established. To this end it will be assumed that the subscriber of line 100 in the manual office wishes to converse with the subscriber of line 125 in a distant dial switching office 122. Upon removing his receiver from the switchhook, the calling subscriber completes a circuit for the energization of line relay 104, which in turn causes the illumination of lamp 105. The operator upon observing the illumination of lamp 105 answers by inserting the plug 102 of one of her cord circuits in the jack 101. The insertion of the plug in the jack completes a circuit from battery through the lamp 107, resistance 106, sleeves of plug 102 and jack 101, winding of relay 103 to ground. Relay 103 operates and severs the circuit of relay 104 which causes the line lamp 105 to become extinguished. The receiver being off the switchhook the insertion of the plug in the jack also completes a circuit from battery through the lower left winding of repeating coil 109, the winding of relay 110, rings of plug 102 and jack 101 over the loop of the line, returning over the tips of jack 101 and plug 102, upper left winding of repeating coil 109 to ground. Relay 110 operates in this circuit and closes a circuit from battery through its contact, resistance 108, resistance 106, thence over the path previously traced through the winding of relay 103 to ground. This latter circuit shunts the lamp 107 causing the same to remain extinguished. The operator next depresses the listening key 112 connecting her headset into conversational relation with the calling line and ascertains the wishes of the calling subscriber.

Upon learning that he wishes to talk with a subscriber at a distant office 122, the operator depresses the office key 200 of Fig. 2, which key corresponds to such distant office. For the purposes of this description it will be assumed that the wanted line number is CANal 3981 and that therefore upon the depression of key 200, the No. 2 units code register relay 201 is operated over a circuit extending from battery through the left winding of relay 201, the left contact of key 200 to ground at the right back contact of relay 203 and that the tens code register relay 202 is operated over a circuit from battery

through the winding of relay 204, the left back contact of relay 203, the right winding of relay 202 to ground at the right contact of key 200. Relays 201 and 202 both energize, closing a mutual locking circuit for each other extending from battery, through the right winding and inner right contact of relay 201, the left winding and inner left contact of relay 202 to ground at the inner left back contact of release relay 205. Relay 204 operates in the operating circuit of relay 202 and locks through the winding of relay 203, the front contact of relay 204 to ground at the outer left contact of relay 201, but relay 203 does not operate in this locking circuit until the key 200 is released. Upon the release of key 200, relay 203 energizes opening at its back contacts the initial operating circuits of relays 201 and 202 and of all other register relays of the position to prevent interference with a call should the operator depress another office key before a call has been completed and her position equipment released. The code register relays prepare circuits for the transfer of the office code number to the sender as will be hereinafter described.

#### *Association of an idle sender with the operator's position*

Relay 201 upon energizing establishes a circuit for relay 206 extending from battery through the winding of relay 206, the outer right contact of relay 207 to ground at the outer left contact of relay 201, a circuit for relay 208 extending from battery through the winding thereof over the inner right contact of relay 207 to ground at the outer left contact of relay 201, and a circuit for lamp 209 extending from battery through said lamp, the back contact of relay 210, the left back contact of relay 207 to ground at the outer left contact of relay 201. Lamp 209 burns steadily at this time and relay 208 upon energizing connects the contacts of the keys of key set 211 over conductor 220 to battery through the right winding of relay 210. Should the operator prematurely depress a key of the key set, that is, while the lamp 209 is burning steadily denoting that a sender has not yet been associated with her position equipment, relay 210 will operate, locking over its left winding and the outer right back contact of release relay 205 to ground at the outer left contact of relay 201. The operation of relay 210 will at this time disconnect lamp 209 from steady ground and connect it to intermittent ground through the fast interrupter 221, whereby the lamp will flicker as a signal that the operator should release her position and start the call over. She may do this by depressing release key 222 thereby operating release relay 205 which, in turn, releases all operated relays of the position. Relay 208, upon operat-

ing, also dissociates the key contacts of key set 211 from conductors 223 to 226, inclusive, extending to the position finders of Fig. 3.

Relay 206 upon operating, at its left contact prepares an operating circuit for the cut-off relay 207 extending to conductor 227 and at its right contact establishes an obvious circuit for the group relay 228. By referring to Fig. 11 it will be noted that provision is made for 100 operators' positions, said positions being subdivided into ten groups of ten positions each. Each sub-group of ten positions has common thereto a group start relay 228. In Fig. 11 the individual start relays 206 and 206' and cut-off relays 207 and 207' of the first and tenth positions of the first sub-group and the individual start relays 206<sup>2</sup> and 206<sup>3</sup> and cut-off relays 207<sup>2</sup> and 207<sup>3</sup> of the 91st and 100th positions in the tenth sub-group of positions together with their corresponding group relays 228 and 228' have been illustrated. Inasmuch as it is necessary to extend eleven control conductors from the operator's position equipment to a sender and as a line finder of the type employed is provided with but six brushes, it is necessary to provide two line finders, arranged to operate in parallel, individual to each sender. A pair of such position finders individual to a sender such as shown in Figs. 5 to 8, inclusive, is provided for normally serving each group of ten positions, but the start circuits are so arranged, as shown in Fig. 11, that a pair of finders individual to any idle sender may be made available to serve any one of the 100 positions. Referring to Fig. 3 in which one pair of such finders is disclosed for normally serving the group of positions in which the position of Fig. 2 is located, one finder of the pair is disclosed above the dot and dash line having rotary magnet 300, vertical magnet 301, release magnet 302, off-normal contact 303, commutator brush 304 and brushes 305 and 310, inclusive, and the other of the pair is disclosed below the dot and dash line having rotary magnet 320, vertical magnet 321, release magnet 322, off-normal contacts 323 and 324 and brushes 325 to 330, inclusive. The relays shown in the dotted rectangle of Fig. 3 are common to all pairs of position finders.

When, therefore, the group relay 228 of the sub-group in which the position equipment of Fig. 2 is located operates, assuming that the pair of finders normally allotted for serving such sub-group is idle, a circuit is extended from battery through the winding of relay 311, the make-before-break contacts of relay 312, transfer key 344, conductor 313, the left contacts of relay 228, conductor 314 to ground at the left back contact of relay 312. Relay 228 at its outer right contact also connects ground over a conductor, such as 315, to place a calling potential on

the commutator of the upper position finder of each pair corresponding to the bank level thereof in which the sub-group of positions appear and at its inner right front contact connects ground to conductor 316 for operating the common relay 317. Relay 317 energizes, in turn, operating the common relay 318 in a circuit extending to ground at the back contacts of all relays similar to relay 312 of line finder pairs that are at the time idle. Relay 318, upon operating, furnishes locking battery for the relay of each position finder pair corresponding to relay 312 for a purpose to be later explained. Relay 311, upon operating, establishes a circuit for relay 319 extending from battery through the right winding thereof, the back contacts of magnets 300 and 301, the front contact of relay 311 to ground at the outer right back contact of relay 331. Relay 319 operates in this circuit and locks from battery through its right winding and inner right contact, over the back contacts of magnets 320 and 321, the outer left alternate contact of relay 319 to ground at the outer right back contact of relay 331. At its outer right contact relay 319 establishes a circuit for vertical magnet 301 of the upper finder extending from battery, winding of magnet 301, the right back contact of relay 332 to ground at the outer right contact of relay 319, and at its inner left contact establishes a circuit for magnet 321 extending from battery, through such magnet, the left back contact of relay 332 to ground at the inner left contact of relay 319. Magnets 301 and 321 both energize, magnet 301 opening the initial energizing circuit of relay 319 and magnet 321 opening the locking circuit thereof. When therefore both vertical magnets are completely energized and the finder shafts have been advanced vertically one step, relay 319 releases, in turn opening the operating circuits of magnets 301 and 321.

It will be assumed that the calling operator's position terminates in the first bank level of each of these finders and that therefore when the finders have been stepped to this level, ground potential placed upon commutator terminal 333 by the group relay 228 will be encountered by the commutator brush 304 and a circuit will be completed therefrom over conductor 335 through the right winding of relay 332 to battery through the right winding of relay 319 before the vertical magnet 301 releases. Relays 319 and 332 thereupon energize, relay 319 locking itself operated over its right winding and inner right contact, the back contacts of magnets 320 and 321, the outer alternate left contact of relay 319, the front contact of relay 311 to ground at the outer right back contact of relay 331, and relay 332 locking itself from battery, over its left winding and inner left contact to ground at the outer right back

contact of relay 331. With relays 319 and 332 both energized circuits are now established for the rotary magnets 300 and 321 extending from battery through the winding of magnet 300, the right front contact of relay 332 to ground at the outer right contact of relay 319, and from battery through the winding of magnet 320, the outer left front contact of relay 332 to ground at the inner left contact of relay 319. Magnets 300 and 320 both energize, advancing the brushes of both finders one step in a rotary direction. The energization of magnet 320 now opens the locking circuit of relay 319 and since its initial energizing circuit was opened at the commutator brush 304, as soon as the upper finder rotated one step, relay 319 deenergizes opening the operating circuits of magnets 300 and 320. These magnets, in turn, deenergize again closing an operating circuit for relay 319 extending from battery through its right winding, the back contacts of magnets 300 and 301, the front contact of relay 311 to ground at the outer right back contact of relay 331. Relay 319 again energizes and locks as before and establishes the operating circuits of magnets 300 and 320. In this manner magnets 300 and 320 and relay 319 reciprocally operate to advance the brushes of the position finders in a rotary hunting movement.

When the brushes have been so advanced to the terminals associated with the calling operator's equipment, a circuit becomes established from battery, winding of cut-off relay 207, the left contact of relay 206, conductor 227, test terminal 352, test brush 309, the winding of relay 340, the right normal contacts of relay 331 to ground, through the left winding of relay 319, thereby differentially releasing relay 319 and energizing relays 207 and 340. Relay 207, upon energizing, locks over its winding and inner left front contact, the outer left back contact of relay 205 directly to conductor 227 independently of relay 206, opens at its right contacts the circuits of relays 206 and 208, thereby releasing said relays and at its outer left front contact establishes a circuit from ground through the slow interrupter 230 over the right back contact of relay 210 to battery through the lamp 209. Lamp 209 now flashes to indicate that the operator's position has been attached to an idle sender and that she may proceed to operate the keys of keyboard 211 to set the numerical registers of such sender to record the numerical designation of the desired line. The release of relay 206 opens the circuit of group relay 228 which, in turn, releases, releasing relays 311, 317 and 318, the two latter relays releasing only in case there is no other call initiated at the time.

Relay 340, upon operating, closes obvious circuits over its left contact for relays 331 and 341 which upon operating extend control

circuits from the operator's position equipment over brushes 305 to 308, 310 and 325 to 330, inclusive. At its right back contact relay 331 opens the holding circuit of relay 332, the circuit previously traced through the right winding of relay 319 and at its right make-before-break contacts substitutes direct ground in the circuit of relays 207 and 340 in place of ground through the left winding of relay 319. Relay 332 thereupon releases. At its intermediate right contact relay 331 also closes a circuit extending from ground over such contact, conductor 342, winding of relay 621, conductor 626 to battery. A circuit is also established in parallel with relay 621 from ground on conductor 342, over conductor 718, the winding of relay 700, conductor 719 to battery on conductor 626.

Relay 621 upon energizing prepares several circuits. At its intermediate right contact it establishes a circuit for relay 805 extending from ground over conductor 502, brush 503 and the first position terminal of steering switch 550, conductor 501 to battery through the winding of relay 805. At its inner right contact relay 621 connects ground to conductor 509 for furnishing locking ground to relays of Figs. 5, 6 and 8. At its inner left contact relay 621 connects ground over conductor 801, through the winding of relay 800, conductor 902, off-normal terminals 901 of the first selector of Fig. 9 to battery through the left winding of relay 900. Relay 900 energizes in this circuit, but relay 800 does not. Relay 900, upon operating, closes a locking circuit for itself extending over its left winding and left contact to the front contact of relay 915, which latter relay energizes upon the energization of relay 700 over a circuit extending from battery through the winding of relay 915, conductor 702 to ground at the innermost lower front contact of relay 700. Relay 915 also at its back contact opens one point in the operating circuit of the release magnet 917 of the first selector. Relay 805, upon energizing, in the circuit previously traced connects locking ground over its inner front contact to conductor 806 for furnishing locking ground for the counting relays and operating ground for the relays of group 825 of Fig. 8. At its outer right front contact relay 621 also closes a circuit for stepping magnet 512 of the steering switch 550 extending from battery through the winding of magnet 512 over conductor 513, the next to the outer front contact of relay 805, the back contact of counting relay 802, conductor 815, the outer front contact of relay 621, conductor 604 first position terminal and brush 514 of steering switch 550, conductor 515 to ground at the inner right back contact of relay 600, preparatory to advancing the steering switch into position 2. At its outer left contact relay 621 also closes a locking circuit for itself ex-

tending from battery on conductor 626, through its own winding and outer left contact, conductor 720 to ground at the inner upper front contact of relay 700.

5 Relay 700 at its uppermost contact connects ground to conductor 701 for furnishing locking ground to the register relays of Fig. 7 and connects ground over its intermediate lower front contact over conductor 721,  
10 back contact of relay 820 to conductor 921 for a purpose to be later explained and at its lowermost front contact establishes a circuit extending from ground over conductor 722 to battery through the left winding of relay  
15 312. Relay 312 thereupon energizes, locking over its left winding and inner left front contact and off normal contact 324 to ground, removes ground at its left back contact from the start conductor 314, removes ground at  
20 its right back contact from the common conductor 343 and at its inner right make-before-break contacts extends the starting conductor 313 to the start relay corresponding to relay 311 of the pair of position finders  
25 associated with the next idle sender.

It will be explained at this point how another call, initiated at a position of the same sub-group, is able to associate another idle sender with such position. For this  
30 purpose it will be assumed that upon the depression of an office key at such other position, for example, the tenth position of such sub-group, relay 206' disclosed in Fig. 11 becomes energized, in turn, operating the  
35 common group relay 228'. It will further be assumed that the next idle sender is the sender normally assigned for serving positions 91 to 100, inclusive. Referring to Fig. 11 with relay 312 energized as just described,  
40 a circuit is now established from ground at the lower back contact of relay 312' associated with the pair of position finders individual to such idle sender, over the common conductor 314, the lower front contact of  
45 group relay 228, conductor 313, transfer key 344, the front contact of relay 312, thence in a chain circuit through the front contacts of other relays similar to relay 312 associated with position finders of other busy senders,  
50 thence to transfer key 344', the normal contact of relay 312' to battery through the winding of start relay 311'. Start relay 311' upon operating starts the pair of position finders associated with the idle sender in the  
55 manner previously described. So long as there is an initiated call at any position and any group relay such as 228 is energized relay 317 remains energized, in turn, maintaining relay 318 operated until all senders  
60 have been taken for use, since relay 318 receives operating ground over common conductor 343 and a back contact of the relay 312 of the position finders associated with  
65 each idle sender. With relay 318 energized,

battery is connected to common conductor 345. Thus, upon the energization of relay 312 an auxiliary locking circuit is established for relay 312 extending from battery on conductor 345, through a winding and inner  
70 front contact of relay 312, key 344, the front contact of group relay 228 to ground on common conductor 314. This insures that relay 312 will be maintained operated if a second call has been initiated in the first sub-group  
75 even though the sender which was taken for use by a previously initiated call in that sub-group should become idle. Since relay 312 cannot therefore release to open the chain starting circuit the second call is not  
80 therefore mutilated.

#### *Setting code register for first office code letter*

85 As soon as the position finders of Fig. 3 have associated an idle sender with the operator's position equipment, circuits are effective for setting the relays 803, 804, 807 and 808 of the office code register of the sender.  
90 At the operator's position equipment upon the operation of the units code register relay 201 a circuit was established for operating the transfer relay 400 extending from ground at the outer left front contact of relay 201,  
95 over the inner right back contact of release relay 205, conductor 411, the right back contact of counting relay 406, the left back contact of counting relay 401, thence to battery through the winding of relay 400. It will  
100 first be assumed that both a first and second selector such as shown in Figs. 9 and 10 are to be operated to select a trunk to the desired dial switching office in response to the office code letters C, A, the letter C corresponding  
105 to the digit 2. For this purpose the armature contacts of the tens office code register relay 202 of Fig. 2, which was operated in response to the depression of the office key 200, are cross-connected in such a manner as  
110 to operate the code register relay 804 of the sender, over a circuit extending from battery, through the winding of relay 804, conductor 819, the intermediate right back contact of relay 504, conductor 506, the inner left con-  
115 tact of relay 341, brush 327, conductor 231, the inner lower front contact of transfer relay 400, conductor 402, to ground at the inner left contact of register relay 202.

120 In order to register digits corresponding to all of the code letters used in office codes, four register relays 803, 804, 807 and 808 are employed in the sender which may be operated individually and in combination over  
125 circuits extending in the manner previously traced for relay 804 to grounded armature contacts of the code register relays of Fig. 2. To enable a better understanding of the manner in which the code digits may be registered  
130

in the sender the following chart has been prepared.

|    |   | 410 | 408 | 409 | 407 |
|----|---|-----|-----|-----|-----|
|    |   | 405 | 402 | 404 | 403 |
| 5  | 2 | 804 |     |     |     |
|    | 3 | 808 |     |     |     |
| 10 | 4 | 803 | 804 |     |     |
|    | 5 | 803 |     | 808 |     |
|    | 6 |     | 804 |     | 807 |
| 15 | 7 |     |     | 808 | 807 |
|    | 8 | 803 | 804 |     | 807 |
| 20 | 9 | 803 |     | 808 | 807 |

The vertical column of figures at the left of the chart indicates the digits corresponding to office code letters that may be registered by the office code relays. The numbers in the sub-divisions of the chart opposite this vertical column indicate the relays of the sender register which are operated for the corresponding digits to be registered and the numbers above each vertical column of the chart indicate the conductors of Fig. 2 which may be variously grounded by the register relays of Fig. 2 to operate the register relays of the sender. Thus, for example, if the digit 8 is to be registered, by reading horizontally across the chart it will be apparent that register relays 803, 804 and 807 must be operated in combination and that to operate these relays a tens code relay of Fig. 2 must be operated which will ground conductors 405, 402 and 403 or a units code relay which will ground conductors 410, 408 and 407.

#### Operation of first selector in accordance with first code letter

With the register relay 804 operated a pulsing circuit extending from the first selector of Fig. 9 may be traced from battery through the winding of relay 904, back contact of rotary magnet 905, back contact of vertical magnet 903, inner right back contact of relay 906, intermediate right back contact of relay 907, conductor 908, outer right back contact of relay 809, back contact of the counting relay 810, conductor 811, back contact of relay 601, winding of relay 602, inner left back contact of relay 600, left back contact of relay 603, conductor 812, left contact of relay 804, conductor 604, normal terminal of brush 514 of steering switch 550, conductor 515 to ground at the inner right contact of relay 600. Relays 602 and 904 energize in this circuit, relay 602 upon energizing closing a circuit from ground at its front con-

tact, over the outer left back contact of relay 605, conductor 606, brush 516 and normal terminal of switch 550, conductor 517, right front contact of register relay 804, right back contact of register relay 803, counting relay lead 813, right back contact of counting relay 814, winding of counting relay 832 to battery. Relay 832 energizes and locks through the winding of relay 814, over the front contact of relay 832 to ground on conductor 806, but relay 814 does not energize until relay 602 deenergizes and removes the shunting ground from its winding.

At the selector of Fig. 9 upon the energization of relay 904 a circuit is closed for the vertical magnet 903, from battery, through the winding of magnet 903, the outer right front contact of relay 900 to ground at the inner left front contact of relay 904. Relay 904 also closes an obvious circuit for relay 909 which disconnects the tip and ring brushes of the selector during its vertical selection movement. Magnet 903 energizes and at its contact opens the previously traced pulsing circuit through the winding of relay 904 and the winding of relay 602. The selector switch is thus stepped vertically one step, opening at the off-normal contacts 901 the initial energizing circuit of relay 900. Upon the opening of the pulsing circuit and the deenergization of pulsing relay 602 the shunt around the counting relay 814 is opened and such relay energizes in the locking circuit of relay 832, extending the counting relay lead 813 over its front contact, the back contact of counting relay 816, conductor 817, brush 518 and normal terminal of steering switch 550, conductor 519, the right back contact of register relay 807, to battery, through the winding of counting relay 818. Relay 818 energizes upon the next closure of the pulsing circuit and the consequent energization of relay 602, and locks through the windings of relays 802 and 810 in parallel, over the front contact of relay 818 to ground on conductor 806.

At the selector, relay 904 energizes and in the manner previously described causes the advance of the selector shaft another step, opening the pulsing circuit. When the pulsing circuit is again opened and relay 602 deenergizes, relays 802 and 810 energize, relay 810 opening the pulsing circuit, extending as previously traced to the first selector and relay 802 opening the previously traced circuit extending through the winding of magnet 512. Magnet 512 now deenergizes advancing the steering switch 550 into its second position.

When the steering switch leaves position 1 the circuit of relay 805 is opened and such relay releases, removing ground from conductor 806, thereby releasing the operated counting relays. A circuit is now established for relay 603, extending from battery, through the winding of said relay, conductor

608, the second position terminal and brush 503 of steering switch 550, conductor 502 to ground at the outer intermediate contact of relay 621. A circuit is also established for relay 640, through the second position terminal and brush 520 of steering switch 550, conductor 521 to ground at the left back contact of relay 617. Relay 640 locks over its right contact to ground at the back contact of relay 505 and closes a circuit for relay 401 of the operator's position circuit extending from battery, through the winding of relay 401, the left back contact of relay 406, conductor 418, brush 329, the next to outer left contact of relay 341, conductor 346, to ground at the left contact of relay 640. Relay 401 operates in this circuit locking through the winding of relay 406, and the right front contact of relay 401 to ground on conductor 411, but relay 406 being shunted by ground on conductor 418 does not operate at this time. At its left back contact relay 401 now opens the circuit of transfer relay 400 and closes a circuit for transfer relay 419, extending from battery, through the winding of relay 419, the left front contact of relay 401, the right back contact of relay 406 to ground on conductor 411. Relay 400 upon deenergizing disconnects the conductors 402 to 405 inclusive extending to contacts of the tens code register relays and relay 419 connects the conductors 407 to 410 inclusive extending to the contacts of the code register relays preparatory to the transferring of the units code letter to the sender. When relay 400 disconnects the conductor 402 the code register relay 804 of the sender releases.

*First selector hunts for idle second selector*

Relay 603 upon energizing opens at its left back contact, the previously traced pulsing circuit through the windings of relays 602 and 904. With relay 805 deenergized a circuit is now established for relay 609, extending from battery, through both windings thereof, the outer right back contact of relay 610, conductor 611, the outer left back contact of relay 805, conductor 612, the right back contact of relay 600, conductor 613, the inner right back contact of relay 809, conductor 910, the outer right back contact of relay 907, the outer right back contact of relay 906, the inner right front contact and right winding of relay 900, which is wound differentially to the left winding thereof, commutator brush 911 to ground on terminal 912 of the commutator corresponding to the second vertical level of the banks of the first selector which level of terminals has been assumed to be connected to terminals of trunks extending to second selectors such as the one shown in Fig. 10. Relay 609 operates in this circuit and closes a circuit for relay 614 extending from battery, winding of relay 614, front contact of relay 609 to

ground on conductor 509. Relay 614 upon operating shunts at its left front contact the left winding of relay 609, thereby increasing the current flowing through the right winding of relay 900, whereupon relay 900 differentially releases, removing the vertical magnet 903 from the control of stepping relay 904. Relay 900 also connects the right winding of relay 609, over the circuit previously traced to the inner right back contact of relay 900, thence to battery, through resistance 913, over the back contact of rotary magnet 905. Relay 609 thereupon releases and at its front contact opens the previously traced circuit of relay 614. Since relay 614 is slow to release a circuit is momentarily closed upon the release of relay 609 from ground on conductor 509, over the back contact of relay 609, the right front contact of relay 614, to battery, through the winding of relay 610 which thereupon energizes and locks to ground at the inner right contact of relay 603.

Relay 610 upon energizing opens the initial circuit of relay 609 at its outer right back contact and at its outer right front contact close a circuit for relay 615, extending from ground therethrough, over the outer right front contact of relay 610, conductor 611, the outer back contact of relay 805, conductor 612, thence as traced to battery, through resistance 913 at the first selector. Relay 615 operates in turn operating relay 616, over a circuit extending from battery, through the winding of relay 616, the inner left back contact of relay 605, to ground at the contact of relay 615. Relay 616 upon operating locks over its left contact to ground at the back contact of pulsing relay 602 and at its right contact establishes an obvious circuit for relay 617, which relay in turn establishes a circuit for magnet 512 of the steering switch 550, extending from battery, through the magnet 512, over conductor 513, the inner right back contact of relay 504 to ground at the left front contact of relay 617. Relay 617 also at its front contact closes a circuit for relay 605, extending from battery, through the winding of relay 605, the right front contact of relay 617, to ground at the right back contact of relay 622.

A circuit is now established for the stepping relay 904 of the first selector, extending from battery, through the winding of relay 904, back contacts of rotary magnet 905 and vertical magnet 903, back contacts of relays 906 and 907, conductor 908, outer right back contact of relay 809, back contact of counting relay 810, conductor 811, back contact of relay 601, winding of sender pulsing relay 602, inner left contact of relay 600, left front contact of relay 603, the left front contact of relay 610, the right front contact of relay 605, conductor 632, the second position terminal and brush 514 of steering switch 550, con-

ductor 515 to ground at the inner right contact of relay 600. Relays 904 and 602 operate in this circuit. Relay 904 upon energizing closes the circuit of relay 909 to disconnect the tip and ring brushes of the selector during its rotary hunting movement and closes the circuit of rotary magnet 905 which may be traced from battery, through the winding of magnet 905, the outer right back contact of relay 900 to ground at the inner left contact of relay 904. Magnet 905 upon energizing in turn opens the previously traced circuit for relays 904 and 602, relay 904 in turn opening the circuit of magnet 905. Thus relay 904 and magnet 905 cooperate with each other to cause the step-by-step rotation of the first selector brushes over the selected second level in search of an idle second selector.

At the sender upon the energization of pulsing relay 602 the holding circuit of relay 616 is opened at the back contact of relay 602 and relay 616 deenergizes in turn opening the initial energizing circuit of relay 617. Relay 617 being slow to release, however, does not release before a holding circuit is established therefor from battery, through its winding, the outer left front contact of relay 605, to ground at the front contact of relay 602. Therefore as long as relay 602 continues to receive impulses of current due to the hunting movement of the first selector relay 617 is held energized and in turn maintains relay 605 operated. Relay 615 is at this time deenergized since its operating circuit was opened at the back contact of rotary magnet 905 upon the first energization of magnet 905 and the initial operating circuit of relay 616 is therefore opened at the contact of relay 615.

When an idle second selector is found a circuit is established for relay 1015 extending from battery, winding of relay 1015, conductor 918, terminal 919, brush 920, next to inner back contact of relay 909, conductor 921, back contact of relay 820 to ground on conductor 721. Relay 1015 energizes connecting locking ground for the relays of the second selector and opening at one point the circuit of the release magnet 1017. Another circuit is also established from battery, through the left winding of relay 1000, off-normal contacts 1001, conductor 1002, terminal 922, brush 914, the outer left back contact of relay 906, the back contact of release magnet 917, inner right back contact and right winding of relay 907, conductor 902, winding of relay 800, conductor 801 to ground at the inner left contact of relay 621. Relays 1000 and 907 operate in this circuit but due to its small number of turns relay 800 does not operate. Relay 1000 upon operating locks over its left contact to ground at the front contact of relay 1015 and at its outer right front contact prepares the operating circuit of the ver-

tical magnet 1003. Relay 907 upon operating locks over its left front contact to ground at the front contact of relay 915, at its left back contact opens the energizing circuit for relay 906 and at its inner right back contact opens its own initial energizing circuit, and connects the trunk conductors 908 and 910 over its outer and intermediate right front contacts, right back contacts of relay 909, ring and tip brushes 923 and 924 to the selected trunk conductors 1008 and 1010. At its inner right front contact relay 907 connects ground on conductor 902, over the back contact of release magnet 917, the outer left back contact of relay 906, brush 914, terminal 922, to conductor 1002. At its intermediate right back contact relay 907 also opens the circuit previously traced through the windings of relays 904 and 602 whereupon these relays are released. Pulsing relay 602 upon releasing opens the holding circuit of slow to release relay 617 which in turn releases relay 605. Relay 617 upon releasing also opens the circuit of magnet 512 which advances the brushes of steering switch 550 into contact with the third position terminals of their associated arcs. As soon as the steering switch leaves position 2 the circuit of relay 603 is opened and that relay releases, opening the holding circuit of relay 610 which also releases. With the steering switch in position 3 the previously traced circuits for relay 805 and stepping magnet 512 are again established and magnet 512 energizes preparatory to advancing the steering switch another step.

*Setting the second selector in accordance with second office code letter registered in sender*

It has been assumed that the second code letter registered on the code register relays of the operator's position was A, having a numerical equivalent of 2, and that the units register relay 201 was energized by the depression of key 200. The armature contacts of relay 201 are cross-connected to conductors 407 to 410 inclusive in such a manner that conductor 408 is grounded to operate the office code register relay 804 of the sender, over a circuit extending from battery, through the winding of relay 804, conductor 819, the intermediate right back contact of relay 504, conductor 506, the inner left contact of relay 341, brush 327, conductor 231, the inner lower front contact of transfer relay 419, conductor 408, to ground at the inner left contact of units code register relay 201. It is to be noted in this connection that the sender code register relays 803, 804, 807 and 808 are operated singly and in combination in accordance with the foregoing table, over conductors 407 to 410 inclusive to register the units code digit in the same manner as previously described in connection

with the registration of the tens code digit, over conductors 402 to 405 inclusive.

With the register relay 804 operated a pulsing circuit extending from the second selector of Fig. 10 may be traced from battery, winding of relay 1004, back contacts of rotary magnet 1005 and vertical magnet 1003, inner right back contact of relay 1006, intermediate right back contact of relay 1007, conductor 1008, brush 923, next to outer back contact of relay 909, intermediate right front contact of relay 907, conductor 908, outer right back contact of relay 809, back contact of counting relay 810, conductor 811, back contact of relay 601, winding of relay 602, inner left back contact of relay 600, left back contact of relay 603, conductor 812, left contact of register relay 804, conductor 604, third position terminal and brush 514 of steering switch 550, conductor 515 to ground at the inner right contact of relay 600. Relays 602 and 1004 energize in this circuit, relay 602 closing a circuit from ground at its front contact, over the left back contact of relay 605, conductor 606, brush 516 and the third position terminal of switch 550, conductor 517, right front contact of register relay 804, right back contact of relay 803, counting relay lead 813, right back contact of counting relay 814, winding of counting relay 832 to battery. Relay 832 energizes and locks through the winding of relay 814, over the front contact of relay 832 to ground on conductor 806, but the relay 814 does not energize until relay 602 deenergizes and removes the shunting ground from its winding.

At the selector of Fig. 10 upon the energization of relay 1004 a circuit is closed for the vertical magnet 1003 from battery, through the winding of magnet 1003, the right front contact of relay 1000, to ground at the inner left front contact of relay 1004. Relay 1004 also closes an obvious circuit for relay 1009 which disconnects the tip and ring brushes of the selector during its vertical selection movement. Magnet 1003 energizes and at its contacts opens the previously traced pulsing circuit through the winding of relay 1004 and the winding of relay 602. The selector switch is thus stepped vertically one step opening at the off-normal terminal 1001 the initial energizing circuit of relay 1000. Upon the opening of the pulsing circuit and the deenergization of pulsing relay 602 the shunt around the counting relay 814 is opened and such relay energizes in the locking circuit of relay 832, extending the counting relay lead 813 over its front contact, back contact of counting relay 816, conductor 817, brush 518 and the third position terminal of steering switch 550, conductor 519, the right back contact of register relay 807, to battery, through the winding of counting relay 818. Relay 818 energizes upon the next closure of the pulsing circuit

and the consequent energization of relay 602 and locks through the windings of relays 802 and 810 in parallel, over the front contact of relay 818 to ground on conductor 806.

At the selector, relay 1004 deenergizes and in the manner previously described causes the advance of the selector shaft another step again opening the pulsing circuit. When the pulsing circuit is again opened and relay 602 deenergizes, relays 802 and 810 energize, relay 810 opening the pulsing circuit extending as previously traced to the second selector and relay 802 opening the previously traced circuit extending through the winding of magnet 512. Magnet 512 now deenergizes advancing the brushes of steering switch 550 one step into engagement with the fourth set of terminals of the arcs to which they have access.

When the steering switch leaves position 3 the circuit of relay 805 is opened and such relay releases removing ground from conductor 806 thereby releasing the operated counting relays. A circuit is now established for advancing steering switch 550 into position 5, extending from battery, through the winding and back contact of magnet 512, the fourth position terminal and brush 514 of the steering switch, conductor 515 to ground at the inner right contact of relay 600. With the steering switch in position 5 a circuit is established for relay 505 extending from battery, through the winding of relay 505, the fifth position terminal and brush 520 of the steering switch, conductor 521 to ground at the left bank contact of relay 617. Relay 505 upon energizing closes a circuit for magnet 512 preparatory to advancing the steering switch 550 into position 6. This circuit extends from battery, through the magnet 512 to ground, through the front contact of relay 505. Relay 505 also at its back contact opens the locking circuit of relay 640, which relay upon releasing disconnects the shunting ground from relay 406 permitting such relay to operate in the locking circuit of relay 401. A circuit is also closed for relay 633, extending from battery, winding of relay 633, conductor 634, the fifth position terminal and brush of steering switch 550, conductor 502 to ground at the intermediate right contact of relay 621. Relay 633 upon energizing extends its own operating ground to relay 805 which also energizes.

A circuit is also established for relay 607, extending from battery, through the winding of said relay, conductor 618, fifth terminal and brush 514 of the steering switch, conductor 515 to ground at the inner right contact of relay 600. Relay 607 upon energizing locks over its outer left contact to ground on conductor 509, closes at its intermediate left front contact an obvious circuit for relay 603, at its inner left contact closes a circuit extending over conductor 619 to battery,

through the winding of relay 504, and at its inner right contact establishes a circuit extending from battery, through the winding of relay 620, contact of relay 607, intermediate left back contact of relay 610, right back contact of relay 614, left back contact of relay 609, to ground on conductor 509. Relay 504 at its outer and intermediate right and left back contacts disconnects the code register relays 804, 808 and 803 from the conductors 506, 508 and 510, extending to the operator's position equipment and connects such conductors to contacts of the train of counting relays designated 825 in Fig. 8. Relay 406 upon operating opens at its right back contact the circuit of transfer relay 419 and closes at its front contact a circuit for transfer relay 420. This latter circuit extends from battery, through the winding of relay 420, the upper back contacts of relays 421 and 422, the front contact of relay 406, to ground on conductor 411. Relay 419 upon deenergizing disconnects the conductors 407 to 410 inclusive extending to contacts of the units code register relays and relay 420 upon operating prepares circuits for operating the tens trunk number indicating register relays 413 to 416 inclusive.

*Selection of idle trunk group at second selector and partial registration of tens digit of trunk number*

It will now be assumed that the group of trunks that is selected by the second selector of Fig. 10 extending to the distant office 122 comprises 40 trunks appearing in the second and third levels of the banks of the second selector and, as in response to the second code letter A the switch shaft of the second selector has positioned its brush sets opposite the second level of each bank, the commutator brush 1011 will now be standing on commutator segment 1012. Should all the trunks in the second level of both banks be busy there will be no ground potential connected to the segment 1012 and the circuit to be hereinafter traced from the brush 1011, through the right winding of relay 1000 will not be effective to differentially release relay 1000. As a consequence with the steering switch 550 in position 5 and relay 603 energized, a circuit is completed from battery, through the winding of relay 1004, thence as previously traced through the winding of pulsing relay 602, the inner left back contact of relay 600, the left front contact of relay 603, the left back contact of relay 610, the right back contact of relay 614, the left back contact of relay 609, to ground on conductor 509. Relay 1004 energizes and again closes the previously traced circuit for the vertical magnet 1003 which in turn opens the pulsing circuit through the windings of relays 602 and 1004 just traced, relay 1004 in turn opening the circuit of magnet 1003. Thus magnet 1003 is operated

and released to advance the switch shaft one step vertically to position the switch brushes opposite the third level of terminals in its banks. At the sender relay 602 upon energizing establishes a circuit from ground at its front contact, over the outer left back contact of relay 605, conductor 606, brush 516 and its fifth terminal, counting relay lead 523, the back contact of counting relay 821, to battery through the winding of counting relay 829. Relay 829 energizes locking itself through the winding of relay 821, the front contact of relay 822, to ground on conductor 806, but relay 821 does not energize until relay 602 deenergizes. When relay 602 deenergizes upon the operation of vertical magnet 1003 counting relay 821 operates. It will be assumed that when the second selector has stepped to position its brush sets opposite the third level of its banks the brush 1011 encounters ground potential on the terminal 1018 corresponding to the third bank levels of the selector.

In Fig. 1 the terminal equipment of two trunks extending to the office 122 both appearing in jacks before the operator has been illustrated, the trunk 136, 137 being the first in the group of ten trunks appearing in the third level of the upper bank of the second selector and trunk 126, 127 being the tenth in such group. In a similar manner ten other trunks extending to the office 122 appear in the terminals of the third level of the lower bank of the second selector but with their tip and ring conductors reversed. It will be noted that so long as any trunk in this group is idle ground will be connected to the commutator terminal 1018, over conductor 1019, the outer back contact of the cut-off relay of such trunk, for example, relay 131, and over the outer back contact of the sleeve relay of such trunk, for example relay 130. Similarly so long as any trunk in the other group of ten, one trunk of which is indicated at 1020, is idle, ground will be connected to the conductor 1021, also connected to the commutator terminal 1018. Thus brush 1011 upon encountering ground potential establishes a circuit from such ground, over brush 1011, right winding and inner right contact of relay 1000, the outer right back contact of relay 1006, the outer right back contact of relay 1007, conductor 1010, brush 924, outer back contact of relay 909, outer right front contact of relay 907, conductor 910, inner right back contact of relay 809, conductor 613, right back contact of relay 600, intermediate right front contact of relay 607, outer right back contact of relay 610, to battery, through both windings of relay 609. Relay 609 energizes and establishes a circuit for relay 614 from battery, winding of relay 614, front contact of relay 609 to ground on conductor 509. Relay 614 at its left contact shunts the left winding of relay 609, thereby reducing the

resistance of the circuit previously traced, through the right winding of relay 1000, so that the right winding of this relay receives sufficient current to cause the differential release thereof. Relay 1000 upon releasing opens the operating circuit of the vertical magnet 1003 to prevent further vertical stepping of the selector.

Relay 609 upon energizing opens the circuit of relay 620 which releases preparing a circuit for relay 826, extending from ground at the left contact of relay 633, back contact of relay 620, conductor 828 to the lower armature of relay 843, this relay being now energized, however, since the second selector has taken but one vertical step and relay 843 releasing to complete the circuit above traced, through the winding of relay 826 only when the selector takes more than five vertical steps. At this time the relays 413 to 416 inclusive of the tens trunk number register are operated in accordance with the released condition of relays of the group 825. Since counting relay 829 has operated, relay 839 whose circuit extends from battery through the back contact of relay 829 to ground on conductor 806 is released and a circuit for register relay 416 is prepared from battery winding of relay 416, lower contact of relay 420, conductor 234, brush 328, next to inner contact of relay 341, conductor 511, outer right front contact of relay 607, conductor 855, lower back contact of relay 839, front contacts of relays 840 to 847 inclusive over the next to inner contact of relay 805 to the inner right front contact of relay 610.

When relay 1000 denenergizes the circuit previously traced through the relay 609 is opened at the inner right front contact of relay 1000 and relay 609 denenergizes in turn opening the energizing circuit of relay 614. Relay 614 being slow to release momentarily closes a circuit for relay 610 before it releases, extending from battery, winding of relay 610, right front contact of relay 614, left back contact of relay 609 to ground on conductor 509. Relay 610 upon energizing locks over its inner left front contact to ground at the inner right front contact of relay 603, at its outer right back contact opens the initial energizing circuit of relay 609 and at its outer right front contact establishes a circuit for relay 615 extending from battery, resistance 1013, left back contact of rotary magnet 1005, inner right back contact of relay 1000, thence as traced to the intermediate right front contact of relay 607, the outer right front contact of relay 610, to ground through the winding of relay 615. Relay 610 at its inner right contact completes the circuit of relay 416 to ground at the left contact of relay 633. Relay 416 energizes and locks to ground over its lower winding and contact, conductor 431, outer back con-

tact of relay 205 to ground at the outer left contact of relay 201.

Relay 615 upon energizing closes a circuit for relay 616, extending from battery, through the winding of relay 616, the inner left back contact of relay 605, to ground at the contact of relay 615, relay 616 locking to ground at the back contact of relay 602, and closing an obvious circuit for relay 617 which in turn closes a circuit for relay 605. Relay 605 upon energizing opens the initial operating circuit of relay 616, and relay 617 upon energizing opens at its left back contact the circuit for relay 505 which in turn denenergizes, opening the circuit of magnet 512 to advance the steering switch 550 out of position 5 into position 6.

As soon as the steering switch leaves position 5, the circuit of relay 633 is opened at brush 503 in turn opening the circuit of relay 805. Relay 805 upon denenergizing unlocks the operated counting relays. With the steering switch in position 6 a circuit is established for the stepping magnet 512, extending from battery, through the winding and contacts of magnet 512, the sixth position terminal and brush 514 of steering switch 550, conductor 515 to ground at the inner right back contact of relay 600, causing the steering switch to advance into position 7.

#### *Hunting for idle trunk and registering units digit of trunk number*

A circuit is now established for relay 524, extending from battery, through such relay, the seventh position terminal and brush 514 of the steering switch 550, conductor 515 to ground at the inner right contact of relay 600. A circuit is also established from battery, through the winding of relay 805, conductor 501, the seventh position terminal and brush 503, conductor 502, to ground at the intermediate right contact of relay 621. A circuit is also established for counting relay 822 extending from battery, through the winding of relay 822, the back contact of counting relay 827, lead 525, the seventh position terminal and brush 516 of the steering switch, conductor 606, the inner left front contact of relay 605 to ground at the front contact of relay 615. Relay 822 energizes locking through the winding of relay 827 and the front contact of relay 822 to ground on conductor 806, but relay 827 being shunted at the contact of relay 615 does not operate.

Relay 524 upon energizing locks over its inner left front contact to ground on conductor 509 establishing a circuit for magnet 512, over its inner right contact to ground at the left back contact of relay 526 and at its outer left contact establishing a circuit from battery, through the winding of transfer relay 421, conductor 427, brush 310, inner right contact of relay 331, conductor 348, outer left front contact of relay 524, conductor 507, 130

to ground at the outer left back contact of relay 622. Relay 421 energizes in this circuit preparing circuits over its front contacts for the units truck number register relays 423 to 426 inclusive and at its upper back contact opening the circuit of transfer relay 420 which thereupon releases, opening the operating circuits of the tens trunk number register relays 413 to 416 inclusive.

A pulsing circuit is now established between the sender and the second selector which may be traced from battery, through the winding of relay 1004, thence as previously traced to the back contact of relay 810, conductor 811, the back contact of relay 601, winding of pulsing relay 602, the inner left back contact of relay 600, the left front contact of relay 603, the outer left front contact of relay 610, the outer right front contact of relay 605, conductor 632 to ground at the intermediate left contact of relay 524. Relays 602 and 1004 energize in this circuit, relay 602 opening the locking circuit of relay 616 which thereupon releases. The release of relay 616 opens the initial energizing circuit of relay 617 but relay 617 remains locked over the outer left front contact of relay 605 to ground at the front contact of relay 602 so long as relay 602 receives pulses from the second selector. At the selector upon the energization of relay 1004 with relay 1000 deenergized, a circuit is established for the rotary magnet 1005, extending from battery, winding of magnet 1005, the outer right back contact of relay 1000, to ground at the inner left contact of relay 1004. Relay 1004 also establishes a circuit for relay 1009 to disconnect the tip and ring brushes during the rotary hunting movement of the selector. Upon the closure of this pulsing circuit magnet 1005 energizes, opening the circuit previously traced, through the windings of relay 1004 and relay 602. Relay 1004 upon deenergizing opens the circuit of magnet 1005, which thereupon deenergizes, again establishing the pulsing circuit. Thus relay 1004 and magnet 1005 reciprocally control each other, the magnet 1005 advancing the switch shaft step by step in search of an idle trunk.

Upon the first energization of magnet 1005 the circuit of relay 615 is opened at the left back contact thereof, and relay 615 releases, removing the shunt from the winding of counting relay 827, whereupon relay 827 energizes. Upon the next deenergization of magnet 1005 relay 615 reoperates, connecting ground at its front contact to the counting relay lead 525, thence over the front contact of counting relay 827, the back contact of counting relay 821 to battery, through the winding of relay 829. In this manner the second selector advances step by step operating a counting relay pair at each step until if the switch still continues to hunt the counting relay pair 814 and 832 become operated.

In the present case it will be assumed that the trunks having an even tens number terminate in the lowermost banks of second selectors and that the trunks having an odd tens number terminate in the upper banks of second selectors and that all trunks terminating in the upper banks have their tip and ring conductors reversed. For example, trunks 0 to 9, 20 to 29, etc. terminate in the lower bank of the second selector of Fig. 10, and trunks 10 to 19, 30 to 39, etc. terminate in the upper bank. It will further be assumed that the selector hunts to its tenth rotary step position and finds the last trunk 126, 127 numbered 39 appearing in the last terminal set of the third level of the upper bank thereof in an idle condition. When counting relay 814 operates after the selector has taken five steps the lead 525 becomes extended over the front contact of relay 814, the back contact of relay 816, conductor 817, brush 518 and the seventh terminal of the steering switch 550, conductor 527 to battery, through the winding of counting relay 833. Upon the tenth rotary step of the second selector the counting relay 837 becomes operated and locks through the winding of relay 824.

At the selector upon the test brush 1014 encountering the test terminal of the idle trunk 126, 127, a circuit is established from battery, through the right winding of cut-off relay 121, the inner right back contact of sleeve relay 120, conductor 1022, test terminal 1023, brush 1014, the left back contact of relay 1007, the intermediate left back contact and right winding of relay 1006, conductor 1002, terminal 922, brush 914, the outer left back contact of relay 906, the back contact of release magnet 917, the inner right front contact of relay 907, conductor 902, the winding of relay 800, conductor 801 to ground at the inner left contact of relay 621. Relays 1006 and 121 energize in this circuit, relay 121 locking over its inner right front contact to conductor 1022 independent of relay 120, and relay 1006 locking from battery, through its left winding and inner left front contact to ground at the front contact of relay 1015. At its outer left back contact relay 1006 opens the operating circuit of relay 1007, at its intermediate left back contact opens its own operating circuit, and at its intermediate left front contact connects conductor 1002, over the outer left back contact of relay 1007 to test brush 1014. At its right front contacts relay 1006 extends conductors 1010 and 1008 over the outer right and intermediate right back contacts of relay 1007, right back contacts of relay 1009 to the tip and ring brushes 1024 and 1025. Also at its inner right back contact relay 1006 opens the circuit previously traced, through the windings of relays 1004 and 602 and at its outer right back contact opens the previously traced circuit of relay 615.

Relay 602 upon deenergizing opens the holding circuit of relay 617 which thereupon releases in turn releasing relay 605. With relay 617 deenergized a circuit is now established for relays 526 and 600, extending from battery, through the windings of these relays in parallel, over the seventh position terminal and brush 520 of steering switch 550, conductor 521 to ground at the left back contact of relay 617. Relay 526 energizes locking itself and relay 600 to ground on conductor 509, over its left front contact and at its outer right back contact opens the circuit of magnet 512, thereby advancing the steering switch 550 into position 8.

As soon as the second selector has taken ten steps and counting relays 822 and 829 to 837 inclusive have been operated all of the relays of the group 825 which operated in circuits extending from ground on conductor 806, over the back contacts of the above mentioned counting relays to battery, through the windings of relays 839 to 847 inclusive, release. The release of relay 847 before the advance of steering switch 550 out of position 7 now prepares three circuits for operating units trunk number register relays of the operator's position equipment. One of these circuits extends from ground at the right back contact of relay 622, over the right back contact of relay 617, outer right contact of relay 524, next to inner contact of relay 805, over the lowermost back contact of relay 847, conductor 823, the left front contact of relay 504, conductor 508, the outer right contact of relay 341, brush 325, conductor 232, the uppermost front contact of relay 421, conductor 428 to battery, through the upper winding of register relay 423. A second circuit extends from ground at the right back contact of relay 622, over the upper back contact of relay 847, conductor 857, the outer right front contact of relay 504, conductor 510, the inner right front contact of relay 341, brush 326, conductor 233, the innermost upper front contact of relay 421, conductor 429, to battery through the upper winding of register relay 424. A third circuit extends from ground at the right back contact of relay 622, over the innermost lower back contact of relay 847, conductor 855, the outer right front contact of relay 607, conductor 511, the next to inner left contact of relay 341, brush 328, conductor 234, the lowermost contact of relay 421, conductor 430, to battery, through the upper winding of register relay 426. Register relays 423, 424 and 426 operate in these circuits and lock from battery, over their lower windings and lower front contacts, conductor 431, the outer right back contact of release relay 205 to ground at the outer left contact of relay 201.

As soon as the steering switch leaves position 7 the circuit of relay 805 is opened and the locking circuits of all of operated count-

ing relays are opened releasing such relays. A circuit is also established for relay 622 with the steering switch in position 8, extending from battery, through the winding of relay 622, conductor 623, the eighth position terminal and brush 503 of steering switch 550, conductor 502, to ground at the intermediate right contact of relay 621, relay 622 upon energizing locking over its inner right contact to ground on conductor 509.

#### *Completion of registration of tens digit of trunk number*

A fundamental circuit is now established from ground at the incoming selector 123, over trunk conductor 127, brush 1024, thence as previously traced to conductor 910, over the inner back contact of relay 809, conductor 613, the intermediate left contact of relay 622, the winding of polarized relay 624, the inner left contact of relay 622, the winding of relay 602, the back contact of relay 601, conductor 811, the back contact of counting relay 810, the outer back contact of relay 809, conductor 908, thence as traced to brush 1025, over trunk conductor 126 to battery, through the control relay (not shown) at the incoming selector 123. If the incoming selector is in condition to be operated at this time relays 624 and 602 operate, the polarized relay receiving current in the proper direction since the trunk conductors 126 and 127 have been assumed to be reversed. Relay 602 is without function, however, at this time. Relay 622 at the time it energizes also disconnects ground at its outer left back contact from conductor 507, releasing transfer relay 421, thereby disconnecting the operating circuits of the units trunk number register relays of the operator's position equipment. The circuits of the sender now remain in this condition until after the operator has caused the registration of the thousands and hundreds digits of the wanted line number on the registers of the sender.

#### *Registration of numerical digits of wanted line number*

All the foregoing circuit operations have resulted from the depression of an office key by an operator. While this has been transpiring the operator has proceeded to depress the digit keys to register the numerical designation of the wanted line on the sender registers shown on Fig. 7, as soon as the lamp 302 flashes, indicating that an idle sender has been attached to her position equipment. It has been assumed that the number of the desired line in the office 122 is 3981. The operator therefore first depresses the #3 digit key 212 to register the thousands digit 3. At its left contact key 212 establishes a circuit from ground, over conductor 213, the outer right back con-

tact of relay 208, conductor 223, brush 305, the outer left contact of relay 331, conductor 336, brush 529 and its first position terminal of the steering switch 500, conductor 533, right winding of thousands register relay 703, conductor 704, to battery, through the winding of relay 627. Relays 703 and 627 operate, relay 703 locking over its left winding and left contact to ground on conductor 701. Relay 627 upon energizing closes an obvious circuit for relay 628, and a circuit in parallel therewith over conductor 629, to battery through magnet 534 of steering switch 500, preparatory to advancing such switch into position 2. A second circuit is also established by the depression of key 212, extending from ground, over the right contact thereof, conductor 214, inner left back contact of relay 208, conductor 225, brush 307, next to inner left contact of relay 331, conductor 337, brush 531 and first position terminal of steering switch 500, conductor 535, right winding of thousands register relay 705 to battery, through the winding of relay 627. Relay 705 upon energizing locks through its left winding and inner left front contact, winding of relay 706, to ground on conductor 701. Relay 706 energizes in this circuit.

Upon the release of key 212, the previously traced circuit extending through the winding of relay 627 is opened, relay 628, however, remaining energized over its winding, the back contact of magnet 534, to ground at the front contact of relay 628, thereby maintaining the magnet winding 534 energized, over its back contact and the front contact of relay 628 until magnet 534 fully energizes, whereupon relay 628 releases and magnet 534 advances the brushes of steering switch 500 into contact with the second position terminals of their respective arcs. The operator then proceeds to depress the #9 key 215 to register the hundreds digit 9. At its left contact key 215 establishes a circuit extending from ground, through the right winding of hundreds register relay 713, conductor 543, brush 532 and the second position terminal of steering switch 500, conductor 338, inner left contact of relay 331, brush 308, conductor 226, the outer left back contact of relay 208, conductor 216, the left contact of key 215, conductor 213, the outer right back contact of relay 208, conductor 223, brush 305, the outer left contact of relay 331, conductor 336, brush 529 and its second position terminal, conductor 536, the right winding of hundreds register relay 707, conductor 704, to battery, through the winding of relay 627. Relays 707 and 713 energize and lock over their left windings and inner left contacts to ground on conductor 701 and relay 627 energizes as before. Key 215 at its right contact establishes a second circuit from ground, over conductor 217, inner right back contact of relay 208, conductor 224, brush

306, next to outer left contact of relay 331, conductor 339, brush 530 and the second position terminal of steering switch 500, conductor 537, right winding of hundreds register relay 708, conductor 704, to battery through the winding of relay 627. Relay 627 in turn causes the energization of relay 628 and of magnet 534. Register relay 708 locks over its left winding and inner left contact to ground on conductor 701. Upon the release of key 215, relays 627 and 628 release in turn releasing magnet 534 to advance steering 500 into position 3.

In response to the depression of the #8 key 218 for registering the tens digit 8 a circuit is established from ground, through the right winding of the tens register relay 709, conductor 538, the third position terminal and brush 532 of steering switch 500, conductor 338, inner left contact of relay 331, brush 308, conductor 226, outer left back contact of relay 208, conductor 216, the left contact of key 218, conductor 213, the outer right back contact of relay 208, conductor 223, brush 305, the outer left contact of relay 331, conductor 336, brush 529, and its third position terminal, conductor 544, the right winding of register relay 717, conductor 704, to battery, through the winding of relay 627. Relays 627, 717 and 709 energize, relays 717 and 709 locking over their left windings and inner left front contacts to ground on conductor 701. A second circuit is established from ground, over the right contact to key 218, conductor 214, inner left back contact of relay 208, conductor 225, brush 307, next to inner left front contact of relay 331, conductor 337, brush 531 and the third position terminal of steering switch 500, conductor 539, right winding of register relay 710, conductor 704 to battery through the winding of relay 627. Relays 710 and 627 energize, relay 710 locking over its left winding and inner left front contact to ground on conductor 701 and relay 627 closing circuits for relay 628 and magnet 534 preparatory to advancing steering switch 500 into position 4. Upon the release of key 218 the circuit of relay 627 is opened in turn releasing magnet 534 to advance the steering switch.

In response to the depression of the #1 units key 219 ground is connected over conductor 214, the inner left back contact of relay 208, conductor 225, brush 307, the next to inner contact of relay 331, conductor 337, brush 531 and the fourth position terminal of steering switch 500, conductor 540, right winding of units register relay 711, conductor 704 to battery, through the winding of relay 627. Relays 711 and 627 energize, relay 627 closing the circuits of relay 628 and magnet 534 preparatory to advancing steering switch 500 out of position 4 and relay 711 locking over its left winding and inner left contact to ground on conductor 701. Upon the re-

lease of key 219 the steering switch advances into position 5. The numerical registers of the sender have now been set.

It will be recalled that the fundamental circuit between the sender and the incoming selector 123 was established with the steering switch 550 in position 8 and that the further advance of said steering switch awaited the registration of the hundreds digit of the wanted line number. Upon the registration of such digit the steering switch 500 advances into position 3 whereupon a circuit is established from ground at brush 549 of steering switch 500, conductor 522 to battery, through the winding of relay 635. Relay 635 upon energizing locks to ground on conductor 509, over its right contact, and at its outer left contact establishes a circuit for magnet 512, extending from battery, through the winding and contact of magnet 512, conductor 544, outer left contact of relay 635, conductor 636, the eighth position terminal and brush 520 of steering switch 550, conductor 521 to ground at the left back contact of relay 617. Steering switch 550 thereupon advances into position 9 and thence directly into position 10, over a circuit extending from battery, through the winding and contacts of magnet 512, the ninth position terminal and brush 520 of said steering switch, conductor 521, to ground at the left back contact of relay 617. In position 10, ground on brush 520 is extended through the winding of relay 552 to battery, said relay locking directly to ground on conductor 509, over its left contact and at its outer right contact, establishing a circuit for transfer relay 422, extending from battery, through the winding of relay 422, conductor 432, brush 330, the outer left contact of relay 341, conductor 349, to ground at the outer right contact of relay 552. At its inner right front contact relay 552 closes a circuit from ground, over strapped terminals 5 to 8 inclusive and brush 554 of steering switch 500, to battery, through the contacts and winding of magnet 534, for advancing the steering switch 500 into position 9 if at the time the registration of the entire numerical designation of the wanted line number has been completed. As steering switch 500 passes into position 9 a shunt around the winding of relay 635 is closed, over conductor 636, and the ninth position terminal and brush 549 to ground whereupon relay 635 releases.

Polarized relay 624 which operates only when a trunk terminating in the upper banks of the selectors has been seized, upon operating over the fundamental circuit previously traced, closes a circuit from ground at its contact, over conductor 515, brush 514 and the ninth position terminal of steering switch 550, conductor 528 to battery, through the winding of relay 625. Relay 625 operates in this circuit and locks over its inner

right contact to ground on conductor 509. Relay 625 also at its outer right contact establishes a circuit for relay 440 of the tens trunk number indicating register which may be traced from ground at the outer right contact of relay 625, over conductor 855, the outer right front contact of relay 607, conductor 511, the next to inner left contact of relay 341, brush 328, conductor 234, the lower contact of relay 422, conductor 433 to battery through the upper winding of register relay 440. Register relay 440 thereupon locks through its lower winding and innermost lower contact to ground on conductor 431.

#### *Trunk number indication*

Circuits are also established at this time for lighting the lamps of the trunk number indicator to indicate to the operator the number of the trunk selected. It has been assumed that relays 416 and 440 of the tens trunk number register and relays 423, 424 and 426 of the units trunk number register have been operated. With transfer relay 422 operated a circuit may now be traced for the #0 hundreds lamp 434, extending from battery, through the lamp 434, the uppermost front contact of relay 422, conductor 232, brush 325, the outer right contact of relay 341, conductor 508, the left front contact of relay 504, conductor 823, the right back contact of relay 826, conductor 852, to ground at the outer right front contact of relay 552. A circuit is also established for the #3 tens lamp 436 extending from ground at the intermediate lower front contact of relay 422, conductor 435, the upper front contact of register relay 416, the lowermost upper back contact of register relay 415, intermediate upper back contact of register relay 414, the intermediate upper back contact of register relay 413, the intermediate upper front contact of relay 440 to battery through lamp 436, and a circuit for the #9 units lamp 439 extending from ground on conductor 435, the upper front contact of units register relay 426, the inner upper back contact of register relay 425, the intermediate upper front contact of register relay 424, the lowermost upper front contact of register relay 423 to battery through the lamp 439. The lighted lamps now indicate the number 039. The operator noting the illumination of the trunk number indicating lamps may at her leisure plug the cord plug 118 into the jack 119 of the indicated trunk.

#### *Incoming brush selection*

It will be recalled that the fundamental circuit has been established and that relay 602 has been energized thereover in series with the control relay of the incoming selector 123. With the steering switch 550 in position 10, a circuit is closed for relay 805 extending from battery through the winding

of relay 805 over conductor 501, the 10th position terminal and brush 503 of steering switch 550 to ground on conductor 502. A circuit is now closed for magnet 512 of steering switch 550 extending over conductor 513, the next to outer contact of relay 805, the back contact of counting relay 802, conductor 815 to ground at the outer left front contact of relay 622 preparatory to advancing the steering switch into position 11. With the steering switch in position 10, relay 602 now closes a counting relay control circuit which may be traced from ground at the front contact of relay 602, the left back contact of relay 605, conductor 606, brush 516 and the tenth position terminal of steering switch 550, conductor 541, the right front contact of thousands register relay 703, the inner right back contact of register relay 712, the outer left front contact of register relay 705, lead 813, the back contact of counting relay 814 to battery through the winding of counting relay 832. Relay 832 energizes and locks through the winding of relay 814, over its own front contact to ground on conductor 806, but relay 814 does not energize until the commutator of the incoming selector places a shunting ground around the winding of relay 602, as soon as the incoming selector reaches its first brush selection position. This selector switch action is well known in the art and it is thought need not be fully described herein. When such shunting ground is applied relay 602 deenergizes, removing ground from lead 813, whereupon relay 814 energizes extending the lead 813 over its front contact, the back contact of counting relay 816, conductor 817, brush 518 and its tenth position terminal, conductor 519, the back contact of relay 807, to battery, through the winding of counting relay 818. Upon the further advance of the incoming selector shaft and the removal of the shunt around the winding of relay 602 by the commutator of the selector, relay 602 again energizes, completing the circuit of relay 818, which energizes and locks through the windings of relays 802 and 810 in parallel over the front contact of relay 818 to ground on conductor 806. Upon the next deenergization of relay 602 relays 802 and 810 operate in this locking circuit. Relay 810 upon energizing opens the fundamental circuit arresting the further movement of the incoming selector and advancing the sequence switch thereof into position for operating the brush tripping magnet. Relay 802 upon energizing opens the circuit of magnet 512 to advance steering switch 550 into position 11 and thereby releasing relay 805 to remove ground from conductor 806, to thereby release all operated counting relays. A circuit is now closed for relay 601 extending from battery, winding of relay 601, outer left front contact of relay 600, front contact of relay 802, conductor

815, to ground at the outer left contact of relay 622 which is effective to hold relay 601 energized to in turn hold the fundamental circuit open until relay 805 has caused the release of the counting relays. As soon as the steering switch advances into position 11 relay 601 is maintained energized from battery, through its winding, conductor 630, the eleventh position terminal and brush 503 of steering switch 550, to ground at the intermediate right contact of relay 621.

Relay 601 upon energizing now closes a circuit for reversing relay 809, extending from battery, winding of relay 809, conductor 848, left contact of relay 625 to ground at the front contact of relay 601, relay 809 upon energizing locking over its left contact directly to ground on conductor 509, and at its right contacts reversing the conductors of the fundamental circuit with respect to the winding of polarized relay 624. In position 11 a circuit is established for advancing the steering switch 550 into position 12 extending from battery through the winding and contacts of magnet 512, the 11th position terminal and brush 520 of the switch, conductor 521 to ground at the left contact of relay 617. The circuit of relay 601 is now opened and this relay deenergizes again establishing the fundamental circuit, extending to the incoming selector 123, whereupon relay 602 and the control relay of the selector energize, the control relay of the selector preparing the selector circuit for brush tripping and incoming group selection, and relay 602 establishing a circuit for controlling the counting relays of the sender. The polarized relay 624 is at this time not energized since relay 809 has now reversed the connection of trunk conductors 908 and 910 with respect to the winding of relay 624. With the steering switch 550 in position 12 a circuit as previously traced is established for relay 805 for supplying locking ground to the counting relays.

#### *Incoming group selection*

With relay 602 energized a circuit is now closed from ground at the front contact of relay 602, over the outer left back contact of relay 605, conductor 606, brush 516, and its twelfth position terminal, conductor 542, the outer right back contact of the thousands register relay 712, the lower front contact of relay 706, the outer left front contact of hundreds register relay 713, lead 849, the back contact of counting relay 850 to battery through the winding of counting relay 830. Relay 830 energizes and locks through the winding of relay 850 and over its own front contact to ground on conductor 806, but relay 850 being shunted over the contact of relay 602 does not operate. At the incoming selector the brush shaft is started upon the closure of the fundamental circuit to trip the

selected set of brushes and to make the group selection, the selector commutator intermittently shunting the sender pulsing relay 602 as the tripped set of brushes approaches each group selection position. Upon the first shunting of relay 602 it deenergizes permitting the operation of relay 850, which thereupon extends the lead 849, over its front contact and the back contact of counting relay 851 to battery, through the winding of counting relay 831 upon the next energization of relay 602. In the manner previously described the pairs of counting relays are successively operated until relays 818, 810 and 802 operate at which time the incoming selector shaft will have advanced in such a manner as to position the second set of brushes thereof upon the lowermost set of terminals in the fourth group to which said brush set has access. Relay 810 upon operating opens the fundamental circuit thereby arresting the advance of the incoming selector and causing circuit changes thereat to start the incoming selector hunting for an idle final selector trunk. The incoming selector has now selected an idle final selector having access to the 500 lines 3500 to 3999 inclusive. Relay 802 upon energizing opens the circuit of magnet 512 which deenergizes and advances steering switch 550 into position 13. Upon leaving position 12 relay 805 releases in turn unlocking all operated counting relays. In the manner previously described relay 601 is operated over the front contact of relay 802 until relay 802 releases following the release of relay 805 and is held operated over the thirteenth position terminal and brush 503 of steering switch 550 until it leaves position 13. In position 13 the previously traced circuit over brush 520 is closed to advance steering switch 550 into position 14 thereupon reoperating relay 805, releasing relay 601 and reestablishing the fundamental circuit.

#### *Final brush selection*

With the fundamental circuit again established pulsing relay 602 and the control relay of the final selector are operated, the control relay of the final selector preparing the circuits thereof for brush selection and the pulsing relay 602 closing a counting relay control circuit extending from ground at the front contact of relay 602, thence as traced to brush 516 and its fourteenth position terminal, conductor 545, the back contact of hundreds register relay 714, the outer front contact of hundreds register relay 708, the outer front contact of hundreds register relay 707, lead 523, the back contact of counting relay 821 to battery through the winding of counting relay 829. Relay 829 energizes and locks through the winding of relay 821 and its own front contact to ground on conductor 806, but relay 821 being shunted at

the front contact of relay 602 does not energize. As the brush shaft of the final selector advances in its brush selection movement the commutator thereof intermittently shunts the sender pulsing relay 602. Upon the first shunting of relay 602 such relay deenergizes permitting counting relay 821 to operate to extend the operating lead 523 over its front contact and the back contact of counting relay 850 to battery through the winding of relay 830. In the well known manner in response to the advance of the final selector shaft pairs of counting relays are successively operated until relays 818, 810 and 802 operate at which time the selector switch shaft will have advanced to a position to trip the fifth set of brushes having access to lines 3900 to 3999 inclusive. Relay 810 upon operating opens the fundamental circuit thereby arresting the advance of the final selector and causing circuit changes thereat to prepare for tripping the selected set of brushes. Relay 802 upon energizing opens the circuit of magnet 512 which thereupon advances the steering switch 550 into position 15 provided that the numerical registration is completed and steering switch 500 has advanced out of position 4 into position 9. If it has not so advanced relay 635 will still be locked and a holding circuit for magnet 512 will exist, through its winding, over conductor 513, the inner left contact of relay 635, conductor 637, the fourteenth terminal and brush 520 of steering switch 550, conductor 521, to ground at the left back contact of relay 617. Assuming that the registration is completed, however, relay 635 is deenergized and magnet 512 is permitted to deenergize advancing steering switch 550 into position 15. Upon leaving position 14 relay 805 releases in turn unlocking all operated counting relays. In the manner previously described relay 601 is operated over the front contact of relay 802, until relay 802 releases, following the release of relay 805 and is held operated over the fifteenth position terminal and brush 503 of steering switch 550 until it leaves position 15. In position 15 the previously traced circuit over brush 520 is closed to advance the steering switch 550 into position 16 thereupon reoperating relay 805, releasing relay 601, and reestablishing the fundamental circuit.

#### *Final tens selection*

With the fundamental circuit again established pulsing relay 602 and the control relay of the final selector are operated, the control relay of the final selector starting the final selector in its tens selection movement, tripping the selected set of brushes. The pulsing relay 602 now closes a counting relay control circuit for controlling the tens selection movement of the final selector extending

from ground at the front contact of relay 602, thence as traced to brush 516 and its sixteenth position terminal, conductor 546, the outer front contact of tens register relay 710, the outer left front contact of tens register relay 717, counting relay lead 849, the back contact of counting relay 850 to battery through the winding of relay 830. Relay 830 energizes and locks through the winding of relay 850 and its own front contact to ground on conductor 806, but relay 850 does not energize since it is at the time shunted over the front contact of pulsing relay 602. As the brush shaft of the final selector advances in its brush selection movement the commutator thereof intermittently shunts the sender pulsing relay 602. Upon the first shunting impulse relay 602 deenergizes permitting counting relay 850 to operate to extend the operating lead 849 over the front contact of relay 850, the back contact of relay 851 to the counting relay 831. In the well known manner in response to the advance of the final selector shaft, pairs of counting relays are successively operated until relays 814 and 832 operate when the lead 849 becomes extended over the front contact of relay 814, the back contact of relay 816, conductor 817, brush 519 and the sixteenth position terminal of steering switch 550, conductor 547, the right front contact of tens register relay 709 which always operates when the tens digit registered is greater than four, conductor 527 to battery, through the winding of counting relay 833. The remaining counting relays are then successively operated as the final selector advances in its tens selection movement until relays 818, 810 and 802 operate at which time the tripped brush set of the final selector will be positioned beneath the first terminal of the eighth tens group in which lines 3980 to 3989 terminate.

Relay 810 upon operating opens the fundamental circuit thereby arresting the advance of the final selector. Relay 802 upon energizing opens the circuit of magnet 512, which deenergizes and advances the steering switch 550 into position 17. Upon leaving position 16 relay 805 releases in turn unlocking all operated counting relays. In the manner previously described relay 601 is operated following the energization of relay 802 and is held operated over the seventeenth position terminal and brush 503 of steering switch 550 until it leaves position 17. In position 17 the previously traced circuit over brush 520 is closed to advance the steering switch 550 into position 18, thereby reoperating relay 805, releasing relay 601 and reestablishing the fundamental circuit.

#### *Final units selection*

With the fundamental circuit again established pulsing relay 602 and the control

relay of the final selector are operated, the control relay of the final selector starting the final selector in its units selection movement. Pulsing relay 602 closes a counting relay control circuit for controlling the units selection movement of the final selector, extending from ground at the front contact of relay 602, thence as traced to brush 516 and its eighteenth position terminal, conductor 548, the outer front contact of units register relay 711, the left back contact of the units register relay 716, counting relay lead 813, the back contact of counting relay 814 to battery, through the winding of relay 832. Relay 832 energizes and locks through the winding of relay 814 and its own front contact to ground on conductor 806, but relay 814 does not operate as its winding is shunted over the front contact of pulsing relay 602. As the brush shaft of the final selector advances the commutator thereof intermittently shunts the stepping relay 602 thereby causing the operation of successive counting relays until relays 818, 810 and 802 energize at which time the tripped set of brushes will have been positioned upon the terminal of the wanted line 125. Relay 802 upon energizing opens the circuit of magnet 512 which thereupon advances steering switch 550 into position 19. Relay 810 opens the fundamental circuit thereby arresting the further advance of the final selector. Upon leaving position 18 steering switch 550 opens the circuit of relay 805, which deenergizes in turn releasing all operated counting relays. In the manner previously described relay 601 is operated, over the front contact of relay 802 until relay 802 releases, following the release of relay 805 and is held operated over the nineteenth position terminal and brush 503 of the steering switch until it leaves position 19.

In position 19 a circuit is established for advancing steering switch 500 out of position 9 into normal position extending from battery, through the winding and contacts of magnet 534, the nineteenth position terminal and brush 520 of steering switch 550, conductor 521 to ground at the left back contact of relay 617. Upon reaching position 10 steering switch 500 establishes a circuit for magnet 512 extending from battery, through the winding of magnet 512, conductor 513, the tenth position terminal and brush 549 of steering switch 500 to ground preparatory to advancing steering switch 550 into position 20. This circuit is maintained until the steering switch 500 reaches normal position when it is opened and steering switch 550 is permitted to advance into position 20, opening the driving circuit of magnet 534.

#### *Incoming selector advances for ringing called line*

With steering switch 550 in position 20 the

previously traced circuit of relay 805 is established and relay 805 energizes establishing the previously traced circuit for magnet 512, preparatory to advancing steering switch 550 into position 21. Upon leaving position 19 steering switch 550 opens the circuit of relay 601 which thereupon releases again closing the fundamental circuit. At the final selector following the completion of units selection the circuits of the final selector are cut through for talking and the incoming selector sequence switch is advanced in the well known manner to again complete the fundamental circuit through relay 602 and the control relay of the incoming selector, relay 602 at this time establishing a circuit for counting relay 818, extending from ground at the front contact of relay 602, thence as traced to brush 516, counting relay operating lead 853, the back contact of counting relay 816, conductor 817, brush 518, the twentieth position terminal of steering switch 550, conductor 519, the back contact of relay 807 to battery, through the winding of relay 818. Relay 818 operates and locks through the windings of relays 802 and 810 in parallel but the latter relays being shunted over the contact of relay 602 do not operate until the sequence switch of the incoming selector advances under the control of the control relay thereof to open the fundamental circuit and release relay 602. When the sequence switch of the incoming selector advances and relay 602 deenergizes relays 802 and 810 operate. Relay 810 upon operating opens the fundamental circuit and relay 802 upon operating opens the circuit of magnet 512 to advance the steering switch 550 into position 21. The circuit of relay 805 is now opened to release relays 818, 810 and 802. Upon the operation of relay 802 relay 601 again operates but releases as soon as relay 802 releases to again establish the fundamental circuit. Upon the reestablishment of the fundamental circuit at the incoming selector the control relay of the incoming selector and relays 602 and 624 of the sender operate. Relay 624 operates at this time because the fundamental circuit has been reversed at the incoming selector in the well known manner. The testing of the wanted line 125 by the final selector and the application of ringing current thereto, if such line is found to be idle, proceeds in the well known manner after which the talking circuit from the wanted line to the trunk conductors 126 and 127 is established.

Upon the energization of the polarized relay 624 a circuit is established from ground at its contact, over conductor 515, the twenty-first position terminal and brush 514 of steering switch 550 to conductor 555 preparatory to releasing the sender. The release, however, does not proceed until after the operator has plugged into the trunk jack 119.

#### *Operator completes connection by plugging into indicated trunk jack*

When the operator plugs into such a jack in accordance with the trunk number 039 indicated to her on her trunk number indicating lamps, a circuit is closed from battery, through the lamp 114, resistance 116, sleeves of plug 118 and jack 119 to ground through the left winding of sleeve relay 120. Relay 120 energizes, at its inner right front contact connects the right non-inductive winding of relay 120 and the left non-inductive winding of relay 121 in parallel with the right winding of relay 121, over the circuit previously traced to ground through the winding of relay 800. Relay 800 now receives sufficient current to energize and at its right contact connects ground, over conductor 857, the outer right front contact of relay 504, conductor 510, the inner right contact of relay 341, brush 326, conductor 233, the inner upper front contact of relay 422, conductor 438, to battery through the winding of release relay 205 at the operator's position equipment.

#### *Release of operator's equipment*

Relay 205 upon energizing opens at its inner left contact the holding circuit of register relays 201 and 202, opens at its outer left contact the holding circuit of relays 207 and 340, at its right contact opens the holding circuits of relays 401 and 406 and at its outer right contact opens the holding circuit of all operated trunk number register relays of Fig. 4. Relay 340 upon deenergizing at its left contact, opens the circuits of relays 331 and 341 which thereupon release. Relay 341 upon releasing now opens the previously traced circuit of relay 422 which releases in turn disconnecting operating ground from the lamps of the trunk number indicator which now become extinguished. Relay 331 upon deenergizing now closes a circuit extending from ground at its outer right back contact, over the back contact of relay 311, thence to conductor 350 and from conductor 350 in parallel, over off-normal contact 303 and release magnet 302 to battery, and through off-normal contact 323 and release magnet 322 to battery. These release magnets upon energizing now release the position finder switches of Fig. 3 to normal. As soon as the finders reach normal the off-normal contacts 303 and 323 open the circuits of the release magnets and off-normal contact 324 opens the locking circuit of relay 312 which thereupon releases.

Upon its release relay 340 completes at its right back contact the circuit previously traced to conductor 555, over conductor 351 to battery, on conductor 626. This circuit is in shunt of the winding of relay 700 which

thereupon deenergizes in turn releasing relay 621. The release of relay 621 removes ground from conductor 501, whereupon operated relays 607, 603, 615, 504, 610, 524, 526, 600, 552, 622, 624, 625, 826 and 809 release. A circuit is now closed for advancing steering switch 550 out of position 21 into normal position, extending from battery, through the winding and contacts of magnet 512, brush 553 and the strapped terminals of its arc, conductor 556, to ground at the inner right back contact of relay 621. Relay 700 upon deenergizing opens at its uppermost contact the holding circuits of the numerical register relays of Fig. 7 and at its innermost lower contact opens the circuit of relay 915 of the first selector.

Relay 915 upon deenergizing now closes the circuit of release magnet 917 which energizes and restores the first selector of Fig. 9 to normal. As soon as this selector reaches normal the circuit of magnet 917 is opened at off-normal contacts 916. At its front contact relay 915 also unlocks all operated relays of the first selector. At its intermediate lower contact relay 700 also removes ground from conductor 921, thereby releasing relay 1015 of the second selector of Fig. 10 which thereupon releases unlocking all operated relays of such selector and closing at its back contact the circuit of release magnet 1017. Magnet 1017 energizes and releases the second selector, its own circuit being opened at off-normal contacts 1016 as soon as the selector is completely restored.

Upon the release of relay 621 ground is removed from conductor 801 releasing relays 800 and 121. Relay 121 upon releasing now connects the trunk conductors 126 and 127 to the tip and ring contacts of jack 119 and disconnects such conductors from the terminal banks of second selectors such as the one shown in Fig. 10. With relay 121 released and relay 120 energized ground potential is maintained on test conductor 1022, over the outer right front contact of relay 120 and the inner right back contact of relay 121 to mark the trunk as busy to second selectors and ground is removed at the outer right back contact of relay 120 from conductor 1019 to mark the trunk as busy in the group of twenty trunks to which it belongs. The lamp 114 which lighted when the operator plugged into jack 119 becomes extinguished in the well known manner when the called subscriber answers and relay 111 operates. All of the equipment which the operator has employed to select the trunk 126, 127 has now been restored. The talking connection between the calling subscriber of line 100 and the called subscriber of line 125 is restored upon the termination of the conversation in the well known manner and need not be described in detail herein.

#### *Incoming or final selector driven to overflow position*

If the incoming selector during group selection or the final selector during any of its selection movements goes to an overthrow position thereby reversing the fundamental circuit, with the steering switch 550 in positions 12, 14, 16 or 18 polarized relay 624 operates over the fundamental circuit closing a circuit for overflow relay 551 extending from ground at the contact of relay 624, conductor 515, brush 514 to battery through the winding of relay 551. Relay 551 upon energizing locks to ground on conductor 509, and at its right contact connects ground over conductor 857, the outer right front contact of relay 504, conductor 510, thence as previously traced to battery, through the winding of release relay 205 at the operator's position equipment. In the manner previously described all apparatus which the operator has employed to reach the trunk 126, 127 is restored. The operator may then proceed to reestablish the connection.

#### *Outgoing trunk reached directly from first selector*

In the foregoing discussion it has been assumed that both first and second selectors were necessary to reach an idle trunk extending to the desired office 122. It will now be assumed that the trunks of Fig. 1 terminate directly in the banks of the first selector of Fig. 9 and that in response to the registration of the first code letter on the office code relays of the sender the first selector has positioned its brush sets opposite the first level of its banks in which trunks extending to the office 122 terminate. By this time the steering switch 550 will have advanced to position 2. On all levels in which access to outgoing trunks may be directly made from the first selector, the shaft springs 930 are closed. Therefore when the first selector has been advanced to such a level, for example to the first level, a circuit is closed from battery, through the right winding of relay 820, conductor 931, shaft springs 930, conductor 932, the outer right contact of relay 603 to ground at the inner left back contact of relay 607. Relay 820 upon energizing, locks over its left winding to ground on conductor 509 and closes a circuit for advancing steering switch 550 out of position 2 into position 3. This circuit extends from battery, through the winding and contacts of magnet 512, brush 553 and the second position terminal of the steering switch, conductor 557, the right front contact of relay 820, conductor 721 to ground at the intermediate lower front contact of relay 700. The shaft contacts 930 also close a circuit for the release magnet 917 of the first selector, extending from battery, through the winding of magnet 917, off-normal contacts 916, shaft contacts 930, con-

ductor 932 to ground at the inner left back contact of relay 607. Magnet 917 energizes releasing the selector to normal, its own circuit being opened at the off-normal contacts 916 when the selector is completely restored.

With the selector in normal position and the steering switch 550 of the sender in position 3 the first selector is controlled again in a vertical movement in accordance with the second code letter of the office code in the same manner as previously described in connection with the operation of the second selector. From this point the call progresses in exactly the same manner as previously described except that the operations which the second selector previously performed are now performed by the first selector, the first selector stepping vertically and then in a rotary direction to select an idle trunk and in such movements controlling the trunk number indicator of Fig. 4 to indicate to the operator the number of the trunk which has been so selected.

What is claimed is:

1. In an automatic telephone exchange system, a plurality of operators' positions, a plurality of offices, a group of trunks outgoing to each of said offices and terminating therein in switching mechanism, a plurality of senders common to said operators' positions for operating said switching mechanism, a selector switch individual to each sender for associating an idle sender with a calling operator's position, a second selector switch operable in accordance with the selective operation of said first switch to extend additional control conductors from said sender to said calling position, and selector switches for associating a selected sender with an idle trunk in any desired ones of said trunk groups.

2. In an automatic telephone exchange system, a plurality of operators' positions, a plurality of offices, a group of trunks outgoing to each of said offices and terminating therein in switching mechanism, a plurality of senders common to said operators' positions for operating said switching mechanism, a selector switch individual to each sender for associating an idle sender with a calling operator's position, a second selector switch operable in unison with said first selector switch to extend additional control conductors from said sender to said calling position, and selector switches for associating a selected sender with an idle trunk in any desired ones of said trunk groups.

3. In an automatic telephone exchange system, a plurality of operators' positions, a plurality of offices, a group of trunks outgoing to each of said offices and terminating therein in switching mechanism, a plurality of senders common to said operators' positions for operating said switching mechanism, a step-by-step switch having vertical and rotary hunting movements individual to each sender

for associating an idle sender with a calling operator's position, a second selector switch of the same character as said first selector switch operable in unison therewith as to both of its hunting movements to extend additional control conductors from said sender to said calling position and selector switches for associating a selected sender with an idle trunk in any desired ones of said trunk groups.

4. In an automatic telephone exchange system, a plurality of mechanisms, a second mechanism, a selector switch individual to said second mechanism for associating it with any one of said first named mechanisms, a second selector switch also individual to said second mechanism, and means for operating said second selector switch in accordance with the selective operation of said first switch to extend additional control conductors from said second mechanism to the selected first mechanism.

5. In an automatic telephone exchange system, a plurality of mechanisms, a second mechanism, a selector switch individual to said second mechanism for associating it with any one of said first named mechanisms, a second selector switch also individual to said second mechanism, and means for operating said second selector switch in unison with said first selector switch to extend additional control conductors from said second mechanism to the selected first mechanism.

6. In an automatic telephone exchange system, a plurality of mechanisms, a second mechanism, a step-by-step selector switch having vertical and rotary hunting movements individual to said second mechanism for associating it with any one of said first named mechanisms, a second selector switch of the same character as said first selector switch, and means for operating said second selector switch in both of its selective movements in unison with the corresponding selective movements of said first selector switch to extend additional control conductors from said second mechanism to the selected first mechanism.

7. In an automatic telephone exchange system, a plurality of mechanisms, a second plurality of mechanisms, a selector switch individual to each of said second mechanisms for associating it with any one of said first named mechanisms, a second selector switch individual to each of said second mechanisms, means for operating said second selector switch in accordance with the selective operation of the corresponding first selector switch to extend additional control conductors from the second mechanism to which it is individual to the selected first mechanism and a chain start circuit for starting the pair of selector switches of an idle second mechanism to select a first mechanism.

8. In an automatic telephone exchange system, a plurality of first mechanisms ar-

5 ranged in groups, a second plurality of mechanisms, a pair of selector switches individual to each of said second mechanisms for associating it with any one of said first named mechanisms, means for operating said pairs of selector switches in unison, a start circuit extending from each group of said first mechanisms for starting the pair of selector switches normally assigned for serving such group if idle, and means for extending said start circuit for starting a pair of selector switches normally assigned for serving a different group of first mechanisms if the normally assigned pair of selector switches is busy.

10 9. In an automatic telephone exchange system, a plurality of mechanisms, a second mechanism, a selector switch individual to said second mechanism for associating it with any one of said first named mechanisms, a second selector switch also individual to said second mechanism for extending additional control conductors from said second mechanism to the first mechanism selected by said first selector switch, a stepping relay common to said switches, stepping magnets individual to said switches, and circuits for said relay controlled by said magnets.

15 10. In an automatic telephone exchange system, a plurality of mechanisms, a second mechanism, a selector switch individual to said second mechanism for associating it with any one of said first named mechanisms, a selector switch also individual to said second mechanism for extending additional control conductors from said second mechanism to the first mechanism selected by said first selector switch, a stepping relay common to said switches, stepping magnets individual to said switches, an operating circuit for said relay controlled over a back contact of one of said magnets, a holding circuit for said relay controlled over a back contact of the other of said magnets and operating circuits for said magnets controlled by said relay, whereby said relay and magnets reciprocally control each other to cause said switches to step in unison.

20 11. In an automatic telephone exchange system, a plurality of mechanisms, a second mechanism, a step-by-step selector switch having vertical and rotary hunting movements individual to said second mechanism for associating it with any one of said first named mechanisms, a second selector switch of the same character as said first selector switch also individual to said second mechanism for extending additional control conductors from said second mechanism to the first mechanism selected by said first selector switch, a stepping relay common to said switches, a vertical and a rotary stepping magnet individual to each of said switches, an operating circuit for said relay controlled over back contacts of the magnets of one

of said switches, a holding circuit for said relay controlled over back contacts of the magnets of said other switch, and operating circuits for all of said magnets controlled by said relay whereby said relay and magnets reciprocally control each other to cause said switches to step in unison as to both their vertical and rotary movements.

25 12. In an automatic telephone exchange system, a plurality of mechanisms, a second mechanism, a step-by-step selector switch having vertical and rotary hunting movements individual to said second mechanism for associating it with any one of said first named mechanisms, a second selector switch of the same character as said first selector switch also individual to said second mechanism for extending additional control conductors from said second mechanism to the first mechanism selected by said first selector switch, a stepping relay common to said switches, a vertical and a rotary magnet individual to each of said switches, an operating circuit for said relay controlled over back contacts of the magnets of one switch, a holding circuit for said relay controlled over back contacts of the magnets of said other switch, operating circuits for said vertical magnets controlled by said relay whereby said relay and vertical magnets reciprocally control each other to cause said switches to step vertically in unison, and a transfer relay for substituting said rotary magnets for said vertical magnets in said operating circuits, whereby said stepping relay and rotary magnets reciprocally control each other to cause said switches to rotate in unison.

30 13. In an automatic telephone exchange system, an operator's position, a plurality of offices, a group of trunks outgoing to each of said offices, office keys at said position corresponding to said plurality of offices, a train of selector switches, certain of said trunk groups terminating in the first switch of said train and others of said trunk groups terminating in the last switch of said train, and means controlled by said office keys for directing the first or all of said train of switches to associate said operator's position with an idle trunk in any desired ones of said trunk groups.

35 14. In an automatic telephone exchange system, an operator's position, a plurality of offices, a group of trunks outgoing to each of said offices, office keys at said position corresponding to said plurality of offices, a train of selector switches, certain of said trunk groups terminating in the first switch of said train and others of said trunk groups terminating in the last switch of said train, means controlled by said office keys for causing a plurality of selective operations of said train of switches to associate said operator's position with an idle trunk in any desired trunk group, and means effective if the de-

sired trunk group terminates in the first switch of said train to restore said first switch following the first selective operation thereof whereby it is then responsive to further control by said office keys to select an idle trunk in the desired trunk group.

15. In an automatic telephone exchange system an operator's position, a plurality of offices, a group of trunks outgoing to each of said offices, office keys at said position corresponding to said plurality of offices, an office code register at said position controlled by said keys for registering the office code digits of office designations, a train of selector switches, certain of said trunk groups terminating in the first switch of said train and other of said trunk groups terminating in the last switch of said train, means controlled by said register for successively directing the switches of said train to connect said position with any desired trunk group which terminates in the last switch of said train, means for restoring the first switch of said train following the first selective operation thereof if the first digit of the registered office code is indicative that the desired trunk group terminates in said first switch, and means for then reoperating said first switch in accordance with the remainder of said registered office code to select the desired trunk group.

In witness whereof, we hereunto subscribe our names this 28th day of September, 1928.

EDGAR H. CLARK.

WARREN W. CARPENTER.