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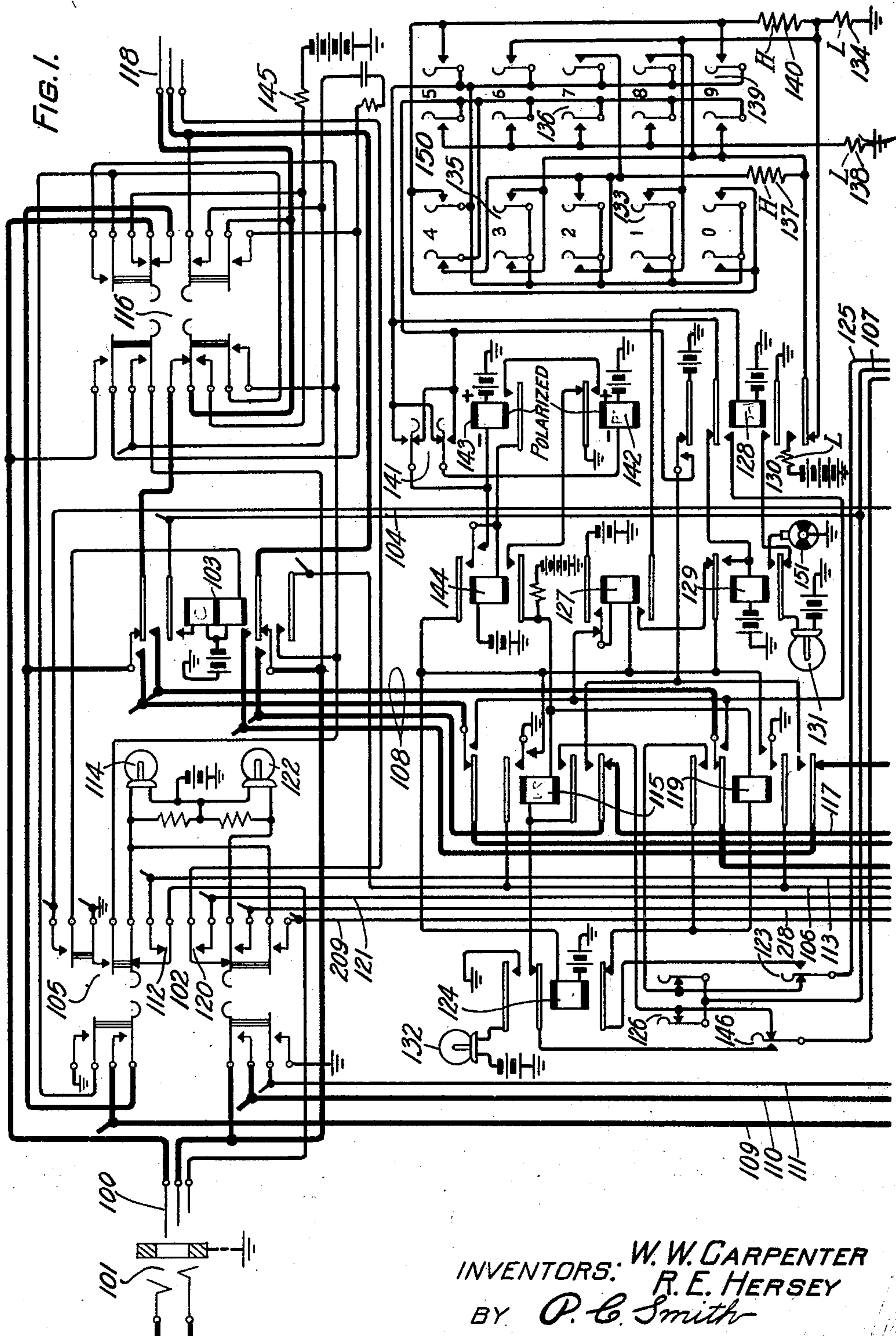
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1,780,906

AUTOMATIC TOLL SWITCHING TELEPHONE SYSTEM

Filed May 4, 1929

8 Sheets-Sheet 1



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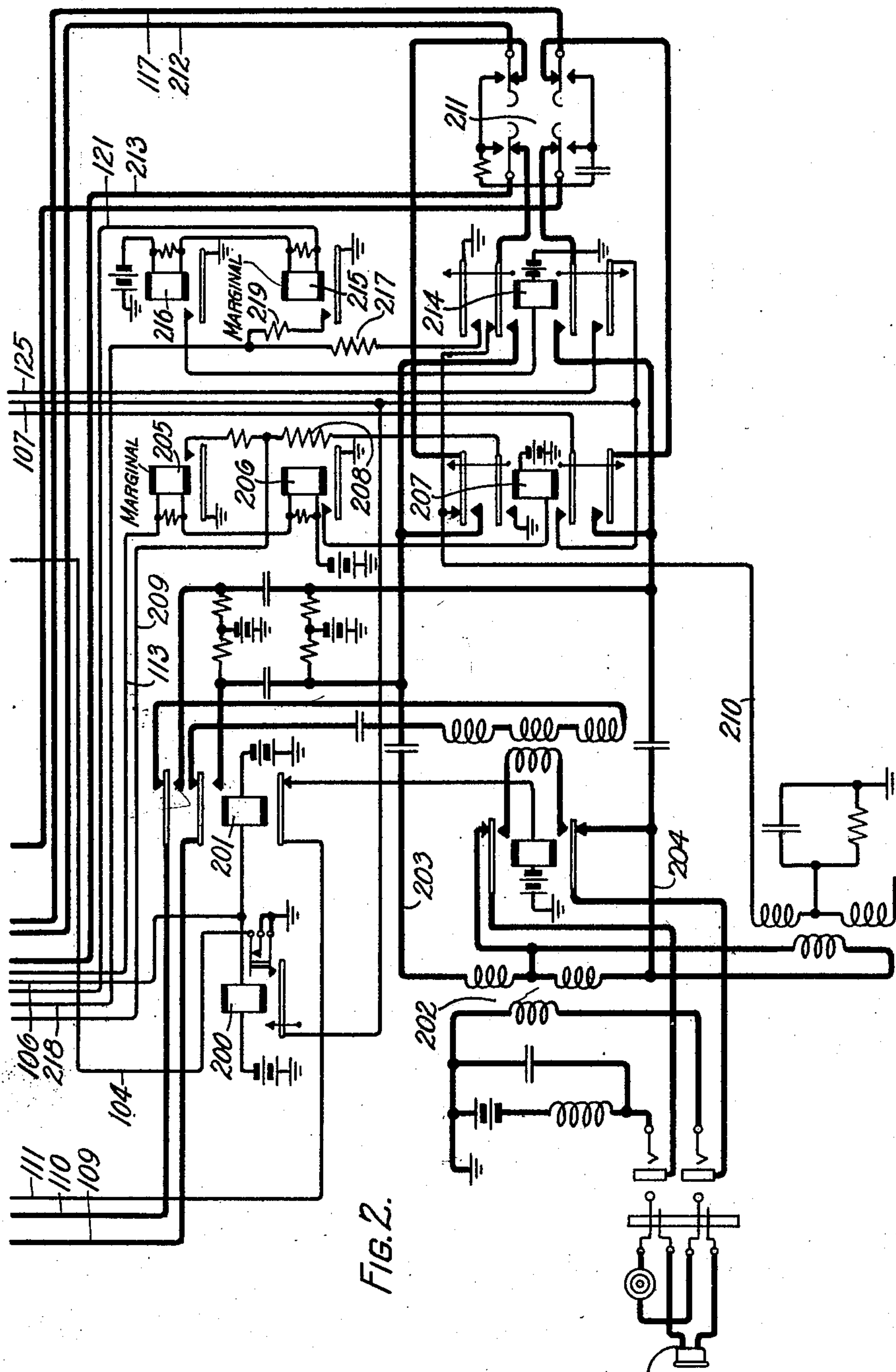
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8 Sheets-Sheet 2



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8 Sheets-Sheet 3

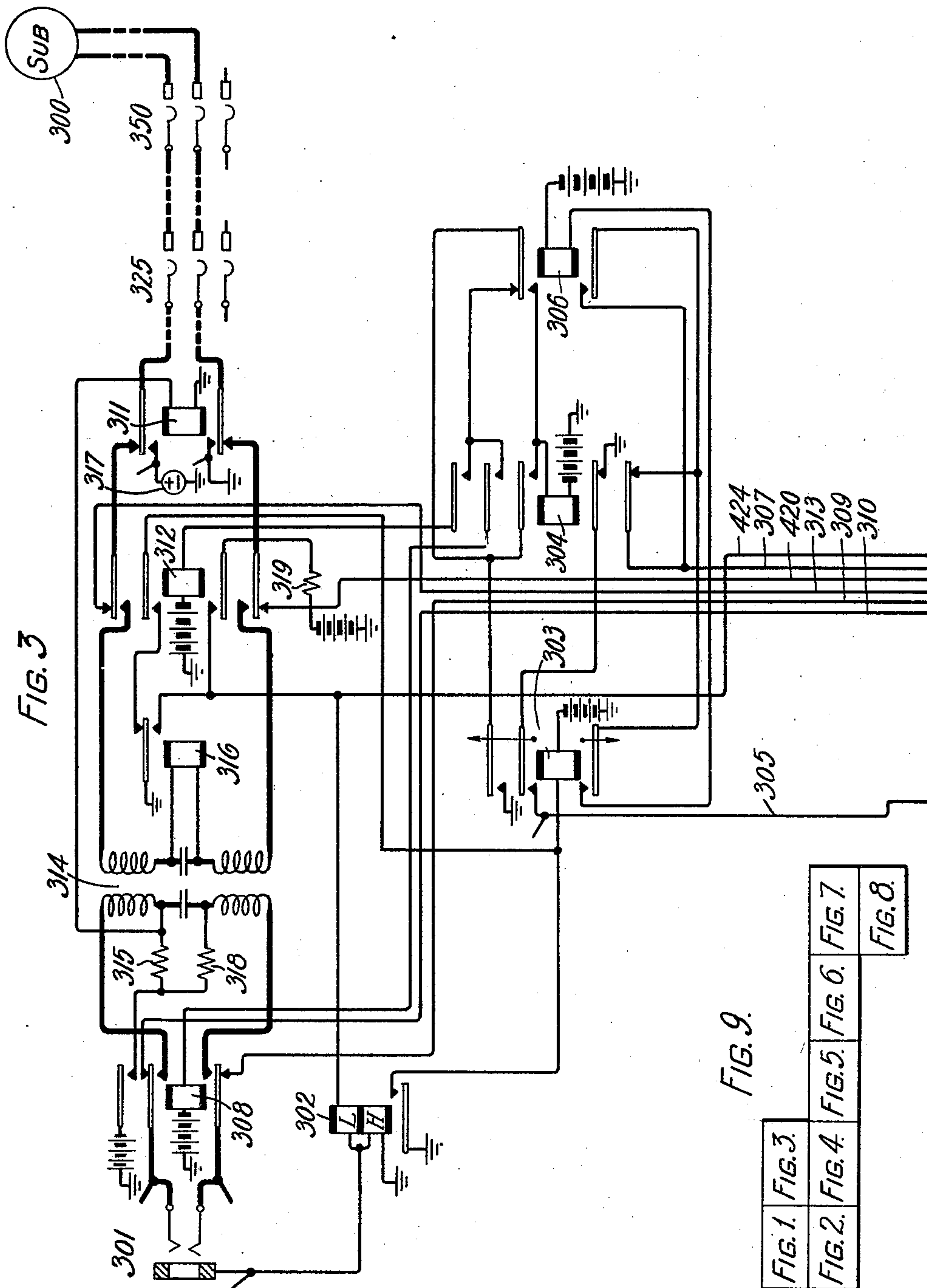


FIG. 9.

FIG. 1.	FIG. 3.	FIG. 5.	FIG. 6.	FIG. 7.	FIG. 8.
FIG. 2.	FIG. 4.	FIG. 5.	FIG. 6.	FIG. 7.	FIG. 8.

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8 Sheets-Sheet 4

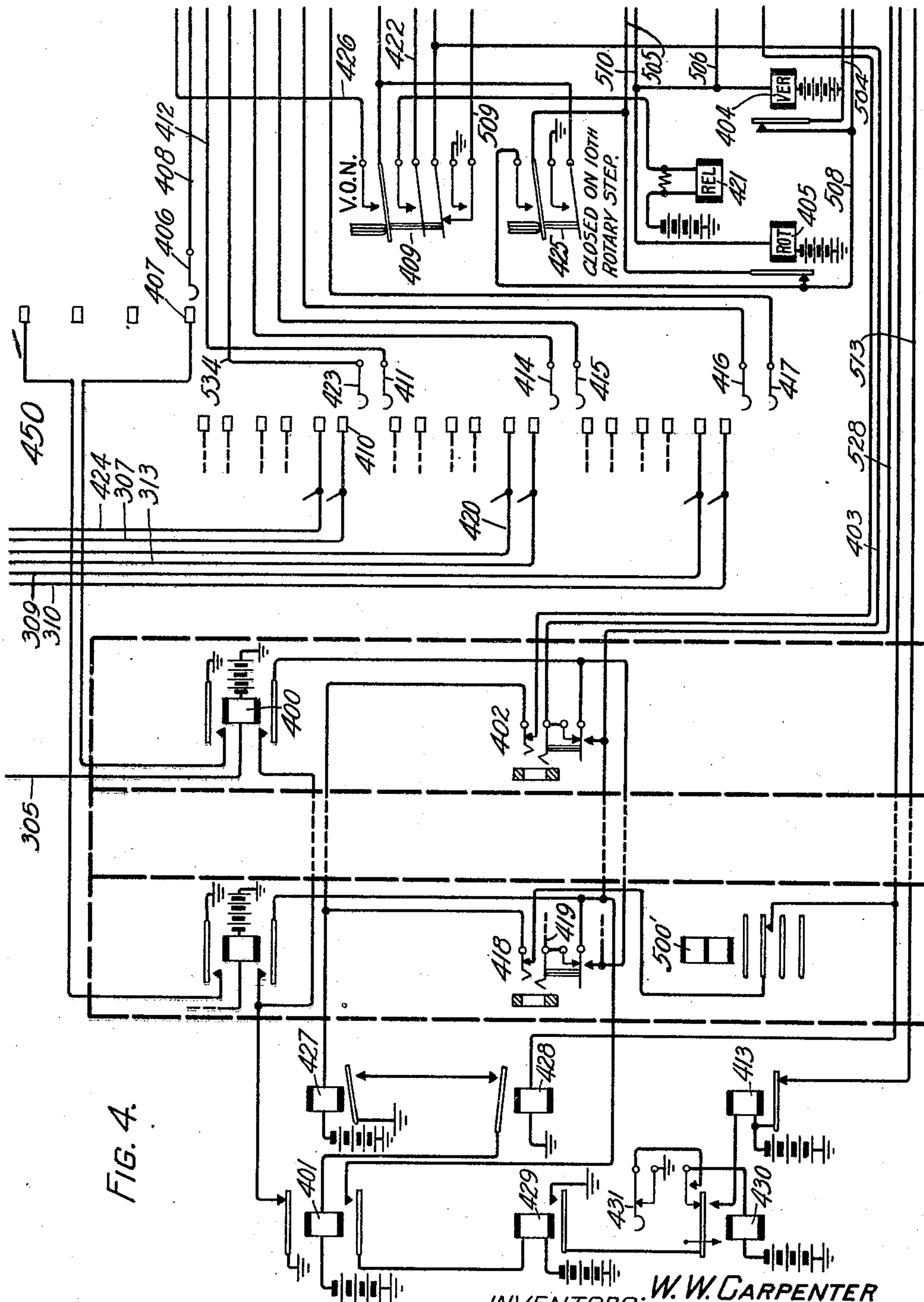


FIG. 4.

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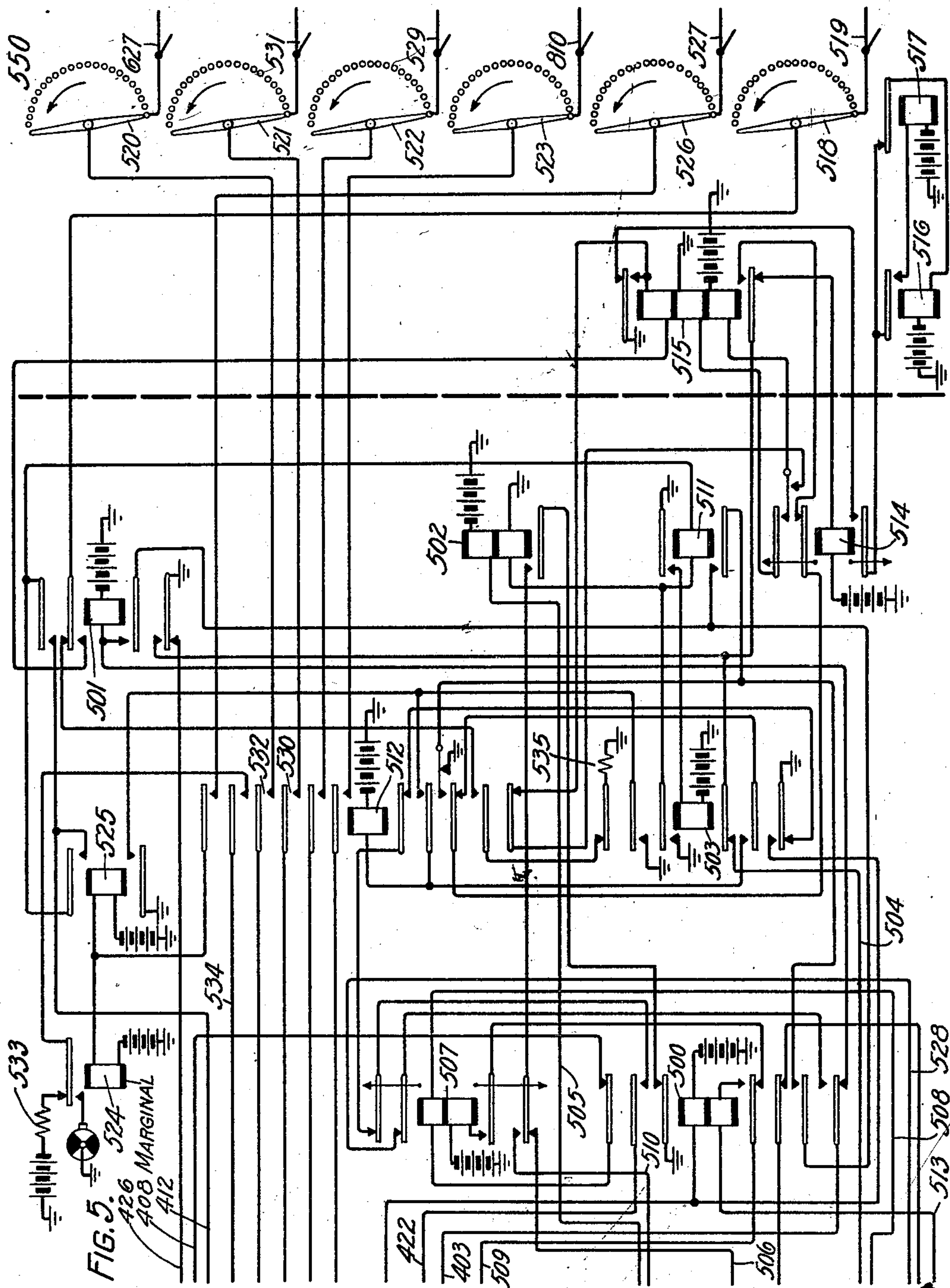
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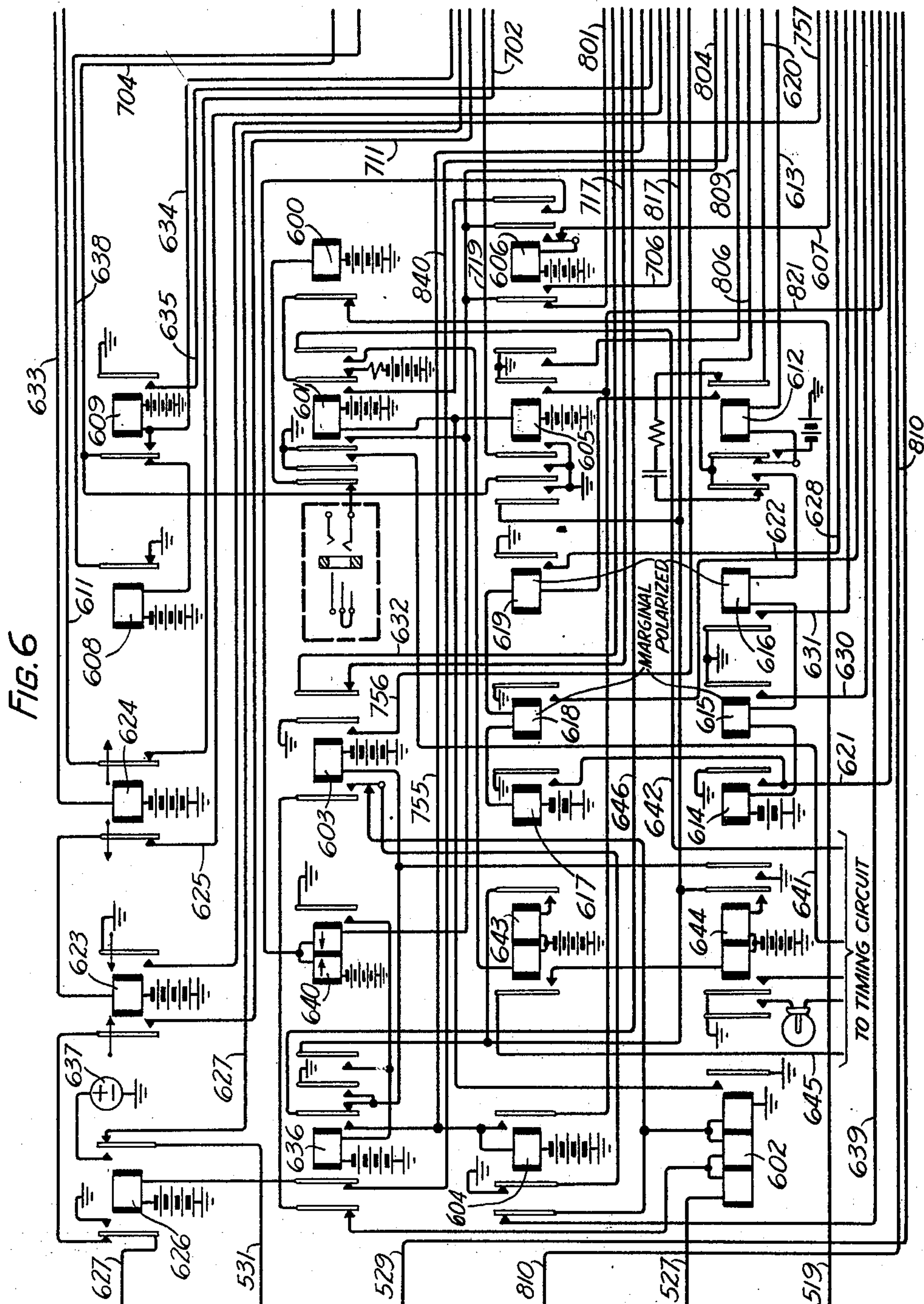
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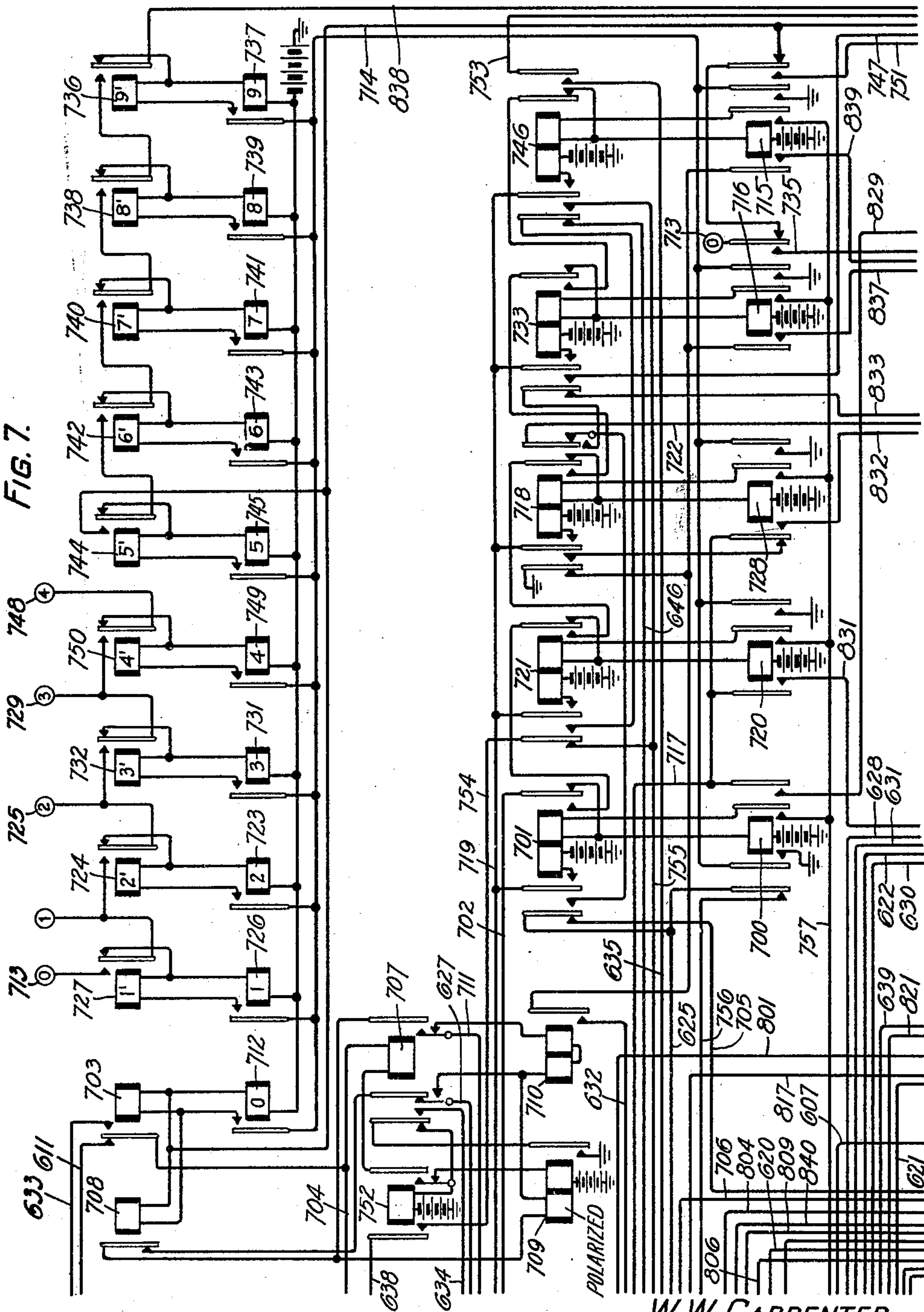
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FIG. 7.



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1,780,906

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Filed May 4, 1929

8 Sheets-Sheet 8

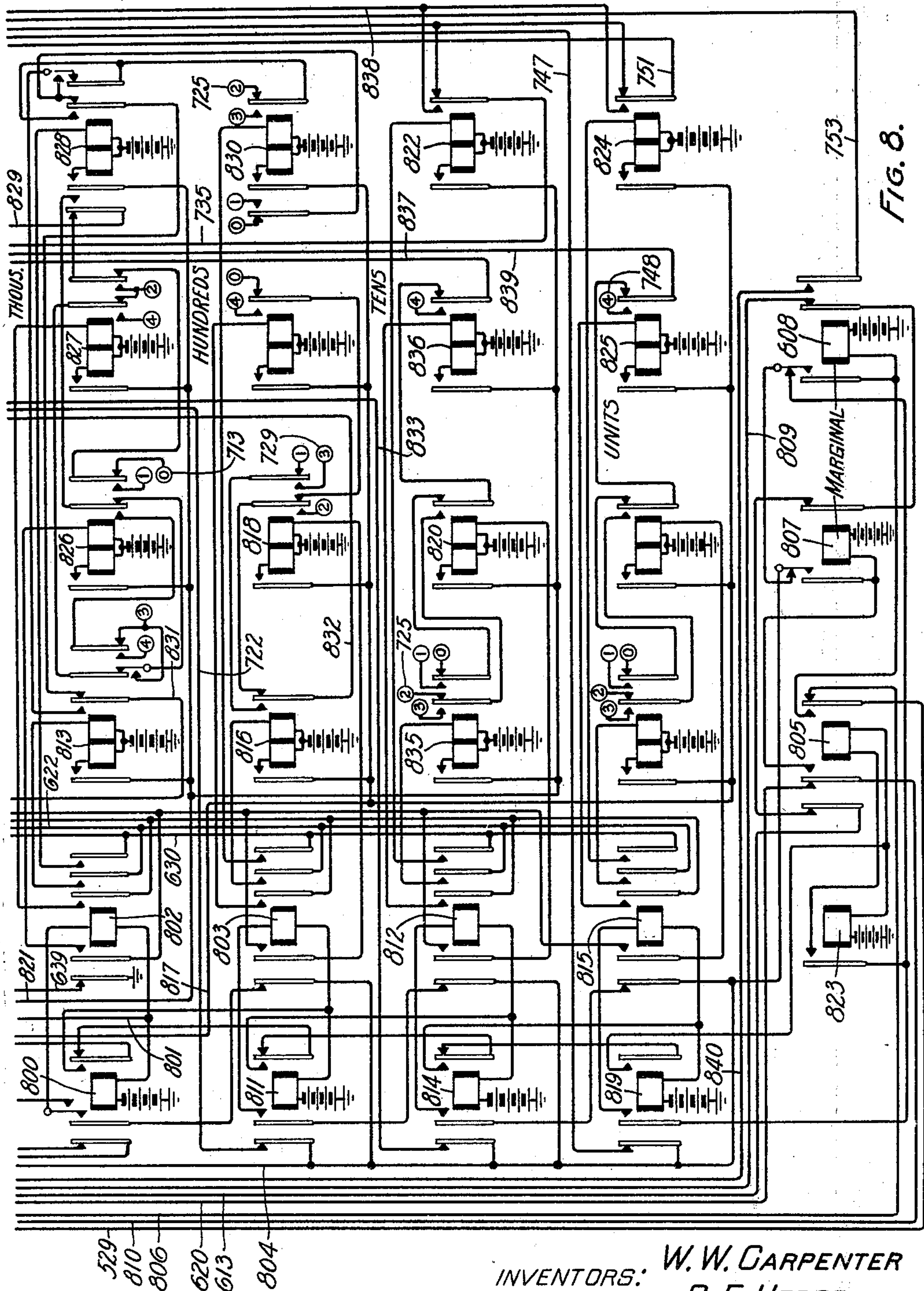


FIG. 8.

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UNITED STATES PATENT OFFICE

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AUTOMATIC TOLL-SWITCHING TELEPHONE SYSTEM

Application filed May 4, 1929. Serial No. 360,458.

This invention relates to a telephone exchange system, and more particularly to a system in which connections are established between subscribers' lines in different offices over toll trunks by automatic switching mechanism under the control of a toll operator in the originating office. The object of the invention is to economize in the amount of apparatus required for the toll operator to control and supervise the establishment of such connections and to simplify the circuits required for establishing and maintaining such connections.

In the establishment of connections to or from offices of a dial switching exchange area for which toll rates should be assessed for service, it is customary for a calling subscriber in such an office who desires to obtain a connection with another subscriber at a remote point to dial a number whereby connection is first obtained with a toll operator, who then proceeds to obtain the desired connection and to supervise the assessment of the required toll charge.

Several methods of establishing such toll connections have heretofore been proposed for use in connection with panel type dial switching systems. In accordance with one of these methods disclosed by way of example in the patent to Gooderham 1,506,743, granted September 2, 1924, the calling subscriber desiring an outward toll connection dials the machine switching "A" operator's position of the office in which the calling line terminates and transmits to her, his own number and the number of the desired subscriber. The "A" operator then proceeds by means of a sending equipment to establish a connection to a toll operator's position. The toll operator then makes out a toll ticket and over an order wire assigns for the use of a "B" cordless operator at the originating office a trunk line over which the toll connection may be completed and gives the cordless operator the necessary information for establishing a connection back to the calling line. This is accomplished by the cordless operator by means of a sender at her position and selector switches. As soon as this connection is established back, the connection

formerly established through the "A" operator's position to the toll operator's position is dismissed. The toll operator then proceeds to cause a connection to be established to the desired line, the final connection extending from the calling line through the selector switches set up by the "B" cordless operator over the trunk extending to the toll operator's position and thence by the toll line to the desired subscriber's line. Inward connections from distant toll points are completed according to this method over the toll operator's cord circuit and by means of the machine switching equipment of a toll cordless "B" operator at the dial switching office.

Another method which has been proposed for completing inward connections from a distant toll point is disclosed in the patent to A. C. Powell 1,577,076 granted March 16, 1926. According to this method an inward toll connection is handled by a toll operator in the terminating dial switching office, who receives instructions for terminating the connection over the toll line and utilizes so-called key indicator equipment at her position to either terminate the connection by dial switching apparatus if the desired line terminates in an office equipped with selector switching mechanism or by call indicator apparatus if the desired line terminates in a manual office. The key indicator apparatus comprises a plurality of operator's position equipments each including a key set, there being a position equipment individual to each toll operator's position, a plurality of register senders for either setting the call indicator apparatus or the dial switching apparatus of the terminating office and a plurality of link circuits each comprising a plurality of trunk selectors, a sender selector and a position finder.

In accordance with the present invention outward toll connections may be established from a dial switching office in either of two ways depending upon the extent of the exchange area. In a large exchange area the subscriber would dial a number to obtain connection with an "A" operator's position, which operator then passes the call to a re-

cording toll operator who makes out a ticket for the call and passes the information to a toll switching operator. The toll switching operator then builds up the toll connection to the desired toll point and obtains connection with the desired subscriber and then builds back a connection over the dial switching equipment of the originating office to the calling subscriber's line, the original connection from the calling line to the recording operator then being dismissed. In smaller exchange areas the call would be handled in a similar manner, except that the subscriber would dial such a number as to obtain a connection directly with the toll operator's position.

Calls incoming from a distant toll point are answered by the toll switching operator who then terminates the call by plugging directly into an idle trunk extending to the dial switching office in which the desired subscriber's line terminates, and then setting the dial switching apparatus of such office by means of the improved apparatus at her position associated with such trunks. The toll switching operator is thus enabled to serve toll connections to connect her position automatically with subscribers' lines in dial switching offices to complete outward calls or to connect her position with such subscribers' lines to terminate inward calls.

The toll switching operator's equipment in accordance with the present invention has been very much simplified over the key indicator type previously described in that the operator is enabled to connect with trunks extending to dial switching offices on a straightforward basis. According to one embodiment of the invention disclosed herein by way of illustration, the toll operator is provided with a ten button key set common to the cords of her position which becomes associated with a cord of her position when she takes it for use. Associated with each group of trunks extending to a dial switching office to which she has access is a group of link circuits each comprising a step-by-step Strowger type trunk finder and a step-by-step sender selector. For controlling the positioning of the dial switching equipment in which the interoffice trunks terminate and over which access to dial switching subscribers' lines may be had, a plurality of common register type senders is provided. When the operator plugs into a trunk extending to an office in which a desired subscriber's line terminates an idle link circuit is taken for use and through the operation of the trunk finder and sender selector thereof, an idle sender is associated with the trunk which the operator has taken for use. By the manipulation of her key set the operator may then set the registers of such sender in accordance with the designation of the desired line, whereupon the sender proceeds to set

the selector switches to connect with such line.

The registers of the sender are set from the key set through the application of current of two current strengths and of either negative or positive potential in code combinations over the talking conductors of the operator's cord circuit and the trunk circuit. Over the same talking conductors signaling impulses are also transmitted between the sender and the position apparatus to connect the operator's key set as soon as a sender has become attached to the trunk which the operator has taken for use, to inform the operator when the sender has completed its registration functions and that the key set has been disassociated from such sender, and to inform the sender whether the operator's position is functioning on inward or outward toll calls. Provision is also made in the sender for applying ringing current directly from the sender to the interoffice trunk following the completion of its control of selections if the call has been made by a toll operator at an inward position.

For a more complete understanding of this invention reference may be had to the attached drawings in which:

Fig. 1 shows an operator's cord circuit for extending incoming toll connections to trunks extending to a dial switching office and a portion of the equipment of an operator's position including a set of pulsing keys.

Fig. 2 shows additional equipment of the operator's position including a telephone headset.

Fig. 3 shows a trunk circuit terminating in a jack accessible to the operator's cord circuit of Fig. 1 and in an incoming selector of a dial switching office and a diagrammatic representation of a final selector and called subscriber's line.

Figs. 4 and 5 taken together show a link circuit for associating the sender such as is disclosed in Figs. 6, 7 and 8 with the trunk circuit of Fig. 3. In Fig. 4 the trunk finder and in Fig. 5 the sender finder of the link are disclosed.

Figs. 6, 7 and 8 show a sender circuit, Fig. 6 disclosing control relay equipment of the sender, Fig. 7 disclosing the counting relays of the selector controlling portion of the sender and Fig. 8 showing the register relays for recording the number of desired lines under control of the pulsing keys of Fig. 1.

Fig. 9 is a diagram showing the manner in which the several figures of the drawing should be assembled to disclose the complete embodiment of the invention.

The trunk finder 450 of Fig. 4 may be of the well known Strowger type having both rotary and vertical stepping movements but being used as a hunting switch it is also equipped with a vertical group commutator and commutator brush. In addition it is

equipped with three additional brushes to afford additional points of access to control conductors extending to trunk circuits.

The sender finder 550 of Fig. 5 is of the well known step-by-step rotary type having no definite normal position but always remaining standing when idle on the terminals of the sender last used in extending a connection.

The incoming selector 325 and final selector 350 diagrammatically disclosed in Fig. 3 are of the well known panel type but are more particularly of the toll switching type disclosed in detail in Patent 1,575,299 issued to W. C. Weaver, March 2, 1926.

The toll operator's cord circuit and position circuit shown in Figs. 1 and 2 with the exception of key pulsing equipment are of the general character shown and described in Patent 1,675,956 issued to L. F. Porter on July 3, 1928.

Establishment of an inward connection

It will be assumed that a toll call is incoming to the operator's position of Fig. 1 and that the operator answers the call on the toll line by plugging the plug 100 into the toll line jack 101. She then depresses her cord key 102 to the right into the talking position. A circuit is thereupon established for relay 103 extending from battery through the lower winding of relay 103, the uppermost contact of key 102, conductor 104 to ground at the normal contacts of relay 200. Relay 103 upon energizing closes at its lower contact a circuit extending from ground at contact 105 of key 102 over the lower contact of relay 103, conductor 106 in parallel through the windings of relays 200 and 201 to battery. These relays thereupon operate, relay 200 removing ground from conductor 104 to prevent another cord relay such as relay 103 from operating, and connecting ground to conductor 107 whereupon a circuit is established through the upper inner contacts and upper winding of relay 103 to battery to hold relay 103 locked so that as long as the key 102 is in its operated position relay 103 individual to the cord circuit and relay 200 common to the cord circuits of the operator's position are held operated. Relay 103 splits the cord circuit and associates the group of conductors 108 with the cord circuit.

The operation of relay 201 connects the tip and ring talking conductors 203 and 204 of the operator's headset circuit over conductors 109 and 110 extending to the left or monitoring contacts of the key 102 and opens conductor 111. If at this time the key 102 of another cord circuit of the operator's position is operated to the left or monitoring position the operator will be able to talk or listen on both cord circuits, but will be able to split transfer or key pulse on only the cord circuit, the listening key of which has been

operated to the right or talking position. The functions of the splitting key 211, talking and monitoring key 102 and ringing key 116 for enabling the operator to talk, monitor or ring on either end of the cord circuit are fully described in the patent to Porter above referred to and will not therefore be discussed in detail herein.

Upon the operation of key 102 a circuit is also established from high resistance ground on the sleeve of jack 101 over the sleeve of plug 100, contacts 112 of key 102, conductor 113 to battery through the windings of relays 205 and 206. Relay 206 upon operating closes an obvious circuit for relay 207. Relay 205 being marginal, however, does not operate at this time. At its inner upper contact relay 207 connects ground through high resistance 208 to conductor 209 to prevent a false operation of the rear cord supervisory lamp 114, should the operator depress a talking key of a repeater cord of her position to the talking position either accidentally or otherwise with such cord circuits normal. At its upper back contact relay 207 disconnects the busy test conductor 210 of the operator's headset from the tip of the answering plug 100 and at its outermost upper and lower front contacts establishes a talking circuit which may be traced from conductor 203, over the uppermost front contact of relay 207, the upper normal contact of splitting key 211, conductor 212, the uppermost normal contact of relay 115, the uppermost alternate contact of relay 103, the upper right normal contacts of ringing key 116, over the tip contacts of plug 100 and jack 101, thence over the toll trunk, returning over the ring contacts of jacks 101 and plug 100, the inner lower alternate contact of relay 103, the lower back contact of relay 115, conductor 117, the right lower normal contacts of key 211, the lower front contact of relay 207 to conductor 204. The operator is now enabled to receive instructions over the toll trunk for the further extension of the connection.

Having received instructions and it having been assumed that a connection is desired with the subscriber's line 300 the operator proceeds to test the trunks extending to the office in which the line 300 terminates by touching the tip of the plug 118 to the sleeves of the trunks. A circuit is thereupon established from the tip of plug 118, over the inner lower left normal contact of key 116, the uppermost front contact of relay 103, the upper inner normal contact of relay 119, conductor 213, the upper left normal contacts of key 211, the upper back contact of relay 214 to the test lead 210. It will be assumed that the trunk terminating in jack 301 tests idle and that the operator on receiving a busy click in her headset inserts the plug 118 into jack 301. A circuit is

thereupon established from ground through the lower high resistance winding of trunk sleeve relay 302, over the sleeves of jack 301 and plug 118, contacts 120 of key 102, conductor 121 to battery through the windings of relays 215 and 216. Due to the high resistance of relay 302 marginal relay 215 does not operate at this time but relays 216 and 302 both operate. With relay 216 operated an obvious circuit for relay 214 is established whereby relay 214 operates opening the connection between the tip of plug 118 and the test conductor 210 and establishing a talking path from the tip and ring conductors 203 and 204 of the operator's headset to the left normal contacts of splitting key 211, thence over normal contacts of relay 119, alternate contacts of relay 103 to the tip and ring contacts of plug 118. At its upper front contact relay 214 also connects ground through high resistance 217 to conductor 218 for preventing the false operation of the front supervisory lamp 122 should the operator depress a talking key of a repeater cord of her position to the talking position either accidentally or otherwise with such cord circuit normal.

Starting a link circuit to hunt for the selected trunk

Relay 302 of the trunk circuit upon operating establishes an obvious circuit for relay 303 which in turn establishes a start circuit for starting an idle link in search of the trunk which has been taken for use and in search of an idle sender. This start circuit may be common, for example, to a group of ten trunks and extends from ground at the inner lower back contact of relay 304, over the inner upper contact of relay 303, conductor 305 to battery through the winding of group relay 400 of the link circuit which has first choice access to the group of trunks in which the selected trunk is located. Relay 400 upon energizing places ground over its upper contact upon segment 407 of the group commutator of the trunk finder 450 corresponding to the bank level in which the selected trunk appears, in the case assumed the first or lowermost segment, and at its lower contact establishes a circuit from ground at the back contact of relay 401, over the lower normal contacts of make busy jack 402, conductor 403, the lowermost back contact of relay 500 to battery through the winding of relay 501. Relay 501 energizes in this circuit and establishes a circuit for relay 502 extending from ground, over the lower front contact of relay 501, the inner lower back contact of relay 503, conductor 504, the back contacts of vertical magnet 404 and rotary magnet 405, conductor 405 to battery through the upper winding of relay 502.

With relay 502 operated a circuit is now established for the vertical magnet 404 of the

trunk finder 450 which may be traced from battery through the winding of magnet 404, conductor 506, the lower back contact of relay 507, front contact of relay 502 ground at the inner upper back contact of relay 500. Magnet 404 upon operating opens at its back contact the circuit of relay 502 whereupon relay 502 in turn deenergizes opening the circuit of magnet 404. Thus magnet 404 and relay 502 reciprocally control each other to cause the magnet 404 to step the brushes of finder 450 vertically step by step until the commutator brush 406 engages the grounded segment 407. When this occurs a circuit is established for relay 507 extending from ground on brush 406, over conductor 408, the uppermost back contact of relay 500, the upper winding of relay 507, conductor 508, the back contact of rotary magnet 405, conductor 505 to battery through the upper winding of relay 502. Relays 502 and 507 operate in this circuit, relay 507 locking over its lower winding and inner lower front contact, inner lower back contact of relay 500, conductor 509 to ground at the lower alternate contacts of vertical off-normal springs 409 which closed when the trunk finder 450 took the first step off normal. Relay 507 at its lower back contact also opens the operating circuit of the vertical magnet 404.

With both relays 502 and 507 energized a circuit is now established for the rotary magnet 405 extending from battery through the winding of magnet 405, conductor 510, the lowermost front contact of relay 507, the contact of relay 502 to ground at the innermost upper back contact of relay 500. Magnet 405 upon energizing opens at its back contact the previously traced circuit extending through the upper winding of relay 502 whereupon relay 502 deenergizes in turn opening the circuit of magnet 405. Thus magnet 405 and relay 502 reciprocally control each other to cause magnet 405 to step the brushes of finder 450 over the terminals of the first bank level to which they were previously raised until the set of terminals is reached in the level to which the selected trunk is connected. Thereupon a circuit is established from battery through the winding of trunk relay 306, the lower contact of relay 303, the lowermost contact of relay 304, conductor 307, bank terminal 410, brush 411, conductor 412, upper contact of relay 501, winding of relay 511 to ground through the lower winding of relay 502. Relays 306, 502 and 511 operate in this circuit, relay 511 closing an obvious circuit for relay 503 and a locking circuit for relay 501 extending from battery through the winding and inner lower front contact of relay 501, the lower front contact of relay 511 to ground at the intermediate lower normal contacts of relay 512 for holding relay 501 operated after relay 500 operates as later described. Relay 503 upon operat-

ing closes at its innermost upper contact a shunt around the lower winding of relay 502 causing the release of relay 502, closes at its lower front contact an obvious operating circuit through the upper winding of relay 500 and at its lower intermediate contact prepares a circuit for relay 512. Relay 500 upon operating locks from off-normal ground on conductor 509 over its innermost lower front contact and lower winding, conductor 513 to battery at the back contact of relay 413 and at its uppermost back contact and innermost lower contact opens the initial operating and locking circuits of relay 507. Relay 507 thereupon releases.

At the trunk circuit upon the operation of relay 306 a circuit is established for relay 304 extending from battery through the winding of relay 304, over the upper front contact of relay 306 to ground at the upper contact relay 303 and transfers the circuit of relay 306 from the lower contacts of relay 304 through its own lower contacts. Relay 304 upon operating locks to ground at the upper contact of relay 303 over its own inner upper contact independently of the upper front contact of relay 306, and disconnects ground from the common start conductor 305 at its inner lower back contact thereby releasing group relay 400, if there is at the time no other trunk in the same group in a selectable condition.

Hunting for an idle sender

At the time relay 501 operated immediately following the starting of the link circuit a circuit was also established for relay 514 extending from battery through the winding of relay 514, over the lower back contact of test relay 515 to ground at the lower front contact of relay 501. At its upper front contact relay 514 establishes a saturating circuit for the test relay 515 which may be traced from battery through the lower winding of relay 515, the front contact of relay 514 to ground through the middle winding of relay 515. Relay 515 does not, however, become energized sufficiently to attract its armatures. At its lower contact relay 514 establishes a circuit for the stepping relay 516 of the sender finder 550 which extends from battery through the winding of relay 516, the back contact of stepping magnet 517, the lower contact of relay 514 to ground at the upper back contact of test relay 515. Relay 516 upon energizing connects the winding of the stepping magnet 517 to ground at the upper back contact of relay 515 whereupon magnet 517 energizes opening the energizing circuit of stepping relay 516. Magnet 517 and relay 516 thus reciprocally control each other thereby advancing the brushes of the sender finder 550 step by step in search of an idle sender. As soon as a terminal set is reached to which an idle sender is connected a circuit

becomes established for test relay 515 extending from ground through the middle winding of test relay 515, the upper front contact of relay 514, the lowermost back contact of relay 512, the upper winding of relay 515, the innermost upper front contact of relay 501, brush 518, conductor 519, back contact of relay 600 to battery through the inner right back contact of relay 601. Relay 515 now receiving current through all of its windings operates quickly locking in a circuit extending from ground, over its upper front contact and upper winding, thence as traced to battery at the back contact of relay 601, opening at its upper back contact the operating circuits of relay 516 and magnet 517 and opening at its lower back contact the operating circuit of relay 514.

After an interval measured by its slow releasing characteristic relay 514 deenergizes and if at this time the trunk finder has completed its operation and relay 503 has operated a circuit is established for relay 512 extending from battery through the winding of relay 512, the lower intermediate front contact of relay 503, the intermediate lower back contact of relay 512, the upper back contact of relay 514, the lower front contact of relay 515 to ground at the lower front contact of relay 501. Relay 512 upon energizing closes a holding circuit for itself extending from battery through its winding, its next to innermost lower contact to ground at the intermediate upper contact of relay 503, opens at its intermediate lower back contact its own initial operating circuit, transfers the locking circuit of relay 501 from direct ground to ground through the upper back contact of relay 514, the lower front contact of relay 515 and the lower front contact of relay 501, connects brushes 414 to 417 inclusive of finder 450 to brushes 520 to 523 inclusive of sender finder 550, establishes a circuit extending in parallel through the windings of relays 524 and 525 over the upper front contact of relay 512, brush 526, conductor 527 through the left and intermediate windings of relay 602, the left normal contacts of relay 603 to ground at the inner left contact of relay 604 and at its next to upper contact connects battery through high resistance 533, the back contact of relay 524, conductor 534, brush 423, conductor 424, through the upper winding of relay 302 to the sleeve of jack 301 for the purpose of marking the trunk busy so long as the link circuit is engaged therewith. Relays 525 and 602 operate in the circuit traced, but relay 524 being marginal does not operate. At its upper contacts relay 525 bridges the upper contacts of relay 501 in the holding circuit of relays 511 and 306 to hold the latter relays operated following the release of relay 501 and at its lower contact establishes an alternative holding circuit for relay 512 for hold-

ing relay 512 operated following the release of relay 503.

Should a second trunk of the same group be selected at this time with relay 500 operated and relay 507 deenergized and the group relay 400 be operated, relay 400 will again mark the lowermost commutator terminal 407 as before, but will now start the trunk finder normally having first choice access to the group of trunks in the first level of its bank and in the tenth level of finder 450. This start circuit extends from ground at the back contact of relay 401, over the lower front contact of relay 400, lower normal contacts of jack 402, conductor 403, the lowermost front contact of relay 500, the innermost upper back contact of relay 507, conductor 528, the lower normal contacts of jack 419, thence through the relay of that link corresponding to relay 501. Since the commutator segments and bank multiples are slip-multiplied in the well known manner the line finder started will step vertically to its tenth bank level when it will be arrested by its commutator brush corresponding to brush 406 engaging the tenth segment of its commutator which is multiplied to the segment 407. In a similar manner should other trunks be placed in a calling condition in the same trunk group the start conductor 305 will be extended to start succeeding line finders which normally have first choice access to other groups of trunks. This starting arrangement is in accordance with the well known so-called "paddle-wheel" start circuit arrangement.

At the sender upon the operation of relay 602 an obvious circuit is established in parallel through the windings of off-normal relays 601 and 605. Relay 601 upon energizing removes battery at its inner right back contact from the test lead 519 thereby releasing test relay 515 in the link circuit which in turn opens the holding circuit of relay 501 which thereupon releases. Relay 601 also opens the operating circuit of the make busy relay 600, closes at its inner left front contact a circuit from ground through both windings of differential relay 640 to battery and closes a circuit for relay 800 which may be traced from battery through the winding of relay 800, conductor 801, left back contact of relay 606 to ground at the inner left front contact of relay 601. Relay 640 being differentially wound does not operate at this time. Relay 800 upon operating locks over a circuit extending through its winding and the winding of relay 802, the inner left front contact of relay 800, the left back contact of relay 803, conductor 804 to ground at the inner left front contact of relay 601. Relay 802 being shunted at this time, however, does not operate in this locking circuit. Relay 800 also establishes a circuit for operating relay 606 which may be traced from battery through the winding and inner right normal

contacts of relay 606, conductor 607, over the left front contact of relay 800 to ground as previously traced at the inner left front contact of relay 601. With relay 606 operated the shunt around the winding of relay 802 is removed and relay 802 operates. At its inner right front contact relay 606 locks directly to ground at the inner left front contact of relay 601, opens its own initial operating circuit and at its outer left back contact opens the initial operating circuit of relay 800. The purpose of relay 606 is to prevent the reoperation of relays 800 and 802 after the first digit of the desired subscriber's number has been set up by the operation of the operator's key set. In addition relay 606 establishes a circuit from ground at the inner left front contact of relay 601 through the right low resistance winding of relay 640, over the outer right contact of relay 606, the inner right front contact of relay 601, the back contact of relay 600, conductor 519, brush 518, the innermost upper back contact of relay 501, the next to lowermost front contact of relay 512 to the uppermost back contact of relay 503, but relay 503 being energized at this time this circuit is ineffective.

Relay 605 upon operating supplies holding ground for certain relays of the sender, establishes a circuit for relay 608 extending from battery, through the winding of relay 608, the back contact of relay 609, conductor 704 to ground at the intermediate left contact of relay 605 and establishes a circuit for relay 700 extending from battery through the winding of relay 700, the right back contact of relay 701, conductor 702, the right back contact of relay 624, conductor 611, the back contact of relay 703, conductor 704 to ground at the intermediate left contact of relay 605. Relay 700 energizes in this circuit preparatory to controlling incoming brush selection at the incoming selector 325 in which the trunk of Fig. 3 terminates.

Setting the sender registers

Preparatory to registering the number of the desired subscriber's line on the registers of the sender the operator depresses the key 123 thereby closing a circuit for relay 119 which may be traced from battery through the winding of relay 119, the lower back contact of relay 124, front contact of key 123, conductor 125, lower contact of relay 214, conductor 107 to ground. Relay 119 upon operating locks over its upper front contact, the right contact of release key 126 to ground on conductor 107, at its inner lower front contact, furnishing an additional operating circuit for relays 200 and 201 and closes an obvious circuit for relay 124. In addition at its back contacts it opens the talking circuit from the tip and ring contacts of plug 118 to the operator's headset and establishes an operating circuit for relay 612 of the

sender which may be traced from battery at the upper normal contact of relay 128, over the lower front contact of relay 119 thence as traced to the ring of plug 118, ring of jack 301, lower back contact of relay 308, conductor 309, brush 416 of trunk finder 450, next to innermost upper contact of relay 512, brush 522 of sender finder 550, conductor 529, right back contact of relay 805, conductor 806, the inner back contact and winding of relay 612, conductor 613, outer left back contact of relay 805, right back contact of relay 807, right back contact of relay 808, conductor 809 to ground at the outer right contact of relay 605.

Relay 612 energizes in this circuit locking directly to battery over its inner left continuity contacts and opening its initial energizing circuit. At its outer left front contact relay 612 connects the windings of sensitive relay 614, marginal relay 615 and polarized relay 616 to the ring conductor of the pulsing circuit previously traced to the lower front contact of relay 119 and at its right front contact connects the windings of sensitive relay 617, marginal relay 618 and polarized relay 619 over conductor 620, the inner left back contact of relay 805, conductor 810, brush 523 of the sender finder 550, the innermost upper contact of relay 512, brush 417 of the trunk finder 450, conductor 310, the upper back contact of relay 308, tips of jack 301 and plug 118 and thence as traced to the inner upper front contact of relay 119, through the upper normal contacts and winding of relay 127 to ground at the inner lower front contact of relay 119.

Relay 127 operates in this circuit if the sender is ready to receive impulses, locking directly to battery over its upper front contact and opening its initial operating circuit. At its lower contact relay 127 also establishes a circuit for relay 128 extending from battery through the winding of relay 128, the lower contact of relay 127, the upper back contact of relay 129 to ground at the inner lower front contact of relay 119. Relay 128 at its lower front contact connects battery through a low resistance to certain key contacts of key set 150. At its upper continuity contacts it removes battery from the ring conductor of the pulsing circuit extending to the sender as previously traced connecting such conductor to certain key contacts of the key set, connects the conductor of the pulsing circuit extending to the sender as previously traced to other key contacts of the keyset over its inner upper front contact and at its lower front contact establishes a circuit for lamp 131 extending from battery through lamp 131 to ground at the inner lower front contact of relay 128. At the operator's position upon the operation of relay 124 the initial operating circuits of relays 115 and 119

are opened and the circuit of guard lamp 132 is closed.

The operator noting the illumination of lamp 131 then proceeds to write up upon key set 150 the designation of the desired subscriber's line 300. It will be assumed that the designation of this line is 1379. The operator first depresses the No. 1 digit key 133 thereby connecting ground through the low resistance 134, the contacts of key 133, the inner upper front contact of relay 128 thence over the tip pulsing conductor as previously traced to battery through the windings of relays 617, 618 and 619. Due to the inclusion of the low resistance 134 sufficient current flows to operate both the sensitive relay 617 and the marginal relay 618, but polarized relay 619 does not receive current in the proper direction through its winding to cause its operation.

Relay 617 upon operating with relay 800 operated as previously described establishes a circuit from ground at the contact of relay 617 over conductor 621, the inner right front contact of relay 800 to battery through the winding of relay 811. Relay 811 operates in this circuit closing a locking circuit for itself through its winding and the winding of relay 803 in series, over its own left front contact, the left back contact of relay 812 to ground on conductor 804, but relay 803 being shunted as long as relay 617 remains operated does not operate at this time. Relay 618 upon operating closes a circuit extending from ground at its contact, over conductor 622, the intermediate right contact of relay 802 to battery through the right winding of thousands register relay 813. Relay 813 upon operating locks over its left winding and left contact, conductor 821 to ground at the inner right contact of relay 605.

When the operator releases the depressed key 133, relays 617 and 618 release, relay 617 opening the shunt around the winding of relay 803, whereupon relay 803 operates in the locking circuit of relay 803. Relay 811 upon operating now opens at its left back contact the locking circuit of relays 800 and 802 whereupon these relays release, relay 802 disconnecting the operating circuits of the register relays of the thousands register from the contacts of pulsing relays 615, 616, 618 and 619 and relay 803 upon operating connecting the contacts of these pulsing relays to the windings of the hundreds register relays.

With relay 800 released a circuit is now established for relay 623 extending from battery through the winding of relay 623, the left contact of relay 624, conductor 625, the left back contact of transfer relay 701, conductor 705, the left back contact of relay 800, conductor 706, the left front contact of relay 606 to ground at the inner left front contact of relay 601. With relay 623 oper-

ated a fundamental circuit is established between the sender and the incoming selector 325 which may be traced in part from battery through the control relay (not shown) of the incoming selector, over the upper back contact of relay 311, the upper back contact of relay 312, conductor 313, brush 415 of the trunk finder 450, contact 530 of relay 512, brush 521 of the sender finder 550, conductor 531, the right back contact of relay 626, conductor 627, the inner left normal contacts of relay 707, the back contact of relay 708, the left winding of polarized overflow relay 709, the winding of sender stepping relay 710, the right normal contacts of relay 707, conductor 711, the left contact of relay 623, the left back contact of relay 626, conductor 627, brush 520 of the sender finder 550, contact 532 of relay 512, brush 414 of trunk finder 450, conductor 420, the lower back contacts of relays 312 and 311 to ground in the incoming selector. The control relay of the incoming selector and sender stepping relay 710 energize in this circuit but overflow relay 709 being polarized does not receive current in the right direction to operate at this time. The setting of the selector under the control of the thousands register may now take place. The manner in which this is accomplished will be described hereinafter. Relay 623 also establishes a holding circuit for transfer relay 700 extending from battery through the winding of relay 700, the right winding of transfer relay 701, the inner right contact of relay 700, conductor 757 to ground at the right contact of relay 623. Relay 701 does not however operate in this holding circuit being shunted until counting relay 703 operates.

The operator now proceeds to depress the No. 3 key to register the hundreds digit of the wanted line number. With the No. 3 key 135 depressed the 48 volt battery is connected through low resistance 130, over the lower front contact of relay 128, the contacts of key 135, the inner upper front contact of relay 128 to the tip pulsing conductor thence as previously traced through the windings of pulsing relays 617, 618 and 619 to 24 volt battery. The direction of current now flowing through the windings of these pulsing relays is such as to operate the polarized relay 619 and since a low resistance has been included in the operating circuit both relays 617 and 618 also operate.

Relay 617 upon operating closes a circuit from ground at its contact over conductor 621, the right back contact of relay 800, the right front contact of relay 811 to battery through the winding of relay 814. Relay 814 operates in this circuit closing a locking circuit for itself through its winding and the winding of 812 in series, its own left front contact, the left back contact of relay 815

to ground on conductor 804 (but relay 812 being shunted as long as relay 617 remains operated does not operate at this time. Relay 618 upon operating closes a circuit extending from ground at its contact, over conductor 622, the intermediate right contact of relay 803 to battery through the right winding of hundreds register relay 816. Relay 816 upon operating locks over its left winding and left contact, conductor 817 to ground at the outer left contact of relay 605. Relay 619 upon energizing closes a circuit extending from ground at its contact, over conductor 628, the inner left contact of relay 803 to battery through the right winding of hundreds register relay 818. Relay 818 upon operating locks over its left winding and left contact to ground on conductor 817.

When the operator releases the depressed key 135, relays 617, 618 and 619 release, relay 617 opening the shunt around the winding of relay 812 whereupon relay 812 operates in the locking circuit of relay 814. Relay 812 upon operating now opens at its left back contact the locking circuit of relays 811 and 803 whereupon these relays release, relay 803 disconnecting the operating circuits of the register relays of the hundreds register from the contacts of the pulsing relays and relay 812 upon operating connecting the contacts of the pulsing relays to the windings of the tens register relays.

The operator now proceeds to depress the No. 7 tens key to register the tens digit of the wanted line number. With the No. 7 key 136 depressed the 48 volt battery is connected through resistance 130, over the lower front contact of relay 128, through high resistance 137, the right contacts of key 136, the inner upper front contact of relay 128 thence as traced over the tip pulsing conductor through the windings of pulsing relays 617, 618 and 619 to the 24 volt battery. The direction of current now flowing through the windings of these pulsing relays is such as to operate polarized relay 619 and since high resistance 137 has been included in the circuit the current strength is sufficient to operate relay 617 but not to operate relay 618.

Relay 617 upon operating closes a circuit from ground at its contact over conductor 621, the right back contacts of relays 800 and 811, the right front contact of relay 814 to battery through the winding of relay 819. Relay 819 operates in this circuit closing a locking circuit for itself through its winding and the winding of relay 815 in series, the left front contact of relay 819, the right normal contacts of relays 808 and 807 to ground on conductor 804, but relay 815 being shunted so long as relay 617 remains operated does not operate at this time. Relay 619 upon operating closes a circuit extending from ground at its contact over conductor 628, the inner left

contact of relay 812 to battery through the right winding of tens register relay 820. Relay 820 upon operating locks over its left winding and left contact to ground on conductor 821.

At its left contacts key 136 closes a circuit from ground through low resistance 138, the uppermost alternate contacts of relay 128 thence as traced over the ring pulsing conductor to battery through the windings of pulsing relays 614, 615 and 616. The direction of the current flowing is not such as to cause the operation of polarized relay 616, but since only low resistance 138 has been included in the pulsing circuit both the sensitive relay 614 and the marginal relay 615 operate. Relay 614 upon operating merely duplicates the function of relay 617 already described and relay 615 connects ground over its contact, conductor 630, the outer right contact of relay 812 to battery through the right winding of tens register relay 822. Relay 822 upon operating now locks over its left winding and left front contact to ground on conductor 821.

When the operator releases the depressed key 136 relays 617, 619, 614 and 615 release, relays 617 and 614 opening the shunt around the winding of relay 815 whereupon relay 815 operates in the locking circuit of relay 819. Relay 815 upon operating now opens at its left back contact the locking circuits of relays 812 and 814 whereupon these relays release, relay 812 disconnecting the operating circuits of the register relays of the tens register from the contacts of the pulsing relays and relay 815 upon operating connecting the contacts of the pulsing relays to the windings of the units register relays.

The operator now proceeds to depress the No. 9 units key to register the units digit of the wanted line number. With the No. 9 key 139 depressed 48 volt battery through resistance 130 over the lower front contact of relay 128 is connected over the left contacts of key 139, the upper alternate contacts of relay 128 thence as traced over the ring pulsing conductor to 24 volt battery through the windings of relays 614, 615 and 616. Due to the connection of 48 volt battery through a low resistance to the pulsing conductor all three relays 614, 615 and 616 respond. Relay 614 upon operating connects ground over its contact, conductor 621, the right back contacts of relays 800, 811 and 814 and the right front contact of relay 819 to battery through the winding of relay 823. Relay 823 upon operating locks in a circuit extending through its winding and the winding of relay 805 in series, the front contact of relay 823, the left normal contacts of relays 808 and 807 to ground on conductor 804, but relay 805 being shunted so long as relay 614 remains operated does not operate at this time. Relay 615 upon operating connects ground over its contact, conductor 630, the outer right con-

tact of relay 815 to battery through the right winding of units register relay 824. Relay 824 operates and locks over its left winding and left contact to ground on conductor 817. Relay 616 upon operating connects ground over its contact, conductor 631, the inner right contact of relay 815 to battery through the right winding of units register relay 825, this relay locking through its left winding and left contact to ground on conductor 817.

Upon the depression of key 139 a circuit is also established from ground through low resistance 134, high resistance 140, the right contacts of key 139, the inner upper front contact of relay 128, thence as traced over the tip pulsing conductor through the windings of pulsing relays 617, 618 and 619, but due to the direction and strength of the current flowing over this conductor only pulsing relay 617 operates duplicating the function of pulsing relay 614 already described.

When the operator releases the depressed key 139, relays 614, 615, 616 and 617 release, relays 614 and 617 removing the shunt from around the winding of relay 805 whereupon relay 805 operates in the locking circuit of relay 823. With relay 805 operated a circuit is established from 48 volt battery through the winding of marginal relay 807, the inner left front contact of relay 805, conductor 810 thence as traced over the tip pulsing lead, the inner upper front contact of relay 128, the lower normal contacts of key 141 to 24 volt battery through the winding of high resistance polarized relay 142. Relay 142 operates in this circuit but due to its resistance, relay 807 does not receive sufficient current to operate at this time. A second circuit is also established by the operation of relay 805 extending from 48 volt battery through the winding of marginal relay 808, the right front contact of relay 805 thence over conductor 529 and as traced over the ring pulsing conductor to the upper alternate contacts of relay 128, the upper normal contacts of key 141 to 24 volt battery through the winding of high resistance polarized relay 143. Relay 143 operates in this circuit, but due to its resistance relay 808 does not receive sufficient current to operate at this time.

With both relays 142 and 143 operated a circuit is now established from ground at the front contact of relay 142 over the contact of relay 143 to battery through the winding of relay 144. Relay 144 upon energizing locks over its upper front contact to ground at the inner lower front contact of relay 119 and connects direct ground over its upper front contact between the winding of polarized relay 143 and the winding of the marginal relay 808 whereupon relay 808 operates locking over its left alternate contacts, the left normal contacts of relay 807 to ground on conductor 804. At its left nor-

mal relay 808 also opens the locking circuit of relays 805 and 823 whereupon these relays release opening the circuits previously traced over which relay 808 of the sender and polarized relays 142 and 143 operated. Relay 808 at its right front contact also prepares a circuit for relay 626 which will be described hereinafter.

Relay 142 upon releasing establishes a shunt circuit around the winding of relay 119 which may be traced from ground at the back contact of relay 142, the lower front contact of relay 144, winding of relay 119, upper front contact of relay 119, right contacts of release key 126 to ground on conductor 107 whereupon relay 119 releases in turn releasing relays 124, 127, 128 and 144. Upon the release of relay 124 the guard lamp 132 becomes extinguished as a signal that the call has been completely registered at the sender. If the talking key 102 has been restored to its normal position the circuit of relay 200 will at this time be opened since its alternative holding circuit through the front contact of relay 119 is now broken and relay 200 upon releasing will open the holding circuit of cord relay 103 disconnecting the tip and ring contacts of plug 118 from the conductors extending to the operator's key pulsing circuit and establishing the continuity of the talking circuit between the tip and ring contacts of plug 100 and the tip and ring contacts of plug 118. The key set is now completely disconnected from the cord circuit and may be used with another cord circuit of the operator's position to control the setting up of another connection.

Incoming brush selection

It will be recalled that following the completion of the thousands digit registration transfer relay 700 and relay 623 became energized and that the fundamental circuit extending to the incoming selector 325 was established and sender stepping relay 710 operated thereover. Upon the energization of relay 710 with the thousands register relay 813 energized a circuit is established for operating the No. 0 counting relay 712 extending from battery through the winding of relay 712 over conductor 714, the outer right back contacts of transfer relays 715 and 716, the No. 0 lead 713, lead 713 Fig. 8, the outer right back contacts of thousands register relays 826 and 827, the outer left back contact of thousands register relay 828, conductor 829, the outer right contact of transfer relay 700, conductor 717, the right back contact of relay 603, conductor 632, the front contact of stepping relay 710 to ground at the left back contact of transfer relay 718. Relay 712 upon operating locks in a circuit through its winding and the windings of relays 703 and 708 in parallel, the front contact of relay 712 to ground at the left front

contact of relay 700. Relays 703 and 708 being shunted by ground over the front contact of stepping relay 710 do not operate at this time.

At the incoming selector the control relay operates in the well known manner over the fundamental circuit and causes the selector switch shaft to be driven upwardly in a brush selecting movement. As the switch approaches its first brush selecting position the switch commutator shunts down the sender stepping relay 710 which deenergizes removing the shunt from around the windings of relays 703 and 708 whereupon these relays operate in the locking circuit of relay 712. Relay 708 upon operating opens the fundamental circuit thereby releasing the selector control relay to arrest the movement of the selector switch shaft and relay 703 closes at its front contact a circuit for relay 624 extending from battery through the winding of relay 624 over conductor 633, the front contact of relay 703 to ground on conductor 704. Relay 624 upon operating opens the shunt around the right winding of transfer relay 701 whereupon relay 701 energizes in the locking circuit of relay 700 and closes a locking circuit for itself over its left winding and inner left front contact, conductor 719 to ground at the inner left contact of relay 605. Relay 624 also opens the circuit of relay 623 which releases opening the fundamental circuit and the locking circuit of transfer relay 700. Relay 700 now releases in turn releasing operated counting relays 703, 708 and 712 and relay 624.

Incoming group selection

A circuit is now established for the transfer relay 720 preparatory to controlling incoming group selection, which circuit may be traced from battery through the winding of relay 720, right back contact of transfer relay 721, right front contact of transfer relay 701, conductor 702, right back contact of relay 624, conductor 611, back contact of relay 703 to ground on conductor 704. If the hundreds digit has been registered at this time and relay 811 has released a circuit will be established for slow operating relay 623 extending through the winding of relay 623, the left contact of relay 624, conductor 625, the left front contact of transfer relay 701, the outer right normal contacts of transfer relay 718, conductor 722, the left back contact of relay 811 to ground on conductor 804. As soon as relay 623 operates it again establishes the fundamental circuit as previously traced causing the energization of the selector control relay and of the sender stepping relay 710, and establishes a locking circuit for relay 720 extending from battery through the winding of relay 720, the right winding of relay 721, the inner right contact of relay 720, conductor 757 to ground at the right contact

of relay 623. Relay 721 being shunted at this time over the circuit previously traced through the right back contact of relay 624 does not operate in this locking circuit.

5 Having assumed that the thousands digit registered was 1 and that the hundreds digit registered was 3 and that therefore thousands register relay 813 and hundreds register relays 816 and 818 are operated the circuit for
10 the No. 2 counting relay 723 is established from battery through the winding of this relay, the back contact of the No. 2' relay, the No. 2 control lead 725, lead 725 Fig. 8, the right back contact of hundreds register relay
15 830, the outer right back contact of thousands register relay 828, the right front contact of relay 813, conductor 831, the left contact of transfer relay 720, conductor 717, the right back contact of relay 603, conductor 632, the
20 front contact of stepping relay 710 to ground at the left back contact of transfer relay 718. Counting relay 723 operates in this circuit and locks through its winding and the winding of the No. 2' counting relay 724, the con-
25 tact of relay 723 to ground at the outer right contact of transfer relay 720, but relay 724 being shunted by ground over the contacts of stepping relay 710 does not operate at this time.

30 At the selector the control relay again causes the selector shaft to advance in a brush tripping and group selecting movement, the switch commutator shunting down the sender stepping relay 710 as it approaches the first
35 group selection position. When the stepping relay 710 becomes shunted and deenergizes the shunt about the No. 2' counting relay 724 is opened and relay 724 energizes extending the operating lead 725 to the winding of the
40 No. 1 counting relay 726. In the well known manner in response to the next shunting impulse at the selector as it reaches its second group selection position the No. 1' counting relay 727 operates in the locking circuit of
45 counting relay 726 again extending the operating lead 725 to the lead 713 and thence as previously traced to battery through the winding of the No. 0 counting relay 712. In response to the third shunting impulse at the
50 selector the counting relays 703 and 708 operate in the locking circuit of the No. 0 counting relay 712. Relay 708 upon operating opens the fundamental circuit thereby releasing the selector control relay to arrest the advance of
55 the selector. The selector has therefore tripped its first set of brushes and advanced them into contact with the first set of terminals of the third group in its lowermost bank.

60 Relay 703 upon operating again establishes the circuit of relay 624, which upon operating opens the shunt around the right winding of transfer relay 721 whereupon relay 721 energizes in the locking circuit of relay 720 and closes a locking circuit
65 for itself over its left winding and inner

left contact to ground on conductor 719. Relay 624 also opens the circuit of relay 623 which releases opening the fundamental circuit and the locking circuit of transfer relay 720. Relay 720 now releases in turn re-
70 leasing all operated counting relays and relay 624.

Final brush selection

A circuit is now established for the trans-
75 fer relay 728 preparatory to controlling final brush selection at the final selector which circuit may be traced from battery through the winding of relay 728, inner right back contact of transfer relay 718, 80
right front contacts of transfer relays 721 and 701, conductor 702, right contact of relay 624, conductor 611, back contact of relay 703 to ground on conductor 704. A circuit is now established for slow operat-
85 ing relay 623 extending from battery through the winding of relay 623, the left contact of relay 624, conductor 625, the left front contact of relay 701, the outer normal contacts of relay 718, conductor 722, the left back
90 contact of relay 811 to ground on conductor 804. Relay 623 being slow to operate does not energize until sufficient time has elapsed to permit the incoming selector to hunt for
95 an idle trunk in the selected group terminating in a final selector having access to the wanted subscriber's line. It will be assumed that the trunk terminating in final selector 350 is selected. When relay 623
100 finally energizes it again establishes the fundamental circuit including the winding of the sender stepping relay 710 and the winding of the control relay (not shown) of the final selector 350 and also establishes a
105 locking circuit for transfer relay 728 extending from battery through the winding of relay 728, the right winding of relay 718, inner right contact of relay 728, conductor 757 to ground at the right contact
110 of relay 623. Relay 718 being shunted at this time over the circuit previously traced through the right back contact of relay 624 does not operate in this locking circuit.

Having assumed that the hundreds digit registered was 3 and that therefore hundreds
115 register relays 816 and 818 are operated a circuit for the No. 3 counting relay 731 is established from battery through the winding of this relay, the back contact of the No. 3' counting relay 732, No. 3 control lead
120 729, lead 729 Fig. 8, the outer right front contact of hundreds register relay 818, the right front contact of hundreds register relay 816, conductor 832, the left front contact of transfer relay 728, conductor 717,
125 the right back contact of relay 603, conductor 632, the contact of sender stepping relay 710 to ground at the left back contact of transfer relay 718. Counting relay 731 operates in this circuit and locks through
130

its winding and the winding of the No. 3' counting relay 732 to ground at the outer right contact of transfer relay 728, but relay 732 being shunted by ground over the contacts of stepping relay 710 does not operate at this time.

At the final selector the control relay establishes in the well known manner the circuit of the high speed up-drive magnet to advance the switch shaft in a brush selecting movement. When the shaft approaches its first brush selection position the switch commutator shunts down the sender stepping relay 710, which upon releasing opens the shunt about counting relay 732 which now energizes in the locking circuit of counting relay 731, and extends the operating lead 729 to the winding of the No. 2 counting relay 723. In the manner previously described in response to further shunting impulses as the selector shaft advances, counting relays 723, 724, 726, 727, 712, 703 and 708 operate in the manner previously described. Relay 708 upon operating opens the fundamental circuit thereby releasing the selector control relay to arrest the further advance of the selector switch shaft. The selector has now been advanced to a position to trip its fourth set of brushes when it is later advanced in a group selecting movement.

Relay 703 upon operating again establishes the circuit of relay 624 which in turn opens the shunt around the right winding of transfer relay 718. Relay 718 now energizes in the locking circuit of relay 728 and closes a locking circuit for itself over its left winding and inner left front contact to ground on conductor 719. Relay 624 also opens the circuit of relay 623 which releases opening the fundamental circuit and the locking circuit of transfer relay 728. Relay 728 now releases in turn releasing all operated counting relays and relay 624.

Final group or tens selection

A circuit is now established for the transfer relay 716 preparatory to controlling final group or tens selection at the final selector 350 which circuit may be traced from battery, winding of relay 716, the right back contact of transfer relay 733, the inner right front contact of relay 718, the right front contacts of relays 721 and 701, conductor 702, right contact of relay 624, conductor 611, back contact of relay 703 to ground on conductor 704. A circuit is now established for slow operating relay 623, if at this time the tens digit has been fully registered, which may be traced from battery through the winding of relay 623, the left contact of relay 624, conductor 625, the left front contact of relay 701, the outer right alternate contacts of transfer relay 718, the left back contact of transfer

relay 733, conductor 833, the left back contact of relay 814, which will now be deenergized if the tens digit has been registered, to ground on conductor 804. As soon as relay 623 operates it again establishes the fundamental circuit causing the operation of the selector control relay and of the sender stepping relay 710, and establishes a locking circuit for relay 716 extending from battery through the winding of relay 716, the right winding of relay 733, the inner right front contact of relay 716, conductor 757 to ground at the right front contact of relay 623. Relay 733 being shunted at this time over the circuit previously traced through the right back contact of relay 624 does not operate in this locking circuit.

Having assumed that the tens digit registered was 7 and that tens register relays 820 and 822 have been operated, a circuit for the No. 2 counting relay 723 is established from battery, winding of this relay, the back contact of the No. 2' counting relay 724, the No. 2 control lead 725, lead 725 Fig. 8, the inner right back contact of tens register relay 835, the right front contact of register relay 820, the right back contact of register relay 836, conductor 837, the left contact of transfer relay 716, the front contact of sender stepping relay 710, conductor 632, the right back contact of relay 603, conductor 717, the left back contact of transfer relay 728 to ground at the outer left front contact of transfer relay 718. Counting relay 723 operates in this circuit and locks through its winding and the winding of the No. 2' counting relay 724, the contact of relay 723 to ground at the intermediate right front contact of transfer relay 716, but relay 724 being shunted by ground over the contacts of stepping relay 710 does not operate at this time.

At the selector the control relay again causes the selector shaft to advance in a brush tripping and group selecting movement, the switch commutator shunting down the sender stepping relay 710 as it approaches the first group selection position. When the sender stepping relay 710 becomes shunted and deenergizes the shunt around the No. 2' counting relay 724 is opened and relay 724 energizes extending the operating lead 725 to battery through the winding of the No. 1 counting relay 726. In response to the further advance of the selector switch shaft counting relay 726 and 727 become energized, the No. 1' counting relay 727 extending the operating lead 725 to the No. 0 operating lead 713 thence over the outer right front contact of transfer relay 716, conductor 735, the right front contact of tens register relay 822, conductor 838, the right back contact of the No. 9' counting relay 736 to battery through the winding of the No. 9 counting relay 737. In the well known manner as the selector shaft advances counting relays 738 to 745 operate,

whereupon, through the operation of the No. 5' counting relay 744 the operating lead 725 is extended over the front contact of relay 744 to conductor 714 thence to battery through the winding of the No. 0 counting relay 713. In response to the 8th shunting impulse from the selector counting relays 703 and 708 operate in the locking circuit of relay 712. Relay 708 upon operating opens the fundamental circuit thereby releasing the selector control relay to arrest the advance of the selector. The selector has therefore tripped its fourth set of brushes and has advanced them to a position just beneath the 8th tens group in the fourth bank.

Relay 703 upon operating again establishes the circuit of relay 624 which in turn opens the shunt around the right winding of transfer relay 733. Relay 733 now energizes in the locking circuit of relay 716 and closes a locking circuit for itself over its left winding and inner left front contact to ground on conductor 719. Relay 624 also opens the circuit of relay 623 which releases opening the fundamental circuit and the locking circuit of transfer relay 716. Relay 716 now releases in turn releasing all operated counting relays and relay 624.

Final units selection

A circuit is now established for the transfer relay 715 preparatory to controlling units selection at the final selector which circuit may be traced from battery through the winding of transfer relay 715, the right back contact of transfer relay 746, right front contacts of transfer relays 733, 718, 721 and 701, conductor 702, right contact of relay 624, conductor 611, back contact of relay 703 to ground on conductor 704. A circuit is now established for slow operating relay 623 extending from battery through the winding of relay 623, the left contact of relay 624, conductor 625, the left front contact of relay 701, the outer right alternate contacts of relay 718, the outer left front contact of relay 733, conductor 747, the left back contact of relay 819, if at this time the units digit has been registered, to ground on conductor 804. Upon the operation of relay 623 the fundamental circuit is again established for operating the control relay of the final selector and the sender stepping relay 710 and establishes a locking circuit for transfer relay 715 extending from battery through the winding of relay 715, the right winding of transfer relay 746, the inner right contact of relay 715, conductor 757 to ground at the right contact of relay 623. Relay 746 being shunted at this time over the circuit previously traced from the right back contact of relay 624 does not operate in this locking circuit.

It has been assumed that the units digit registered was 9 and that units register relays 824 and 825 have been operated. A cir-

cuit is now established for the No. 4 counting relay 749 extending from battery through the winding of relay 749, the back contact of the No. 4' counting relay 750, over the No. 4 operating lead 748, lead 748 Fig. 8, the right front contact of units register relay 825, conductor 839, the left contact of transfer relay 715, the contact of sender stepping relay 710, conductor 632, the right back contact of relay 603, conductor 717, the left back contact of transfer relay 728 to ground at the outer left front contact of transfer relay 718. Counting relay 749 energizes and locks through its winding and the winding of the No. 4' counting relay 750, the contact of relay 749 to ground at the intermediate right front contact of transfer relay 715, but relay 750 being shunted by ground over the contacts of stepping relay 710 does not operate at this time.

At the selector the control relay establishes the circuit of the slow speed up-drive magnet in the well known manner, causing the advance of the selector switch shaft in its units or line terminal selection movement. As the switch shaft advances the stepping relay 710 is intermittently shunted causing upon the first application of the shunt the operation of the No. 4' counting relay 750 in the locking circuit of relay 749. Upon successive applications of the shunt about relay 710, counting relays 731, 732, 723, 724, 726 and 727 operate, the operation of relay 727 extending the operating lead 748 to the No. 0 lead 713 thence over the outer right back contact of transfer relay 716, the outer right front contact of transfer relay 715, conductor 751, right front contact of units register relay 824, conductor 838, the back contact of the No. 9' counting relay 736 to battery through the winding of the No. 9 counting relay 737. In response to the further shunting of stepping relay 710 as the final selector advances counting relays 736, 738 to 745 inclusive operate, relay 744 extending the operating lead 748 to the winding of the No. 0 counting relay 712. In response to the 10th shunting of stepping relay 710 the counting relays 703 and 708 operate in the locking circuit of the No. 0 counting relay 712. Relay 708 upon operating opens the fundamental circuit thereby releasing the control relay of the final selector to arrest its line selection movement. The final selector has now advanced its brushes into connection with the terminals of the wanted line 300. The usual test is thereupon made to determine its idle or busy condition.

Relay 703 upon operating again establishes the circuit of relay 624 which in turn opens the shunt around the right winding of transfer relay 746. Relay 746 now energizes in the locking circuit of relay 715 and closes a locking circuit for itself over its left winding and inner left front contact to ground

on conductor 719. Relay 624 also opens the circuit of relay 623 which releases opening the fundamental circuit and the locking circuit of transfer relay 715. Relay 715 now releases in turn releasing all operated counting relays and relay 624. Upon the release of relay 624 the circuit last traced for relay 623 is reestablished and relay 623 operates again establishing the fundamental circuit but performing no other function at this time.

After the completion of units selection at the final selector the sequence switch of the incoming selector is advanced in the well known manner to reconnect the control relay of the incoming selector to the incoming circuit but in such a manner that the current which now flows through its winding over the fundamental circuit through the left winding of overflow relay 709 and the winding of the sender stepping relay is in the proper direction to operate the polarized overflow relay 709. Relay 709 upon operating now locks over its right winding, the right normal contacts of relay 752, the outer left back contact of relay 707 to ground at the contact of relay 709 and establishes a circuit for relay 752 extending from battery over the outer left back contact of relay 707 to ground at the contact of relay 709. Relay 752 upon energizing in this circuit opens the locking circuit of relay 709 at its right make-before-break contacts and locks through the winding of relay 707 to ground on conductor 704. Relay 707 does not operate in this locking circuit so long as overflow relay 709 remains energized.

At the incoming selector upon the operation of the control relay over the fundamental circuit the sequence switch is advanced to connect the control relay to the fundamental circuit in such a manner that the current now flowing through the left winding of relay 709 is not in the proper direction to hold relay 709 energized. Relay 709 upon deenergizing now opens the shunt around relay 707 which then energizes in the locking circuit of relay 752. Relay 707 upon operating at its inner left and right make-before-break contacts reverses the connection of the left winding of overflow relay 709 to the fundamental circuit so that when the incoming selector sequence switch has reached the trunk closure position relay 709 will again operate. Since now relay 709 is energized a circuit is established for relay 609 which may be traced from battery through the winding of relay 609, conductor 634, outer left front contact of relay 707 to ground at the contact of relay 709. Relay 609 upon operating locks over its left front contact to ground on conductor 704, releases relay 608 and at its right front contact establishes a circuit which may be traced from ground over said contact, conductor 635, the

right front contact of transfer relay 746, conductor 753, the right front contact of relay 808, this relay having been energized as previously described, conductor 840, the inner left back contact of relay 636 to battery through the winding of ringing relay 626. This relay upon energizing opens both conductors of the fundamental circuit at its back contacts releasing relay 709, and applies ground and the ringing current sources 637 to the fundamental circuit for operating the ringing relay in the incoming selector for initiating the ringing of the called subscriber's bell. Ringing then proceeds automatically and is tripped at the incoming selector when the subscriber answers.

Release of link circuit and sender

Upon the release of relay 608 a circuit was established from ground at its back contact over conductor 638, the left contact of relay 752, conductor 754, the outer left front contact of relay 721, the outer left front contact of relay 746, conductor 755 to battery through the winding of relay 604. Relay 604 energizes and locks over its right contact to ground at the inner right contact of relay 605, opens at its inner left back contact one shunt around the right winding of relay 602 extending through the left normal contacts of relay 603 and opens a second shunt around the right winding of relay 602 extending through the outer left contact of relay 604, conductor 639 to ground at the left back contact of relay 802. The inclusion of the right winding of relay 602 in the circuit previously traced to battery from the windings of relays 524 and 525 reduces the current flowing to such an extent that relay 525 releases. It will be recalled that relay 524 did not previously operate due to its marginal winding.

The release of relay 525 opens the holding circuit of relay 512 and also opens the holding circuits of relay 306 of the trunk circuit and relay 511 of the link circuit. Relay 511 releases in turn releasing relay 503. With relays 503 and 512 deenergized a circuit is now closed for release magnet 421 of the trunk finder 450 extending from battery through the winding of magnet 421, the intermediate springs of off-normal contacts 409, conductor 422, the intermediate upper contacts of relay 500, the upper back contact of relay 507, the innermost lower back contact of relay 512 to ground at the lower back contact of relay 503. Magnet 421 upon energizing releases the finder 450 to normal whereupon the off-normal contacts 409 are opened, opening the circuit of magnet 421 and the holding circuit of relay 500. Relay 500 thereupon releases. All operated apparatus of the link circuit with the exception of sender finder 550 has now been restored to normal. Switch 550 being of the non-

restoring type, remains in the position into which it was last set and starts from that position to hunt for an idle sender on the next call.

5 Upon the release of relay 512 the circuit previously traced through the windings of relay 602 at the sender is opened and relay 602 releases in turn releasing relays 601 and 605. These latter relays upon releasing re-
10 move the holding ground from the holding circuits of all operated relays of the sender and such relays release restoring the sender to its normal idle condition.

15 At the trunk circuit upon the release of relay 306 circuits in parallel through the windings of cut-through relays 308 and 312 are established from battery through the windings of these relays, the two uppermost contacts of relay 304, the upper back contact
20 of relay 306 to ground at the upper front contact of relay 303. Relay 308 upon operating disconnects the tip and ring contacts of jack 301 from the pulsing conductors 310 and 309 and connects such contacts to the left wind-
25 ings of repeating coil 314 and at its upper contact prepares a circuit for ringing relay 311 and connects battery through resistances 315 and 318 for padding the toll line repeater circuit. Relay 311, however, does not oper-
30 ate at this time due to the inclusion of high resistance 315 in the circuit thereof. Relay 312 upon operating, at its outermost back contacts disconnects the tip and ring conductors of the outgoing end of the trunk circuit from
35 the fundamental circuit conductors 313 and 420 and connects the tip and ring conductors through to the right windings of repeating coil 314 thereby establishing a talking circuit from the toll line terminating in jack
40 101 over the operator's cord circuit, the trunk circuit of Fig. 3, thence over the talking conductors of the incoming selector 325 and final selector 350 to the called subscriber's line 300.

45 After the connection has been established to the called line and before the subscriber has answered there is signaling battery on the incoming selector trunk which as soon as relay 312 operates causes the energization of the supervisory relay 316 over the outer front
50 contacts of relay 312 and the right winding of repeating coil 314. Relay 316 upon operating establishes a circuit from the sleeve of jack 301 over the upper low resistance winding of relay 302 to ground at the upper front
55 contact of relay 316 thereby reducing the resistance of the sleeve supervisory circuit to such an extent that marginal relay 215 at the operator's position operates, if at the time the operator has not restored key 102 to its nor-
60 mal position. Relay 215 upon operating establishes a circuit from ground over its contact through low resistance 219 thence over conductor 218, the next to lower alternate contact of key 102 to battery through lamp
65 122. If the key 102 has been restored the cir-

cuit of relay 215 is not established over the sleeve circuit, but the sleeve circuit is extended directly to lamp 122 over the lower normal contact of key 102. Lamp 122 upon lighting at this time is a special signal to the operator that the wanted subscriber's bell is being rung.

70 When the called subscriber answers thereby discontinuing the application of ringing current as hereinbefore described, the signaling battery is removed from the incoming selector trunk thereby causing relay 316 to re-
75 lease and to extinguish the lamp 122. Had the called line been found to be busy when connection was made therewith the circuit previously traced through the trunk super-
80 visory relay 316 would have been intermittently interrupted at the incoming selector thereby causing the flashing of the supervisory lamp 122. Should the operator desire
85 to rering the called subscriber she may do so by throwing the ringing key 116 of her cord circuit to the left thereby interrupting the tip talking conductor of her cord circuit and establishing a circuit from battery
90 through low resistance 145, the innermost lower alternate contacts of key 116 tips of plug 118 and jack 301, inner upper front contact of relay 308, the upper left winding
95 of repeating coil 314 to ground through the winding of ringing relay 311. Since battery through low resistance 145 is now connected in parallel with battery connected over the
100 upper contact of relay 308 through high resistance 315, relay 311 operates opening at its back contacts the talking circuit of the trunk and connecting the ringing current source
105 317 and ground respectively to the outgoing tip and ring conductors of the trunk circuit. In response to this application of ringing current the ringing relay of the incoming selector again applies ringing current to the
110 called line.

Should the operator desire to change toll
115 cords after the connection has been completed and the called subscriber has answered it becomes necessary to hold the trunk connection and also to provide a busy test potential on the sleeve of jack 301 so that another oper-
120 ator will not seize the same trunk during the interval that it takes the originating operator to remove one toll cord and to insert another. The trunk circuit is held during the change
125 of toll cords by ground supplied over the upper back contact of relay 316, the inner upper front contact of relay 312 to battery through the winding of relay 303 whereby
130 relay 303 is held energized after sleeve relay 302 deenergizes following the removal of the cord plug from the jack 301 and holds the trunk relays 304, 308 and 312 operated. A busy condition is maintained on the sleeve of
135 jack 301 through the upper winding of relay 302 over the inner lower front contact of re-
140 lay 312 thence to battery through high re-

sistance 319. When the second toll cord plug is inserted into the jack 301 relay 302 reoperates under control of battery supplied over the sleeve of the toll cord.

When the established connection is no longer desired the resistance of the sleeve circuit extending over the sleeve of the toll line jack 101, the sleeve of plug 100, the inner upper normal contacts of key 102 to battery through lamp 114 is reduced to such an extent that lamp 114 lights. Upon the hanging up of the called subscriber's receiver the circuit of trunk supervisory relay 316 is again established reducing the resistance of the sleeve circuit extending over the sleeves of jack 301 and plug 118 as previously described thereby causing the illumination of cord lamp 122. The operator noting the illumination of both lamps 114 and 122 then proceeds to take down the connection whereupon the trunk circuit of Fig. 3 and the selectors used in establishing the connection are restored in the well known manner.

Incomplete registration of digits

At the time the sender was seized by the link circuit and relay 601 operated, ground was connected over the left intermediate front contact of relay 601 to the start lead 641 extending to a common timing circuit to start timing on the selected sender. The timing circuit may be of the type disclosed in the patent to A. C. Powell, No. 1,577,076, issued March 16, 1926. Thereupon ground is connected at the timing circuit to conductor 642 thence over the outer right front contact of relay 601 to battery through the left winding of timing relay 643. Relay 643 operates and locks over its right winding and right contact to ground at the outer left contact of relay 605 and connects the left winding of timing relay 644 over its left contact to timing lead 645. After an interval measured by the operation of the timing circuit, if the operator has not at that time completed the setting up of four digits on the sender registers and relay 643 is still locked, ground will be applied to the timing lead 645 thereby operating relay 644 which then locks over its right winding and inner right front contact to ground at the outer left contact of relay 605, establishes at its left contacts alarm circuits extending to the timing circuit and at its outer right contact establishes an obvious circuit for relay 603.

If incoming brush selection has been made and no further digits have been registered relay 603 closes a circuit extending from battery through the winding of relay 623, the left back contact of relay 624, conductor 625, the outer left back contact of transfer relay 700, conductor 756 to ground at the right front contact of relay 603. Relay 623 operates establishing the fundamental circuit for controlling incoming group selection. At its

right back contact relay 603 opens the circuit previously traced through the contact of the sender stepping relay 710 for controlling the sender counting relays whereby the incoming selector is not arrested until it arrives in the tell-tale position. At its left transfer contacts ground on the middle winding of relay 602 is transferred to the low resistance left winding of relay 602 over the outer left back contact of relay 636, the left front contact of relay 603, the inner left back contact of relay 604 thereby reducing the resistance of the circuit previously traced to battery through the windings of relays 524 and 525 of the link circuit. Marginal relay 524 now operates substituting interrupted ground for battery through high resistance 533 over the next to upper contact of relay 512, conductor 534, brush 423 of trunk finder 450, conductor 424 through the upper low resistance winding of sleeve relay 302 of the trunk to the sleeve of jack 301. The application of intermittent ground to this circuit now causes the supervisory relay 122 to flash as a recorder signal that the connection has failed of completion.

At the sender when the incoming selector has reached the tell-tale position and reverses the connection of battery and ground to the fundamental circuit, overflow relay 709 operates followed in turn by the operation of relays 752, 707 and 609 and the release of relay 608 as previously described. Since at this time transfer relay 721 has not been operated a circuit is established for relay 604 extending from battery through the winding of relay 604, conductor 755, the left back contact of relay 721, conductor 754, the left contact of relay 752, conductor 638 to ground at the back contact of relay 608. Relay 604 upon operating now proceeds, as before described, to release relays 524 and 525 thereby initiating the release of the sender and link circuit. Until the link has restored battery through high resistance 533 is applied over the circuit previously traced to the sleeve of trunk jack 301 to hold the trunk busy.

If selection control has proceeded beyond the incoming selector and no further digits have been registered the timing circuit causes relays 643, 644 and 603 to function as previously described, relay 603 opening the circuit previously traced for controlling the sender counting relays whereby the final selector is permitted to advance to the tell-tale position. When the final selector reaches the tell-tale position the incoming selector is advanced as previously described for a completed connection reversing the connection of battery and ground to the fundamental circuit thereby operating the sender overflow relay 709. Relay 709 upon operating causes the operation of relays 752, 707 and 609 and the release of relay 608. From this point the circuits function in the manner

previously described in connection with the advance of the incoming selector to its tell-tale position.

When the operator observes the flashing of lamp 122 she recognizes it as a recorder signal and withdraws the plug 118 from jack 301. This releases all operated relays of the trunk circuit and also releases the operated selector switches.

When the operator prematurely withdraws plug 118 from the jack 301 thereby releasing the relays of the trunk circuit the holding circuit previously traced through the winding of trunk relay 306 and the winding of relay 511 of the link circuit is opened and relay 511 in turn releases relay 503. Since at this time relay 525 is held operated from the sender, relay 512 is held operated and a circuit is established from ground through low resistance 535, the upper back contact of relay 503, the next to lower front contact of relay 512, the innermost upper back contact of relay 501, brush 518, conductor 519, the back contact of relay 600, the inner right front contact of relay 601, the outer right front contact of relay 606 through the right winding of relay 640 to ground at the inner left contact of relay 601. Relay 640 now operates in turn establishing an obvious circuit for relay 636 which operates and locks over its outer right contact to ground at the outer left contact of relay 605. At its intermediate right front contact relay 636 establishes an obvious circuit for relay 603 which functions in the manner previously described and causes either the incoming or final selector, depending on how far the call has progressed, to advance to the tell-tale position.

In the sender relays 709, 752, 707 and 609 are then operated in the manner previously described and relay 608 is released. If the incoming group selection has not at the time been made and the incoming selector is thus advanced to the tell-tale position the release of the sender and link circuit will proceed as above described. If incoming group selection has been made and the final selector is driven to the tell-tale position then upon the release of relay 608 with relays 752 and 636 operated, a circuit is established for relay 604 extending from battery through the winding of relay 604, the inner right front contact of relay 636, conductor 646, the left back contact of transfer relay 746, the outer left front contact of transfer relay 721, conductor 754, the left contact of relay 752, conductor 638 to ground at the back contact of relay 608. Relay 604 thereupon operates initiating the release of the sender and link circuit in the manner previously described. At its inner right back contact relay 636 also removes relay 603 from the control of the timing circuit and at its inner left back contact opens the circuit of relay

626 to prevent the functioning of the ringing relay 626.

Establishment of an outward connection

In the preceding description it has been assumed that the operator has established an inward call, or a call incoming to her position from a distant toll point and has terminated such call in an office of an exchange in which her position is located. When, however, the call has originated from a subscriber's line in a local office, as for example from the subscriber's line 300 and the operator has received a toll ticket indicating that that line desires a toll connection which for example may be reached over the toll line 101, she will proceed to obtain the toll connection and will also plug into the jack 301, if the trunk of Fig. 3 is idle, and will proceed in the manner previously described to establish a connection with the line 300.

In this case, however, she will also depress key 141 at her position for the purpose of canceling the immediate application of ringing current from the sender when the final selector has been set by the sender upon the terminals of line 300, as it is not desirable to ring the subscriber until the connection to the toll point has been fully established and the desired party has been brought in on the toll connection. Since, however, the subscriber's line 300 has been selected that line is held against seizure pending the completion of the toll connection. With key 141 depressed the connection of relays 142 and 143 to the pulsing conductors extending to the sender and to battery through the windings of relays 807 and 808 is reversed. Therefore when registrations have been completed and relays 142 and 143 operate in turn operating relay 144, ground is applied over the upper front contact of relay 144, the upper alternate contacts of key 141 to the circuit previously traced to battery through the winding of relay 807. Relay 807 is therefore operated instead of relay 808. When therefore selections are completed under the control of the sender and relay 609 operates, the circuit previously traced for relay 626 extending to the right front contact of relay 808 is not effective and ringing current is not therefore applied from the sender. From this point the circuits function as previously described for an inward connection.

When the toll connection has been completed and the operator desires to call the subscriber 300 whose line has thus been selected she may do so by operating the ringing key 116 of her cord circuit thereby causing the ringing relay 311 of the trunk circuit to apply ringing current to the incoming selector for applying ringing current to subscriber's line 300.

When the operator discovers that she has depressed a wrong key in setting up the num-

ber of a desired subscriber she may correct her error, provided the sender has not already progressed to the point where the units digit control is exercised, by removing the plug 118 from the trunk jack thereby releasing the trunk circuit, the link circuit, sender and operated selectors and then depressing the key 126. The operation of key 126 opens the holding circuit of relay 119 which thereupon releases relays 127, 128 and 124. The operator may then proceed to reestablish the call taking for that purpose another idle trunk circuit.

Should the operator erroneously depress a key of the key set 150 before the sender has become attached relay 128 will not at the time be operated and a circuit will be established from battery through the winding of relay 129, the inner upper back contact of relay 128, to ground through contacts of any operated key of the key set. Relay 129 upon operating locks over its upper front contact to ground on the inner lower front contact of relay 119, at its lower front contact connects lamp 131 in a flashing circuit to interrupter 151, and at its upper back contact opens the circuit of relay 128. To prepare the key set for use again the operator must depress key 126 to release relay 119 and relay 129.

The operator may, if she desires, use the plug 100 for extending calls outgoing to dial switching offices. In that case she will depress key 146 instead of key 123 thereby operating relay 115 to connect her key set 150 to the tip and ring conductors of plug 100, otherwise her position equipment functions in the same manner as hereinbefore described.

In the previous description the manner in which the digits 1, 3, 7 and 9 are registered has been discussed. By reference to the following table it will be apparent how any digit may be registered for example on the thousands register relays:

Digit	Pulsing relays operated	Register relays operated
0	617	None
1	617 618	813
2	617 618 619	813 826
3	617 618 619	813 826
4	617 614 615 616	813 826 827 828
5	617 614 615	813 826 827 828
6	617 618 614 615	813 826 827 828
7	617 618 619 614 615	813 826 827 828
8	617 618 619 614 615	813 826 827 828
9	617 614 615 616	813 826 827 828

Miscellaneous functions of the link circuit

If the trunk taken for use by the operator terminates in the tenth or last terminal set of a level of the trunk finder 450, when the finder reaches that terminal set in hunting for the trunk, relay 500 is operated in a circuit extending from battery through its upper winding to ground on springs 425 closed when the finder reaches its tenth ro-

tary step position. Relay 500 then arrests the further stepping of the finder and performs the other functions previously described in connection with its operation regardless of whether the circuits for relays 306 and 511 have become effective. If, however, the operator has abandoned the call before the finder has reached the terminal set of the calling trunk, or a false ground has started the finder from normal the relays 306, 511 and 503 will not be operated and therefore when the finder reaches its tenth rotary step position with relay 500 operated as just described a circuit will be closed for release magnet 421 extending from battery through the winding of this magnet and intermediate springs of off-normal contacts 409, conductor 422, the upper intermediate front contact of relay 500, the upper back contact of relay 507, the innermost lower back contact of relay 512 to ground at the lower back contact of relay 503. Magnet 421 will thereupon cause the release of the link circuit.

Should the trunk finder 450 be moved off normal by hand accidentally the upper springs of off-normal contacts 409 will be closed and a circuit will be established for relay 500 extending from battery through its winding, the off-normal contacts, conductor 426 to ground at the lower back contact of relay 501. Relay 500 upon operating then closes the previously traced circuit for release magnet 421 thereby restoring the finder 450 to normal.

Whenever all trunks are busy at the time a call is initiated on a trunk circuit the relays of all links corresponding to relay 500 will be operated and therefore the chain circuit extending from battery through the winding of relay 427 thence in multiple through the upper normal contacts of make busy jacks corresponding to jack 402 of each link and the next to innermost lower back contact of relays corresponding to relay 500 of each link to ground through the winding of relay 428 will be opened and relays 427 and 428 will release. The release of these relays closes an obvious circuit for relay 401 which upon operating opens the start conductors of all links so that all links which have released but still have relays 500 locked may return to normal allowing them to continue to serve calls.

If at the time relay 401 operates a trouble ground exists on the start conductors between the group relays 400 and the corresponding links a circuit will be closed for relay 429 extending from battery through the winding of relay 429, the lower contact of relay 401 to the grounded start conductor, relay 429 operating and in turn closing the circuit of relay 430. The circuit of relay 430 may be traced from battery over the continuity contacts of relay 430 to ground at the

contact of relay 429. Relay 430 upon operating locks to ground at the key 431 over its own contacts and establishes the circuit of relay 413 which thereupon operates. Relay 413 upon operating releases all operated relays 500 of the group of links causing such links to release and return into service.

What is claimed is:

1. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from an operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, link circuits each comprising a trunk finder and a sender finder, means operative upon the connection of a cord circuit with a trunk circuit for causing an idle link circuit to associate an idle sender with said trunk circuit, a key set at said operator's position associable with any cord circuit of said position, and means controlled from said key set over the talking conductors only of said cord circuit for setting the registers of said sender.

2. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, link circuits each comprising a trunk finder and a sender finder, means operative upon the connection of a cord circuit with a trunk circuit for causing an idle link circuit to associate an idle sender with said trunk circuit, a key set at said operator's position associable with any cord circuit of said position, and means controllable from said key set over the talking conductors only of said cord circuit by strong and weak impulses of positive or negative current for setting the registers of said sender.

3. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operative upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, a key set at said operator's position associable with any cord circuit of said position for setting the registers of an associated sender, and means at said position operable over one of the talking conductors of said cord circuit for associating said key set with the talking conductors of said cord circuit as

soon as an idle sender has become connected therewith over said trunk circuit.

4. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operative upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, a key set at said operator's position associable with any cord circuit of said position for setting the registers of an associated sender, means at said position operable from said sender for associating said key set with said cord circuit as soon as an idle sender becomes connected therewith over said trunk circuit, and means for signaling said operator when said sender has become connected.

5. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operative upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, a key set at said operator's position associable with any cord circuit of said position for setting the registers of an associated sender, means at said position operable from said sender for associating said key set with said cord circuit as soon as an idle sender becomes connected therewith over said trunk circuit, and means for signaling said operator if she depresses a key of said key set before said sender has become attached.

6. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operative upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, a key set at said operator's position associable with any cord circuit of said position for setting the registers of an associated sender, a relay at said position controlled from said sender for associating said key set with said cord circuit as soon as an idle sender becomes associated therewith over said trunk circuit, a second relay at said position operable upon the depression of any key of said key set if at the time said first relay has not operated, and means controlled by said second relay

for signaling said operator that she has prematurely operated said key set.

7. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, a key set at said operator's position associable with any cord circuit of said position for setting the registers of an associated sender, means at said position operable from said sender for associating said key set with said cord circuit, and means operable from said sender for disassociating said key set from said cord circuit as soon as said sender registers have been set from said key set.

8. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, a key set at said operator's position associable with any cord circuit of said position for setting the registers of an associated sender, a relay at said position controllable from said sender for associating said key set with said cord circuit, and a pair of relays operable respectively over the two talking conductors extending from said cord circuit over said trunk circuit thence to said sender when said sender has completely registered the digits of a wanted line number, said relays being jointly operative to release said first relay for disassociating said key set from said cord circuit.

9. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, means at said operator's position for setting the registers of an associated sender, and means in said sender operative following the connection of said trunk circuit with a subscriber's line for applying ringing current to said trunk for signaling said subscriber.

10. In a telephone exchange system, an operator's position having a plurality of cord

circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said operator's position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, means at said operator's position for setting the registers of an associated sender, means associated with each cord circuit for applying ringing current to said trunk circuit, means in said sender operative following the connection of said trunk circuit with a subscriber's line for applying ringing current to said trunk circuit, and means at said position for determining whether ringing current shall be applied from said sender or from said cord circuit.

11. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, means at said operator's position for setting the registers of an associated sender, means associated with each cord circuit for applying ringing current to said trunk circuit, means in said sender operative following the connection of said trunk circuit with a subscriber's line to apply ringing current to said trunk circuit, and means at said operator's position operative in accordance with the character of the call for determining whether ringing current shall be applied from said sender or from said cord circuit.

12. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, means at said operator's position for setting the registers of an associated sender, means in said trunk circuit under the control of said operator for applying ringing current to call the wanted subscriber, means in said sender operative following the connection of said trunk circuit with a called line to apply ringing current to call the wanted subscriber, and means at said operator's position operative in accordance with the character of the call for determining whether ringing current shall be applied from said sender

or from said trunk circuit under the operator's control.

13. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, means in said operator's position for setting the registers of an associated sender, means in said sender operative following the connection of said trunk circuit with a called line to apply ringing current to call the wanted subscriber, and means at said sender under the control of said operator in accordance with the character of the call for determining if said sender shall apply ringing current therefrom.

14. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the connection of a cord circuit with a trunk circuit to associate an idle sender with said trunk circuit, means in said operator's position for setting the registers of an associated sender, means in said sender operative following the connection of said trunk circuit with a called line to apply ringing current to call the wanted subscriber, a key at said position operable in accordance with the character of the call for determining if said sender shall apply ringing current, and a relay in said sender controlled by said key for controlling said ringing current applying means.

15. In a telephone exchange system, an operator's position having a plurality of cord circuits, called subscribers' lines, jack-ended trunk circuits and selector switches for extending a connection from said position to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, link circuits, means operative upon the connection of a cord circuit with a trunk circuit for causing an idle link circuit to associate an idle sender with said trunk circuit, means in said operator's position for setting the registers of an associated sender, a signal in said operator's cord circuit, means in said sender for advancing a selector switch to the tell-tale position if a call does not progress in a proper manner and means in said link circuit controlled from said sender when a selector advances to the tell-tale position for operating said signal in a distinctive manner.

16. In a telephone exchange system, called subscribers' lines, trunk circuits and selector switches for extending a connection to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, link circuits each comprising a trunk finder and a sender finder, means operative upon the seizure of a trunk circuit for causing an idle link circuit to hunt for said trunk circuit and for an idle sender, a test relay for said sender finder operable over a test brush of said sender finder when said finder encounters an idle sender, a disconnect relay in said sender, means in said sender upon the seizure thereof for associating said disconnect relay with said test brush and for disassociating said test relay from said brush, and means at said link circuit for establishing an operating circuit over said brush to operate said disconnect relay.

17. In a telephone exchange system, called subscribers' lines, trunk circuits and selector switches for extending a connection to said lines, a plurality of register senders common to said trunk circuits for controlling said selector switches, link circuits each comprising a trunk finder and a sender finder, means operative upon the seizure of a trunk circuit for causing an idle link circuit to hunt for said trunk circuit and for an idle sender, a test relay for said sender finder operable over a test brush of said sender finder when said finder encounters an idle sender, a differentially wound disconnect relay in said sender, means in said sender upon the seizure thereof for establishing a circuit serially through the windings of said disconnect relay, for connecting the joined terminals of said windings to said test brush and for causing the disassociation of said test relay from said brush, and means at said link circuit for establishing a shunting circuit over said brush for shunting one winding of said disconnect relay to cause its operation.

In witness whereof, I hereunto subscribe my name this 1st day of May, 1929.

WARREN W. CARPENTER.

In witness whereof, I hereunto subscribe my name this 2d day of May, 1929.

RALPH E. HERSEY.