

July 4, 1933.

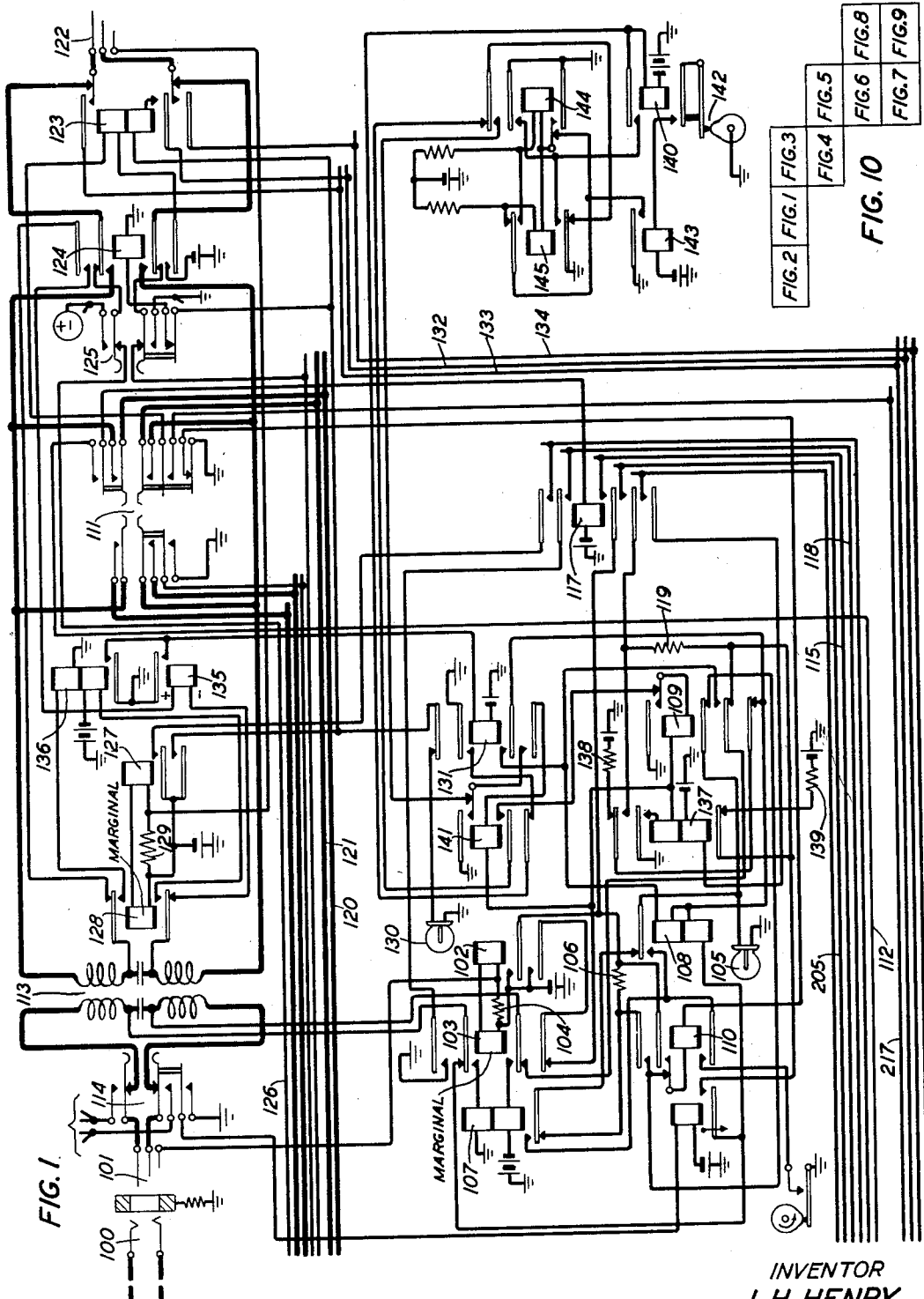
I. H. HENRY

1,916,760

TELEPHONE EXCHANGE SYSTEM

Filed Aug. 23, 1932

9 Sheets-Sheet 1



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

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9 Sheets-Sheet 2

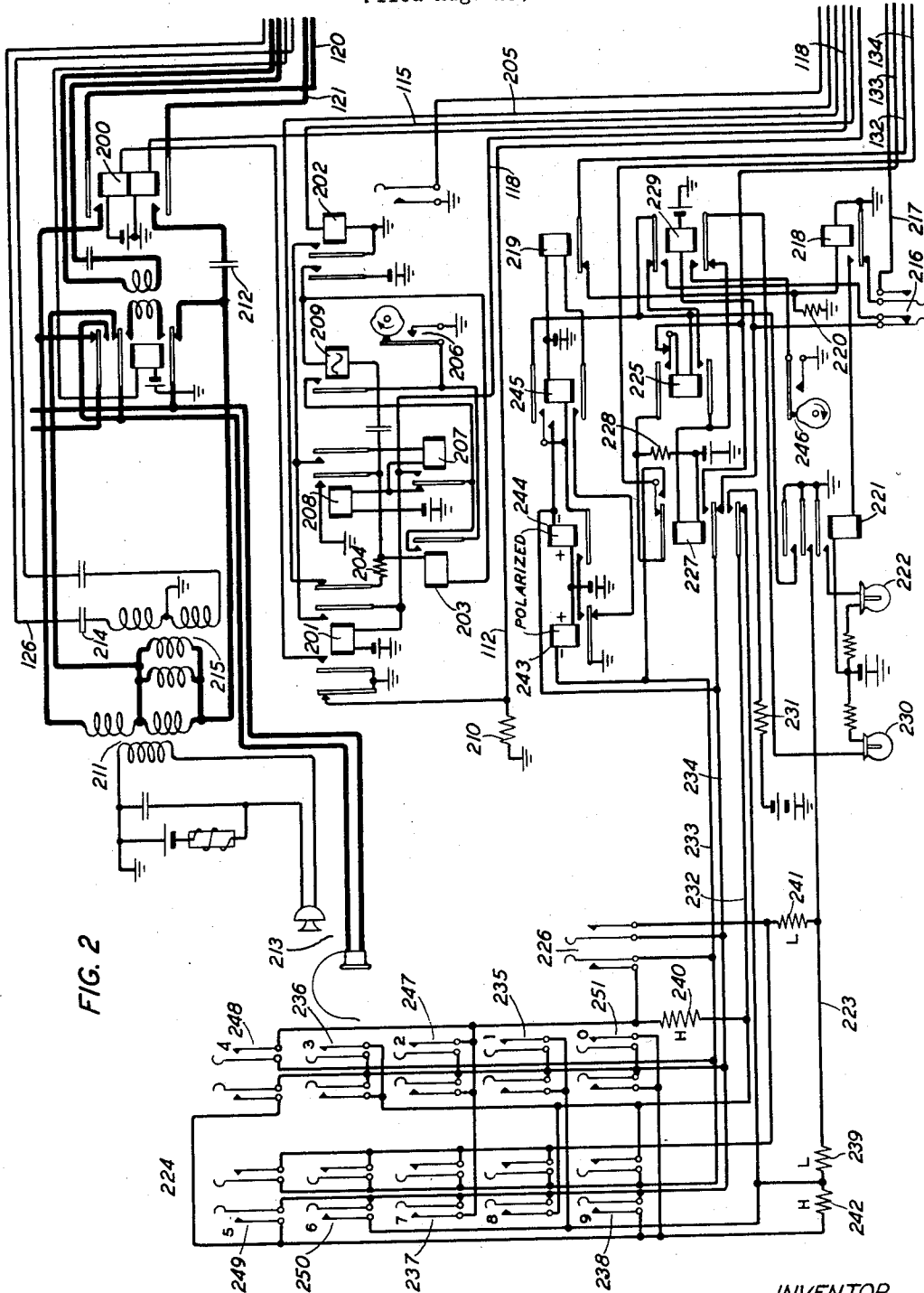


FIG. 2

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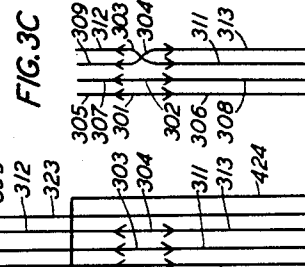
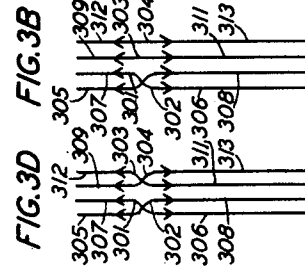
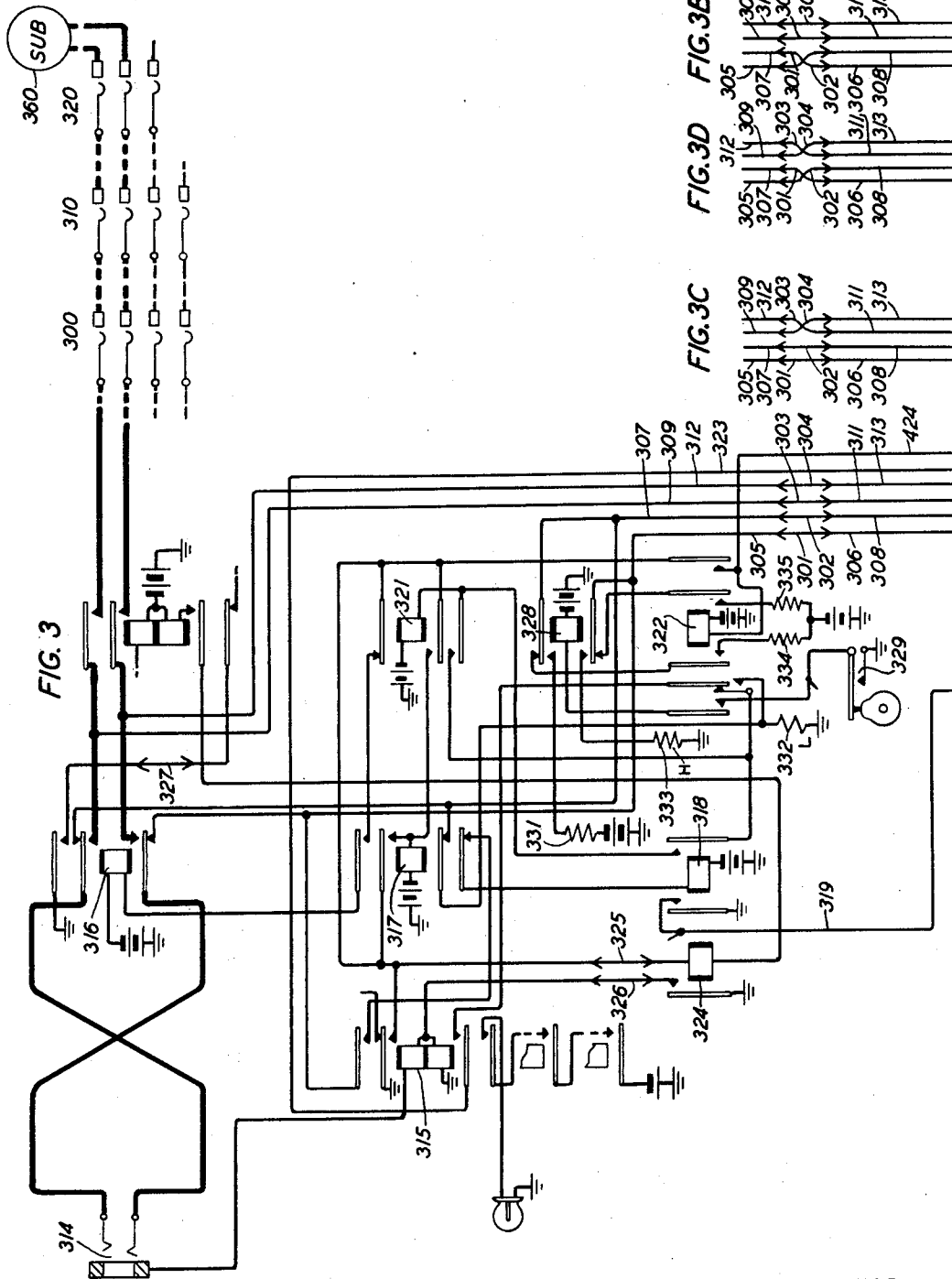
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9 Sheets-Sheet 4

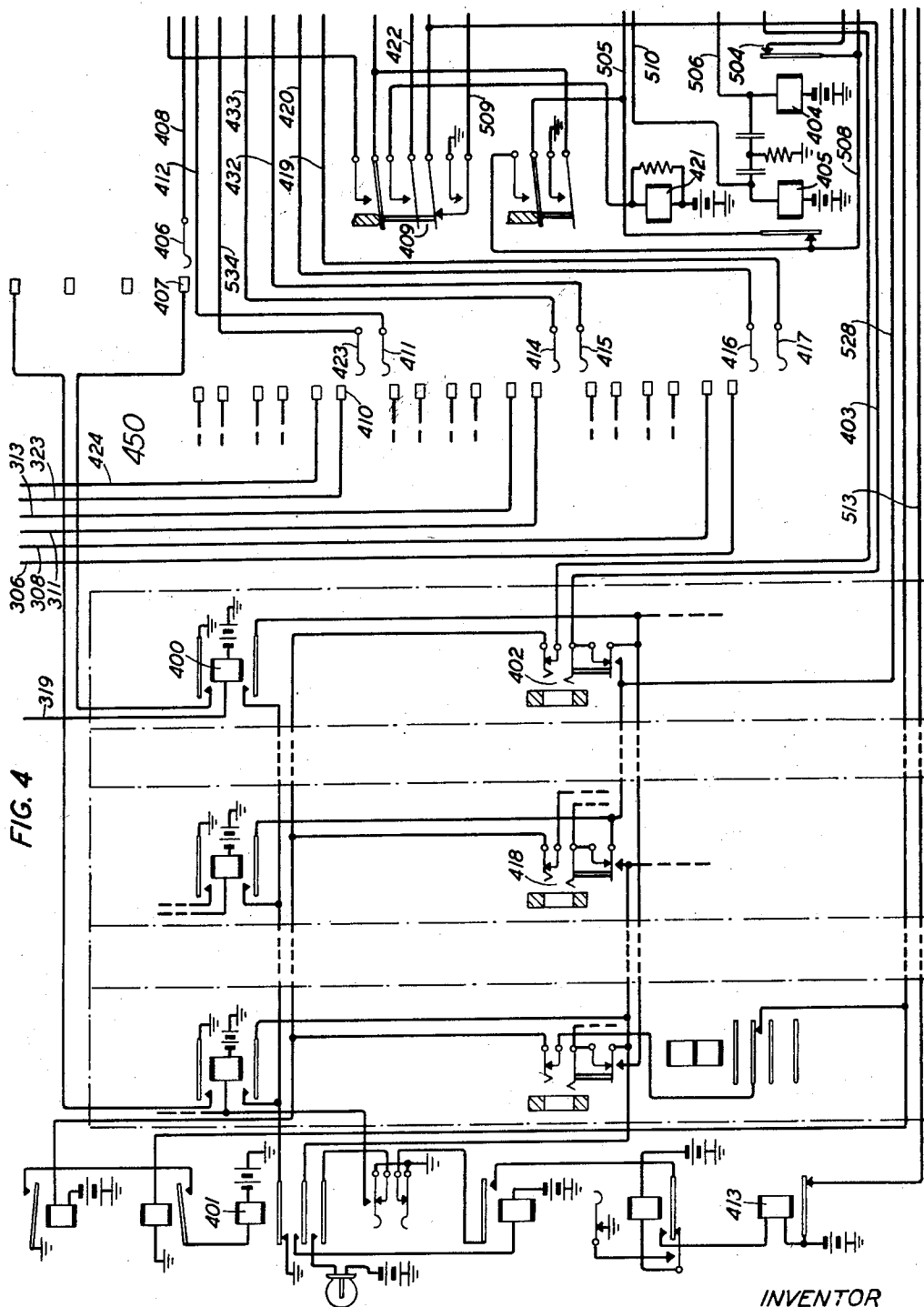


FIG. 4

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9 Sheets-Sheet 5

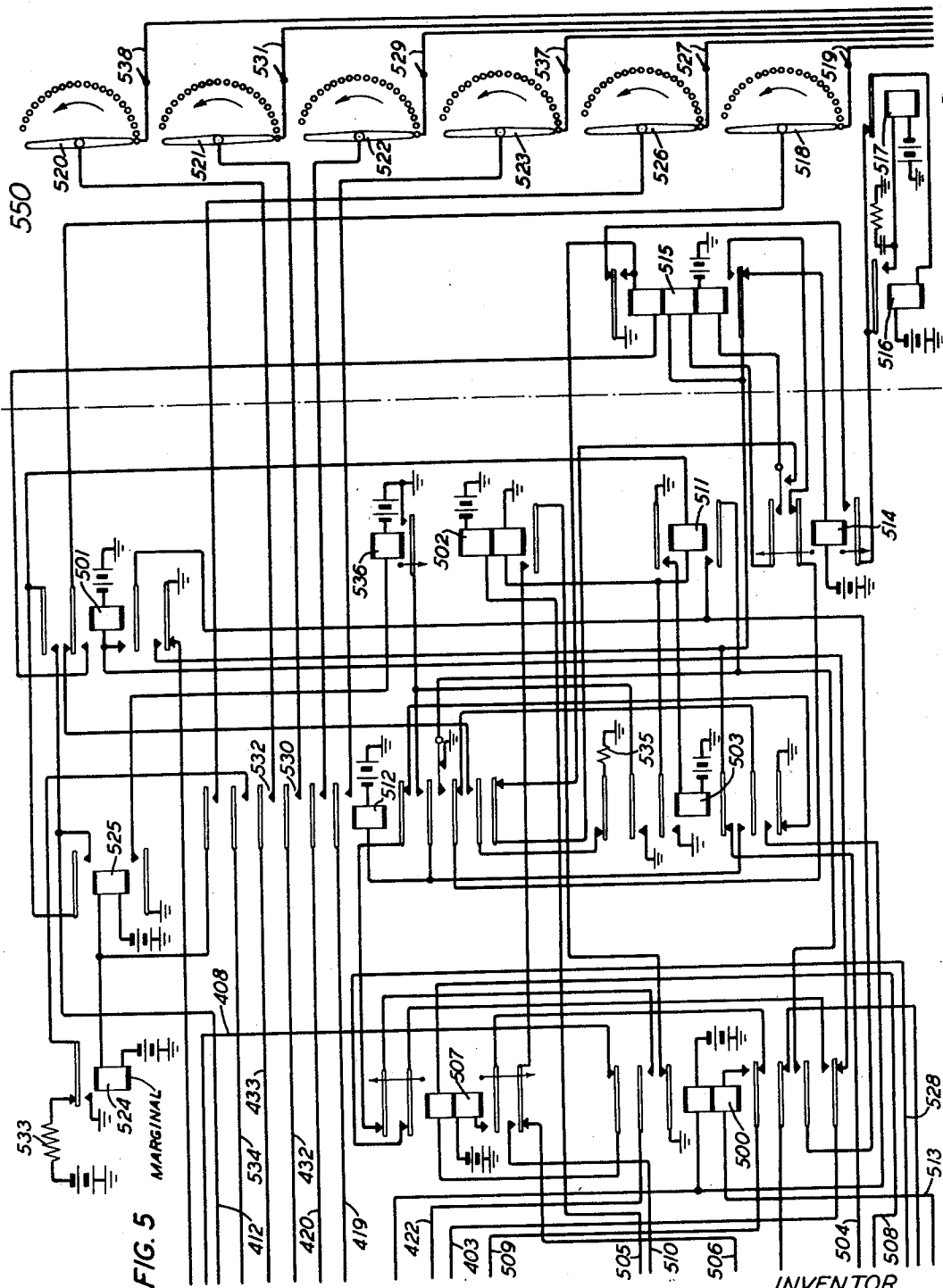


FIG. 5

MARGINAL

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9 Sheets-Sheet 6

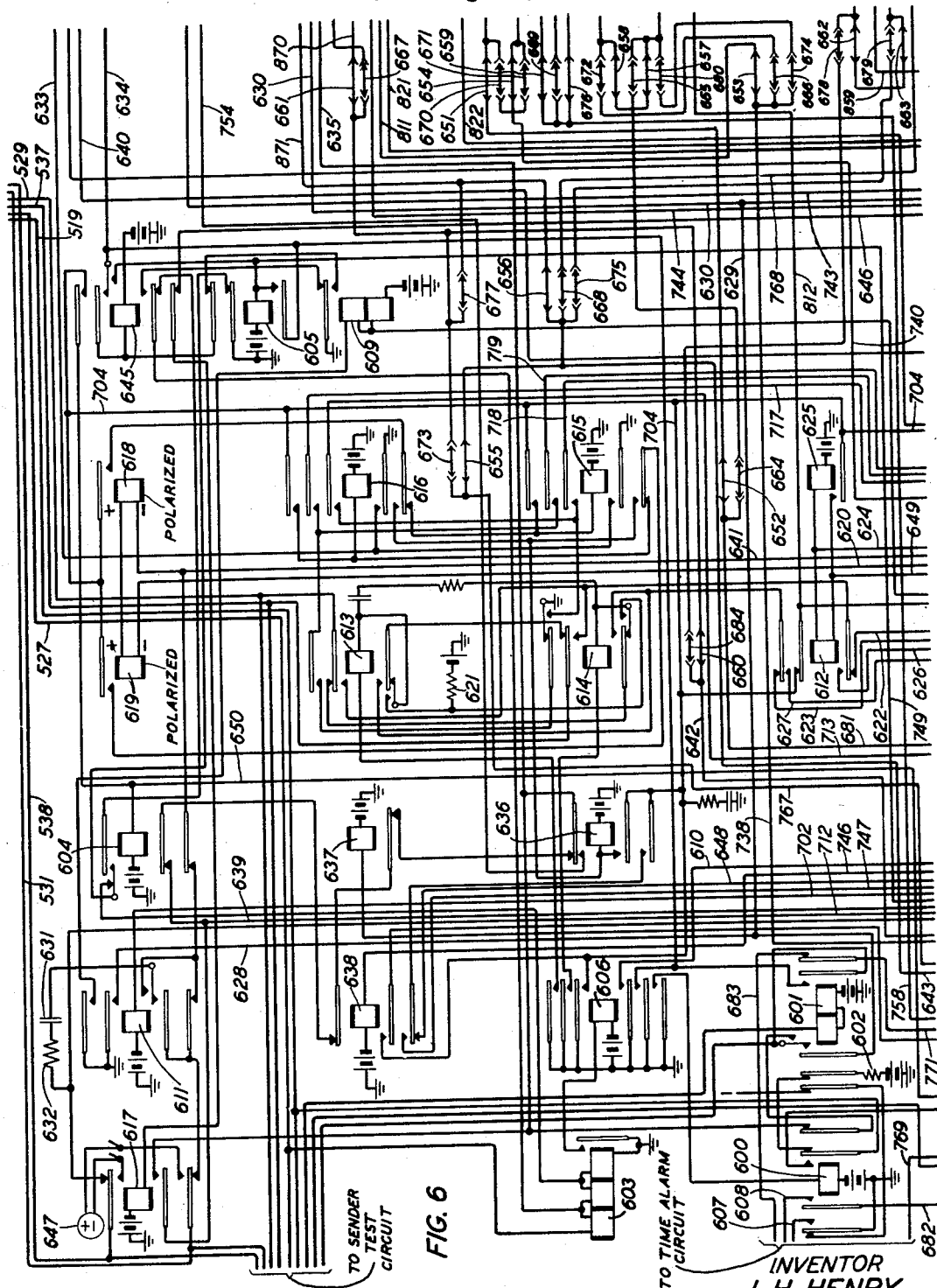


FIG. 6

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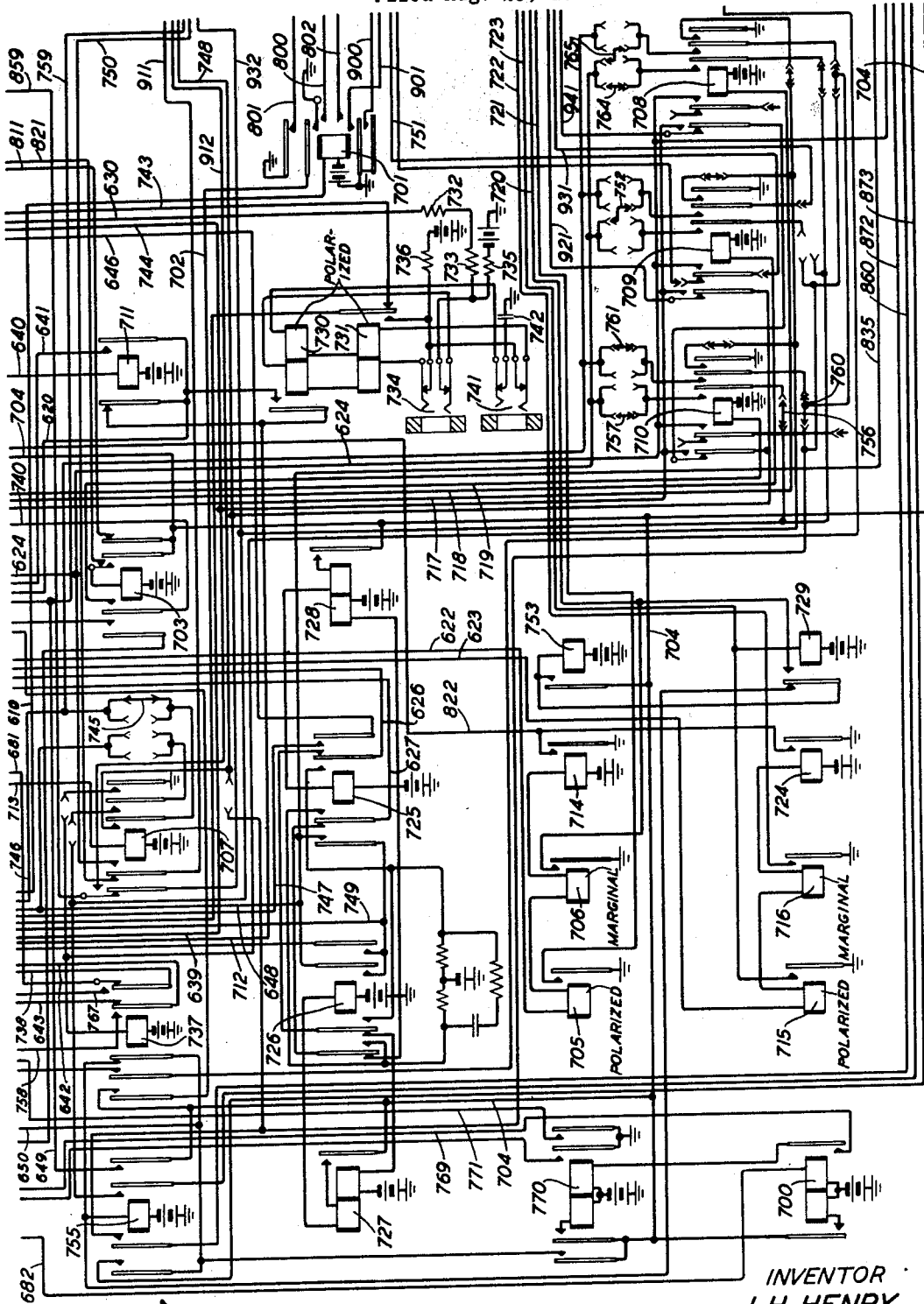


FIG. 7

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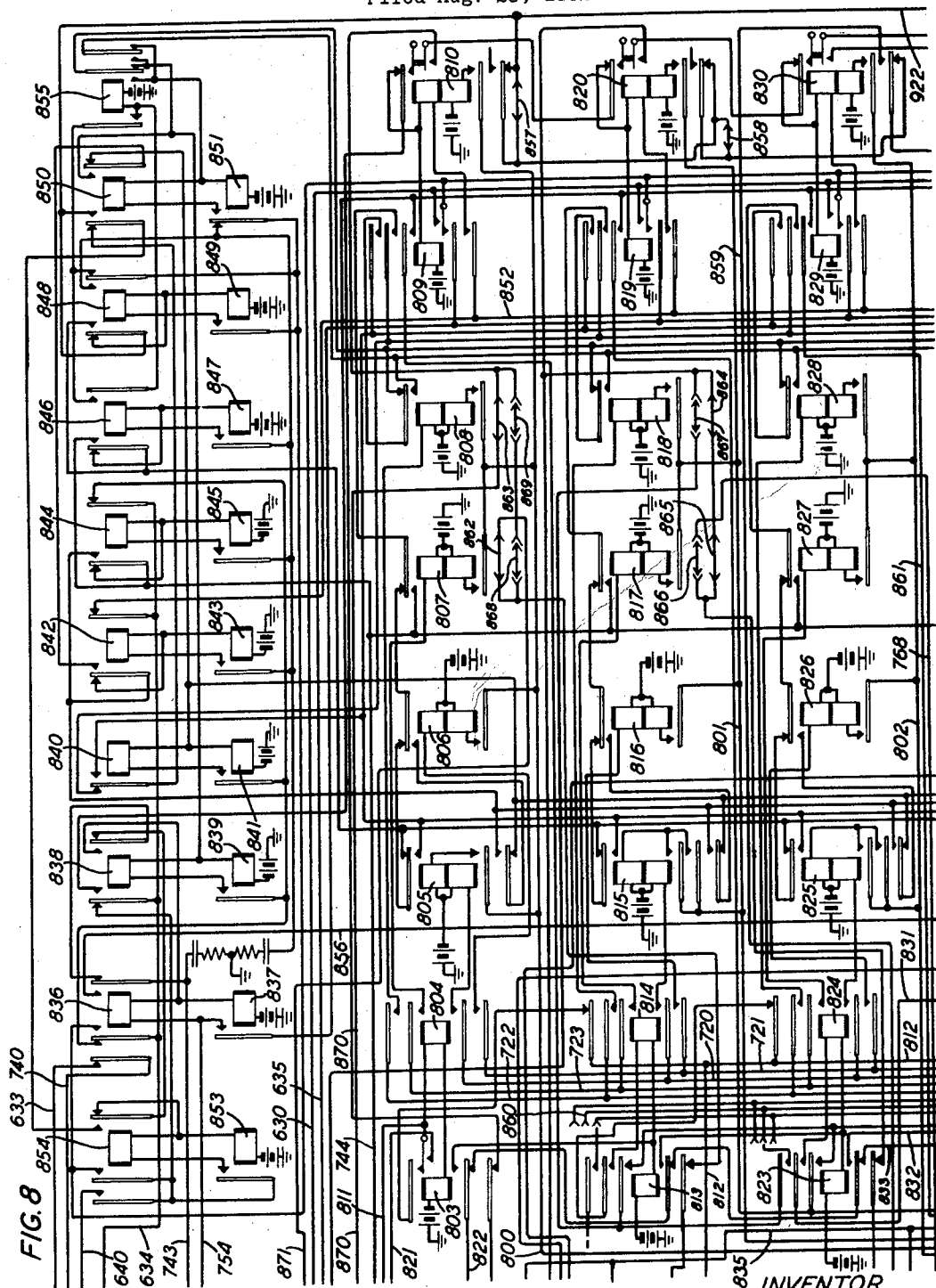
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TELEPHONE EXCHANGE SYSTEM

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9 Sheets-Sheet 8



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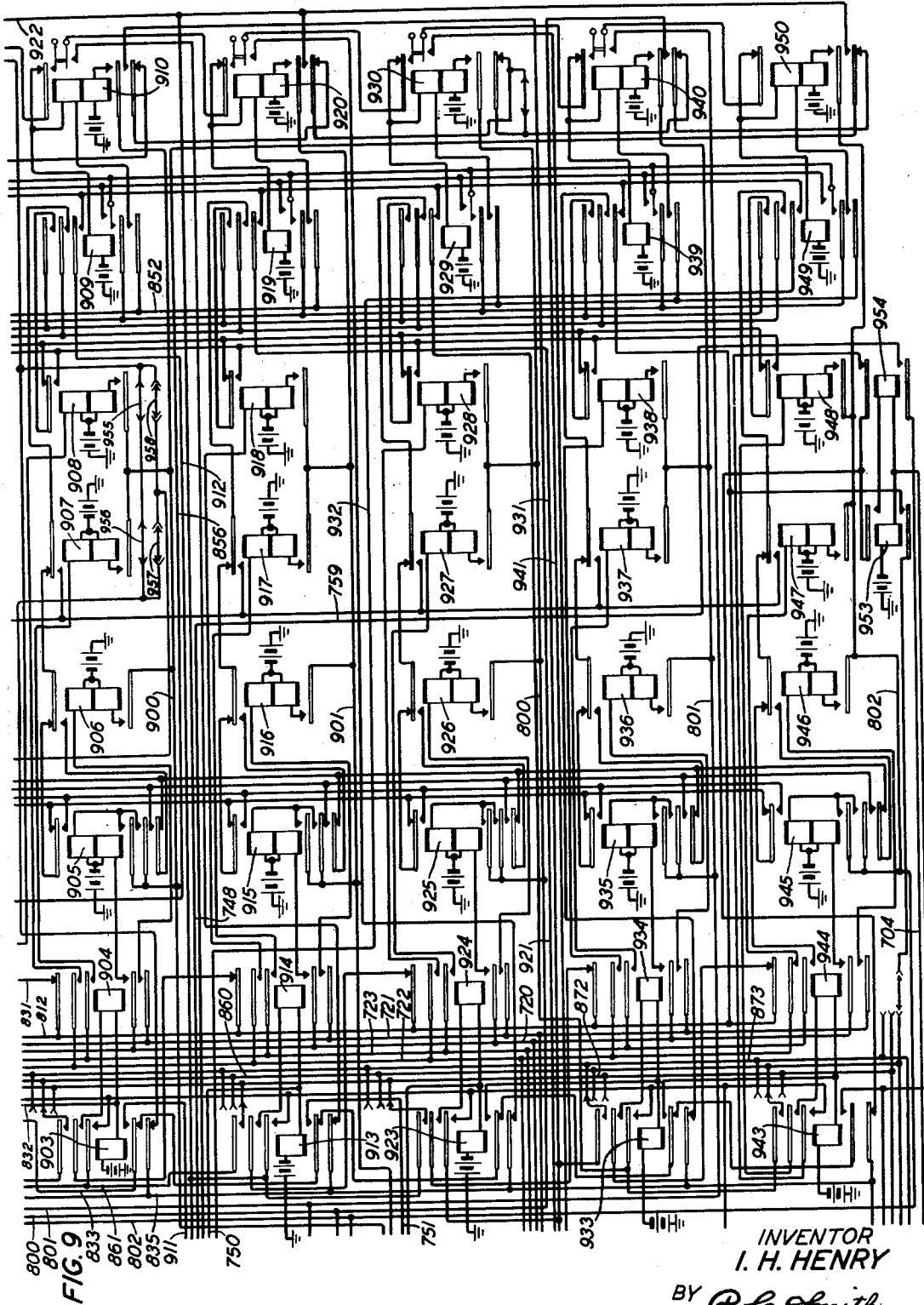
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TELEPHONE EXCHANGE SYSTEM

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9 Sheets-Sheet 9



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## UNITED STATES PATENT OFFICE

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## TELEPHONE EXCHANGE SYSTEM

Application filed August 23, 1932. Serial No. 630,009.

This invention relates to telephone exchange systems and more particularly to circuits for enabling an operator to complete calls over step-by-step switches. The object of the invention is to provide improved apparatus whereby an operator may control the setting of such step-by-step switches by a ten button keyset at her position.

The usual method of controlling step-by-step switches from an operator's position is to provide the operator's position with a dial which impulses directly into the step-by-step switches. It has been found, however, in practice that an operator can establish connections at far greater speed and thus establish more connections within a stated period if provision is made to enable the operator to write up the designations of desired connections upon a keyset at her position. Such an arrangement has heretofore been disclosed for enabling toll operators to complete connections over panel dial switching equipment in the Patent No. 1,780,906 granted November 11, 1930, to W. W. Carpenter and R. E. Hersey.

In accordance with the present invention, provision is made whereby an operator may set step-by-step switches to complete local or toll connections under the control of a set of ten digit keys at her position. This is accomplished through the provision of a sender which becomes associated with the outgoing trunk circuit taken for use by the operator to complete the desired connection, which sender is arranged to record the digits of the line designation keyed by the operator and to transmit directive impulses to step-by-step switches accessible over the outgoing end of the trunk circuit.

In step-by-step exchange systems the switch trains for completing connections may comprise a variable number of selector switches dependent upon the character of the call to be established. For the purpose of discriminating between classes of calls the trunks outgoing from the operator's position are divided into groups, four for example, each group being individual to a particular class of call. All trunks have access through a group of link circuits to a group of senders.

Any trunk taken for use by the operator becomes automatically connected to an idle sender immediately after the operator plugs a cord circuit of her position into the trunk jack. In order that the sender may know what class of call it is to control and therefore how many series of impulses it should transmit to selector switches, provision is made in the trunk circuit for setting up in the sender a class record corresponding to the group or class to which the particular trunk belongs. For this purpose each trunk, depending upon the group to which it belongs, establishes class registration circuits from the trunk to the sender as soon as the sender becomes connected to the trunk, over four control conductors, two of which are later used for transmitting digit registration control impulses from the operator's keyset and two of which later form the impulsing loop from the sender to the selectors to be set thereby.

Four class records are thereby set up in the sender corresponding to the four groups of outgoing trunks. These classes may be fixed, where all connections to be established by the sender will require the transmission of the same number of impulse series, or may be variable, where some connections made over the group of trunks may require a different number of impulse series than other connections over the same group. The grouping of the trunks and the corresponding class record established in the sender may also indicate whether or not immediate ringing is to be applied from the sender or whether a different timing interval is required between successive series of impulses transmitted from the sender.

On calls recorded in the sender as variable class calls a start indication is keyed by the operator which indicates to the sender when the operator has completed keying the entire designation of a call. For all fixed class calls the sender begins to transmit impulses in accordance with any registered digit as soon as the digit is registered. For variable class calls the sender may begin to transmit impulses in accordance with any registered digit as soon as the digit is registered or, if

desired, may delay the sending of impulses for a certain registered digit or digits until a succeeding digit has been registered or until the operator has keyed the start indication. This feature has been made the subject matter of an application of I. H. Henry and R. E. Hersey Serial No. 630,010, filed herewith.

For controlling the transmission of impulses from the sender to selector switches, two polarized relays are provided, the timing of whose operation is controlled through the charging and discharging of a condenser whereby timed impulses of a character which insures accurate setting of the selectors is attained. The number of impulses of any impulse series transmitted is controlled by a group of seven pairs of counting relays which are operated in succession by the impulsing relays, the number of pairs of relays operated during the transmission of any impulse series being under the control of the register upon which the operator has registered that particular digit. The counting relays are also employed in conjunction with the impulsing relays for measuring off time intervals between successive digit series to allow time for selectors to hunt for idle trunks and are also employed for measuring off a time interval for the application of ringing current from the sender on such class calls as require immediate ringing from the sender.

The time interval measured between successive digits for variable class calls may be varied by changing the number of pairs of counting relays which will be operated in accordance with the class of call registration recorded in the sender. This feature has been made the subject matter of the copending application of I. H. Henry and R. E. Hersey above referred to.

For a more complete understanding of this invention, reference may be had to the following detailed description taken in connection with the attached drawings in which:

Fig. 1 shows an operator's cord circuit for extending connections to trunks extending to dial switching offices and a portion of the equipment at the operator's position;

Fig. 2 shows the operator's keyset and telephone set circuits;

Fig. 3 shows a trunk circuit of one group or class terminating in a jack accessible to the operator's cord circuit of Fig. 1, and in a first selector switch and the diagrammatic representation of other selector switches and a called subscriber's line;

Figs. 3-B, 3-C and 3-D show modified strapping necessary when the trunk circuit belongs to other groups or classes;

Figs. 4 and 5 taken together show a link circuit for associating a sender such as is disclosed in Figs. 6 to 9, inclusive, 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 to 9, inclusive, show a sender circuit, Figs. 6 and 7 disclosing control relay equipment of the sender, Fig. 8 disclosing the impulse counting relays and relays of three of the sender registers, and Fig. 9 showing relays of the remaining registers of the sender; and

Fig. 10 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 shown in 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 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 and always remaining standing when idle on the terminals of the sender last used in extending a connection.

The selector switches disclosed diagrammatically in Fig. 3 may be of the well known Strowger type responsive to directive impulses transmitted thereto from the sender, but are preferably of the type usually employed for establishing toll connections.

#### *Completion of a call from an intercepting trunk*

It will be first assumed that a call is incoming to the operator's position of Fig. 1 over the trunk jack 100 from an intercepting trunk from a connector multiple and that the operator answers the call by inserting plug 101 of her cord circuit shown in Fig. 1 into jack 100. A circuit is established thereupon from ground over the sleeves of jack 100 and plug 101 to battery through the winding of relay 102 and the winding of marginal relay 103 in series and to battery in parallel therewith through the non-inductive winding 104 of relay 103. At the same time the trunk lamp (not shown) is extinguished. Relay 102 operates but relay 103 does not operate over a high resistance ground connected to the sleeve of the trunk employed for intercepting service from connector multiples, and establishes a circuit for the supervisory lamp 105 extending from battery over the inner contact of relay 102, resistance 106, back contact of relay 107, back contact of relay 108, to ground through lamp 105, and in parallel therewith from battery over the inner contact of relay 102, resistance 106, back contact of relay 107, back contact of relay 108, inner lower back contact of relay 109, inner normal contacts and winding of relay 110 to ground

at the lower right normal contact of key 111. Relay 110 locks in a circuit from battery at the inner contact of relay 102, inner upper alternate contacts and winding of relay 110 to ground at key 111. A circuit is now closed from battery through one winding of the back bridge relay of the connector (not shown) which has extended the connection to trunk jack 100, over the tips of jack 100 and plug 101, upper normal contact of key 114, upper left winding of repeating coil 113, upper back contact of relay 103, lower winding of relay 108, lower back contact of relay 109, upper back contact of relay 137, resistance 138 to battery and from ground through the other winding of the back bridge relay of the connector over the rings of jack 100 and plug 101, lower normal contact of key 114, lower left winding of repeating coil 113, inner lower back contact of relay 103, intermediate lower back contact of relay 109, lower back contact of relay 137 to battery through high resistance 139. Relay 108 does not operate in this circuit and due to the high resistance 139 the back bridge relay of the connector does not operate.

When the operator throws her listening key 111 to the right or talking position relay 110 releases and a circuit is established from ground at the outer left back contact of relay 201, conductor 112, upper right contact of key 111 to battery through the winding of relay 117 which operates and establishes a circuit from battery at the inner contact of relay 102, inner lower contact of relay 117, conductor 115, to ground through the winding of relay 202. Relay 202 operates and connects battery over its outer contact, winding of relay 203, resistance 204, right back contact of relay 201, conductor 205, middle lower contact of relay 117, resistance 119, middle lower back contact of relay 109, inner lower back contact of relay 103, lower left winding of repeating coil 113, lower normal contact of key 114, rings of plug 101 and jack 100 to the trunk circuit. Ringing current or silent interval battery operates relay 209 or relay 203, which connect ground through interrupter contacts 206, contact of relay 209 or relay 203, back contact of relay 207 to battery through the winding of relay 208. Relay 208 operates and locks through the winding of relay 207, outer contact of relay 208 to ground at the inner contact of relay 202. With relay 208 operated direct ground is connected through resistance 204 to the ring of the trunk over the path traced for tripping ringing current and for holding relay 203 operated. When the interrupter contacts 206 again open, relay 207 operates in the locking circuit of relay 208 and both relays are then held operated to ground at the inner contact of relay 202. When the interrupter contacts again close with relay 207 operated, relay 201 operates in a circuit

from battery through its winding, front contact of relay 207, front contact of relay 203 to ground at interrupter contacts 206. Relay 201 locks over its right front contact to ground at the inner contact of relay 202, opens the ringing circuit from the ring of the trunk through resistance 204 and the windings of relays 203 and 209, closes an obvious circuit through the upper winding of relay 200 and removes direct ground from the operating circuit of relay 117 in the cord circuit. Relay 117 is now held operated over the previously traced circuit to ground through resistance 210. Relay 117 of another cord circuit of the position will not operate in this circuit through resistance 210 in case a talking key of such cord circuit should at this time be operated to the talking position. This is for the purpose of preventing two cord circuits from being connected to the operator's telephone and key-set circuits at the same time.

Had the cord circuit been connected to an intercepting trunk circuit from a selector multiple, not requiring the tripping of machine ringing, relay 201 would be operated over conductor 118, inner upper contact of relay 117 to ground at the contact of relay 103 which in this case will be operated in series with relay 102. Relay 201 upon operating will cause the operation of relay 200.

With relay 200 operated, a talking path is established from the upper right winding of repeating coil 113, inner upper right contact of key 111, conductor 120, upper contact of relay 200, right winding of repeating coil 211, condenser 212, lower contact of relay 200, conductor 121, inner lower right contact of key 111, to the lower right winding of repeating coil 113. Assuming that the operator's telephone set 213 is plugged up, the talking path just traced is inductively associated therewith through the left winding of repeating coil 211 and the operator is enabled to converse with the calling subscriber to ascertain information concerning the desired connection.

It will be assumed that the desired connection is of a character which can be completed over a trunk such as is shown in Fig. 3, with the straps 301, 302, 303 and 304 connected as shown to joint conductors 305 and 306, 307 and 308, 309 and 311, and 312 and 313, and with straps 325, 326 and 327 also connected. The operator first tests for an idle trunk of the group by touching the tip of plug 122 to the sleeve of the jack of a trunk of that group. If the trunk is busy there will be battery potential on the sleeve and this potential will be transmitted over the tip of plug 122, the upper normal contacts of relay 123, the upper back contact of relay 124, the upper normal contact of key 125, conductor 126, condenser 214 to ground through the upper right winding of repeating coil 215

which induces the busy potential through the left winding of coil 215 into the operator's telephone set 213 thus producing a click in her receiver. Assuming that she tests the trunk circuit of Fig. 3 and finds that it is idle and receives no click, she inserts plug 122 into jack 314 thereby establishing a circuit extending from ground through the windings of relay 315, sleeves of jack 314 and plug 122, windings of relay 127 and marginal relay 128 in series to battery and in parallel therewith through resistance 129 to battery. Due to the inclusion of both windings of relay 315 in this circuit, marginal relay 128 does not receive sufficient current to operate but relay 127 operates. Relay 315 also operates and performs functions which will be described hereinafter.

Relay 127 upon operating closes a circuit extending from battery over its lower contact, the lower normal contact of key 125 to ground through the winding of relay 124 which operates, opening the busy test circuit at its upper back contact and at its inner upper and inner lower front contacts, connects the tip and ring contacts of plug 122 to the right windings of repeating coil 113. Relay 127 at its lower contact also establishes a circuit for lamp 130 extending over the upper back contact of relay 131. Preparatory to keying the digits necessary to complete the connection the operator now depresses the key 216 and with the talking key 111 operated to the right a circuit is established from ground at the lower back contact of relay 218, the right contact of key 216, conductor 217, the lower intermediate contacts of key 111, the upper winding of relay 123 to battery at the lower contact of relay 124. Relay 123 thereupon operates and locks in a circuit from battery over the lower contact of relay 124, lower winding and inner front contact of relay 123, conductor 132, back contact of relay 219 and in parallel to ground through resistance 220 and the winding of relay 218. Relay 218 operates in this circuit opening the initial operating circuit of relay 123 and closing an obvious circuit for relay 221 which operates. Relay 123 at its upper and lower alternate contacts disconnects the tip and ring contacts of plug 122 from the right windings of repeating coil 113 and connects these contacts over conductors 133 and 134 with the operator's keyset circuit.

Relay 221 upon operating closes an obvious circuit to light lamp 222, connects ground over conductor 223 for supplying operating ground to the keys of keyset 224 and establishes a circuit from ground at its upper contact, through the winding and upper normal contacts of relay 225, conductor 133, upper alternate contacts of relay 123, tips of plug 122 and jack 314, lower back contact of relay 316, upper front contact of relay 315, lower

back contact of relay 317 to battery through the winding of relay 318. Relay 318 operates in this circuit but relay 225 being marginal does not receive sufficient current to operate at this time due to the high resistance of relay 318.

*Starting a link circuit to hunt for the selected trunk*

Relay 318 upon operating establishes a start circuit which may be common, for example to a group of ten trunks, extending from ground at the left contact of relay 318 over conductor 319 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 connects ground over its upper contact to segment 407 of the group commutator of the link finder 450, corresponding to the bank level in which the selected trunk appears, in the case assumed, the first or lowermost segment, and establishes a circuit from ground at the back contact of relay 401, over the lower contact of relay 400, 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 contacts of relay 501, the inner lower back contact of relay 503, conductor 504, back contacts of vertical magnet 404 and rotary magnet 405, conductor 505 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, contact of relay 502 to 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 segment 407, brush 406, 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 contacts 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 321, the right contact of relay 318, the left normal contacts of relay 322, inner lower contact of relay 315, conductor 323, bank terminal 410, brush 411, conductor 412, upper front contact of relay 501, winding of relay 511 to ground through the lower winding of relay 502. Relays 321, 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 contact of relay 511 to ground at the intermediate lower normal contacts of relay 512 for holding relay 501 operated after relay 503 operates as later described. Relay 503 upon operating 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 back contact opens the initial operating and locking circuits of relay 507. Relay 507 thereupon releases.

At the trunk circuit upon the operation of relay 321, a circuit is established for relay 317 extending from battery, winding of relay 317, inner front contact of relay 321 to ground at the inner upper front contact of relay 315. Relay 317 locks directly to ground at the inner upper front contact of relay 315 over its inner upper front contact and opens the circuit of relay 318 which upon

deenergizing disconnects ground from start conductor 319 and opens the operating circuit of relay 321. Relay 321 is, however, held operated over conductor 323, inner lower front contact of relay 315, left normal contacts of relay 322 and the lower front contact of relay 321. When ground is removed from start conductor 319 group relay 400 releases if there is at the time no other trunk in the same group in a selective 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, front contact of relay 514, through the middle winding of relay 515 to ground at the lower front contact of relay 501. Relay 515 does not, however, become energized sufficiently to attract its armatures. At its lower contact, relay 514 establishes a circuit for stepping relay 516 of the sender finder 550 which extends from battery through the winding of relay 516, back contact of stepping magnet 517, 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. Magnets 517 and 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, inner right back contact of relay 600, inner left back contact of relay 601 to battery through resistance 602. 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 com-



pleted 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 innermost lower front contact to ground at the upper front contact of relay 503, opens at its intermediate lower back contact its own initial operating circuit, transfers the locking circuit of relay 501 from ground at the intermediate normal contacts of relay 512 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 603, the upper normal contacts of relay 604, to ground at the inner upper contact of relay 605 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 winding of relay 322 to battery for the purpose of marking the trunk busy so long as the link circuit is engaged therewith. Relays 525 and 603 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 circuits of relays 511 and 321 to hold the latter relays operated following the release of relay 501 and at its lower contacts establishes an obvious circuit for relay 536 which closes an alternative holding circuit for relay 512 for holding 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 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 418, 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 trunk 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 319 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 603 an obvious circuit is closed for relay 606 which in turn closes an obvious circuit for relay 600. Relay 600 disconnects battery through resistance 602 to make the sender busy to other sender finders, connects ground over its outer left front contact to the start lead 607 extending to the sender time alarm circuit and connects the right winding of the sender time alarm relay 700 to the lead 608 and over its inner right front contact prepares a circuit for relay 609. Relay 606 also closes an operating circuit from ground at its inner lower front contact over conductor 610 to battery through the winding of relay 701 which operates closing ground to conductors 800, 801, 802, 900 and 901 for furnishing locking ground to the sender register relays and closing a circuit over conductor 702 to battery through the winding of relay 611. Relay 611 operates to perform functions to be later described. Relay 606 also closes an operating circuit for transfer relays 803 and 804 in series over conductor 811, outer right back contact of relay 703, conductor 704, to ground at the inner upper front contact of relay 606. Relay 803 upon operating locks itself and relay 804 operated over its upper front contact, the upper back contact of relay 814, conductor 812, upper back contact of relay 612 to ground on conductor 704 and extends its locking ground over conductor 821, the right normal contacts and winding of relay 703 to battery. Relay 703 operates and locks over its right alternate contacts to ground on conductor 704 and opens the initial operating circuit of relays 803 and 804. Relay 804 upon operating connects the operating windings of the relays 805 to 808, inclusive, of the first sender register to the contacts of the key pulsing relays 705, 706, 715 and 716 in readiness to register the first digit keyed by the operator.

#### *Registering the class indication*

The trunks to which the sender has access are arranged in groups in accordance with the number of digits required to complete

calls. Further subdivision in grouping may be made as follows: trunks requiring automatic start of ringing and trunks not requiring automatic start of ringing; trunks requiring 0.6 seconds timing between the transmission of series of impulses and trunks requiring 0.4 seconds timing between the transmission of series of impulses. Each group, consisting of trunks for which the sender is required to pulse out a single fixed number of digits or of trunks for which the sender is required to pulse out several different numbers of digits under the control of the operator's start key 226, and for which similar ringing and timing conditions are required constitute a class. The sender determines the class of the call at the time of seizure by the polarity of leads 306, 308, 311 and 313 of the truck to which it is connected.

The sender is arranged to function with four classes of trunks which will be hereinafter referred to as classes A, B, C and D, class relays 707 to 710, inclusive, being provided to register these classes. Any class may require a fixed number of digits to be keyed or a variable number of digits followed by an operation of start key 226; automatic start of ringing or no ringing; 0.6 seconds timing between any two series of impulses sent out or 0.4 timing between any two series of impulses that do not require trunk hunting, as the impulse series transmitted to set a connector switch. A class containing a variable number of digits may consist of digits requiring automatic start of ringing and also digits requiring no ringing. The polarity connected to leads 306, 308, 311 and 313 leading from each trunk circuit to the sender through the link circuit is determined by the arrangement of straps 301 to 304, inclusive.

With the sender now associated with the trunk circuit the following relays of the sender may or may not be operated, dependent upon the strapping in the trunk circuit. If battery is connected to conductor 306, relay 613 operates in a circuit from conductor 306, brush 417, conductor 419, inner upper front contact of relay 512, brush 523, conductor 537, inner upper back contact of relay 614, lower normal contacts and winding of relay 613 to ground at the upper contact of relay 606. If battery is connected to conductor 308, relay 614 operates in a circuit from conductor 308, brush 416, conductor 420, next-to-inner-upper contact of relay 512, brush 522, conductor 529, upper back contact of relay 613, lower normal contacts and winding of relay 614 to ground at the next-to-upper contact of relay 606. If battery is connected to conductor 311 and ground to conductor 313, relay 618 operates in a circuit from battery on conductor 311, brush 415, conductor 432, contact 530 of relay 512, brush 521, conductor 531, lower back

contact of relay 617, inner lower front contact of relay 611, lower back contact of relay 604, windings of polarized relays 618 and 619 in series, conductor 620, back contact of relay 711, conductor 712, upper back contact of relay 617, conductor 538, brush 520, contact 532 of relay 512, conductor 433, brush 414 to ground on conductor 313, thus operating polarized relay 618, polarized relay 619 not receiving current in the proper direction to operate. Relay 618 in turn closes a circuit from battery, winding of relay 615, lower back contact of relay 616, contact of relay 618 to ground on conductor 704. If battery is connected to conductor 313 and ground to conductor 311 current flows through the windings of polarized relays 618 and 619 in such a direction as to operate relay 619 which in turn closes a circuit from battery, winding of relay 616, lower back contact of relay 615, contacts of relay 619, to ground on conductor 704. Either relay 613 or relay 614 upon operating locks from ground at contacts of relay 606 through its own winding and lower alternate contacts to battery through resistance 621. Either relay 615 or relay 616 upon operating locks from battery through its winding and upper front contact to ground on conductor 704.

Relay 613 if operated connects conductor 306 over the path just traced to conductor 537, thence over the inner upper back contact of relay 614, lower front contact of relay 613, upper back contact of relay 612, conductor 623, windings of relays 715, 716 and 724 to 24-volt battery, and connects conductor 308 over the path just traced to conductor 529 thence over the inner upper front contact of relay 613, lower back contact of relay 612, conductor 622, windings of relays 705, 706 and 714 to 24-volt battery. Relay 614, if operated, connects conductor 306 over the path traced to conductor 537, thence over the inner upper front contact of relay 614, lower back contact of relay 612, conductor 622, windings of relays 705, 706 and 714 to 24-volt battery, and connects conductor 308 over the path traced to conductor 529 thence over the upper back contact of relay 613, lower front contact of relay 614, upper back contact of relay 612, conductor 623, windings of relays 715, 716 and 724 to 24-volt battery. Circuits for class relays 707 to 710, inclusive, are closed as follows: With relays 614 and 616 operated, class relay 707 is operated in a circuit from battery through its winding, conductor 713, inner upper front contact of relay 616 to ground at the upper front contact of relay 614; with relays 613 and 616 operated class relay 708 is operated in a circuit from battery through its winding, conductor 717, intermediate upper contact of relay 616, upper front contact of relay 613 to ground at the upper back contact of relay 614; with relays 614 and 615 oper-



ated class relay 709 is operated in a circuit from battery, through its winding, conductor 718, inner upper front contact of relay 615, to ground at the upper front contact of relay 614; and with relays 613 and 615 operated, class relay 710 is operated in a circuit from battery through its winding, conductor 719, intermediate upper contact of relay 615, upper contact of relay 613 to ground at the upper back contact of relay 614.

The following table indicates the different sender relays that are operated by the transposition of leads 306, 308, 311 and 313 in the associated trunk circuit to give the four-class indications:

| Class indication | Battery on leads | Ground on leads | Relays operated |
|------------------|------------------|-----------------|-----------------|
| A.....           | 308 and 313      | 306 and 311     | 614, 616, 707   |
| B.....           | 306 and 313      | 308 and 311     | 613, 616, 708   |
| C.....           | 308 and 311      | 306 and 313     | 614, 615, 709   |
| D.....           | 306 and 311      | 308 and 313     | 613, 615, 710   |

In the case assumed, the trunk of Fig. 3 is a trunk of a fixed four-digit class requiring the automatic start of ringing from the sender only in case the call is being completed by an inward toll operator and requiring a short interval of 0.4 seconds between the last two impulse series which are to be transmitted therefrom to set the connector switch and, consequently the straps 301 to 304 are connected as shown to connect lead 306 to lead 305 and thence over the lower back contact of relay 316, tips of jack 314 and plug 122, upper alternate contacts of relay 123, conductor 133, upper normal contacts and winding of relay 225 to ground at the upper contact of relay 221; lead 308 to lead 307 thence over the upper back contact of relay 316, rings of jack 314 and plug 122, lower alternate contacts of relay 123, conductor 134, upper back contact of relay 227 to battery through resistance 228; lead 311 to lead 309 thence to ground through one winding of the control relay not shown of the first selector 300 in which the trunk terminates; and lead 313 to lead 312, thence to battery through the other winding of the control relay of the first selector 300. Thus as indicated in the preceding table, relays 614, 616 and class relay 707 are operated. As previously described relay 614 upon operating connects 24-volt battery through the windings of relays 705, 706 and 714 to conductor 306 and thence as traced to ground through the winding of relay 225 at the operator's keyset circuit, thereby operating relay 225 which locks over its upper alternate contact through resistance 228 to battery, closes the circuit of relay 227 over its lower contact, the upper back contact of relay 229 to ground at the upper contact of relay 221 and closes the circuit of lamp 230 from battery through the lamp, the lower back contact of relay 229,

the lower contact of relay 225, upper back contact of relay 229 to ground at the upper contact of relay 221. The lighting of lamp 230 at this time is a signal to the operator that the sender is in condition to receive and register the first digit.

Relay 227 upon operating connects 48-volt battery through resistance 231 and its lower front contact to conductor 232 for supplying battery to key contacts of keyset 224 and connects the keyset conductors 233 and 234 over its upper alternate and inner lower front contacts to conductors 134 and 133 and thence over the circuits traced to 24-volt battery through the windings of pulsing relays 715, 716 and 724 and the windings of pulsing relays 705, 706 and 714, respectively.

#### Keying the called line designation

It will be assumed that the operator in order to establish a connection to the line 360, the designation of which is the four-digit number 1379, depresses the keys 235, 236, 237 and 238 in the order named. Upon the depression of key 235 to register the thousands digit 1 ground on conductor 223 is connected through low resistance 239, the contacts of key 235, conductor 234, thence as traced to 24-volt battery, through the windings of impulse relays 705, 706, and 714. Due to the inclusion of low resistance 239, sufficient current flows to operate both the sensitive relay 714 and the marginal relay 706, but polarized relay 705 does not receive current in the proper direction through its winding to cause its operation.

Relay 714 upon operating, with transfer relay 803 operated as previously described, establishes a circuit extending from ground at its contact over conductor 822, inner lower front contact of relay 803, to battery through the winding of transfer relay 813. Relay 813 operates and locks in series with transfer relay 814 from battery through the windings of relays 813 and 814, middle upper front contact of relay 813, upper back contact of transfer relay 824 to ground on conductor 812, but relay 814 being shunted as long as relay 714 remains operated does not operate at this time. Relay 706, upon operating closes a circuit extending from ground at its contact over conductor 720, inner low contact of transfer relay 804, to battery through the lower winding of register relay 805. Relay 805 operates and locks over its upper winding and inner lower front contact to ground on conductor 800.

When the operator releases the depressed key 235, relays 706 and 714 release, relay 714 removing the shunt from around the winding of transfer relay 814, whereupon relay 814 operates in the locking circuit of relay 813, opening at its upper back contact the locking circuit of transfer relays 803 and 804 whereupon these relays release. Relay 804 dis-

connects the operating circuits extending from the windings of relays 805 to 808 inclusive of the first register from the contacts of impulse relays 705, 706, 715, and 716, and relay 814 upon operating connects the contacts of the impulse relays to the windings of relays 815 to 818, inclusive, of the second register.

When the operator depresses key 236 to register the hundreds digit 3, 48-volt battery on conductor 232 through low resistance 231, is connected over the contacts of key 236, conductor 234, thence as traced to 24-volt battery through the windings of impulse relays 705, 706, and 714. The direction of current now flowing through the windings of these relays is such as to operate the polarized relay 705 and since a low resistance has been included in the circuit relays 706 and 714 also operate. Relay 714 upon operating with transfer relay 814 operated closes a circuit from ground over conductor 822, inner lower back contact of transfer relay 803, lower front contact of transfer relay 813, to battery through the winding of transfer relay 823. Relay 823 operates and locks in series with the winding of relay 824, middle upper front contact of relay 823, conductor 831, upper back contact of transfer relay 904 to ground on conductor 812, but relay 824 being shunted as long as relay 714 remains operated does not operate at this time. Relay 706 upon operating closes a circuit extending from ground at its contact over conductor 720, inner lower front contact of transfer relay 814, to battery through the lower winding of register relay 815. Relay 815 upon operating locks over its upper winding and inner lower front contact to ground on conductor 801. Relay 705 upon operating closes a circuit extending from ground at its contact over conductor 721, lower contact of transfer relay 814 to battery through the upper winding of register relay 816. Relay 816 upon operating locks over its lower winding and front contact to ground on conductor 801.

When the operator releases depressed key 236, relays 705, 706 and 714 release, relay 714 opening the shunt around the winding of transfer relay 824, whereupon relay 824 operates in the locking circuit of relay 823, opening at its back contact the locking circuit of transfer relays 813 and 814 whereupon these relays release. Relay 814 disconnects the operating circuits of register relays 815 to 818 inclusive, from the contacts of impulse relays 705, 706, 715 and 716 and relay 824 upon operating connects the contacts of these impulse relays to the windings of register relays 825 to 828, inclusive.

When the operator depresses key 237 to register the tens digit 7 of the wanted line number, 48-volt battery on conductor 232 through low resistance 231 is connected

through high resistance 240, left contacts of key 237, conductor 234 thence as traced to 24-volt battery through the windings of impulse relays 705, 706 and 714. The direction of current now flowing through the windings of these relays is such as to operate polarized relay 705 and since high resistance 240 has been included in the operating circuit marginal relay 706 does not operate but sensitive relay 714 operates. Relay 714 upon operating with transfer relay 813 now released and transfer relay 823 operated, closes a circuit from ground at its contact over conductor 822, inner lower back contacts of relays 803 and 813, inner lower front contact of relay 823, conductor 832, winding of transfer relay 903 to battery. Relay 903 operates and locks in series with the winding of transfer relay 904, middle upper front contact of relay 903, back contact of transfer relay 914 to ground on conductor 812, but relay 904 being shunted as long as relay 714 remains operated does not operate at this time. Relay 705 upon operating closes a circuit extending from ground at its contact over conductor 721, lower contact of transfer relay 824 to battery through the upper winding of register relay 826. Relay 826 operates and locks over its lower winding and lower contact to ground on conductor 802.

Key 237 also closes a circuit from ground on conductor 223 through low resistance 241, right contacts of key 237, conductor 233 and thence as traced to 24-volt battery through the windings of impulse relays 715, 716 and 724. The current now flowing is not in the proper direction to operate polarized relay 715 but since only low resistance 241 has been included in the operating circuit both relay 724 and marginal relay 716 operate. Relay 724 upon operating merely duplicates the function of relay 714 already described and relay 716 connects ground at its contact over conductor 722, upper front contact of transfer relay 824 to battery through the upper winding of register relay 828. Relay 828 operates and locks over its lower winding and lower contact to ground on conductor 802.

When the operator releases depressed key 237 impulse relays 705, 714, 716 and 724 release, relays 714 and 724 opening the shunt around the winding of transfer relay 904 which now operates in the locking circuit of relay 903 opening at its back contact the locking circuit of transfer relays 823 and 824 whereupon these latter relays release. Relay 824 disconnects the operating circuits of the register relays 825 to 828, inclusive, from the contacts of the impulse relays. Relay 904 upon operating connects the contacts of the impulse relays to the windings of register relays 905 to 908, inclusive.

In response to the depression of key 238 for the units digit 9 48-volt battery is connected

through low resistance 231 over conductor 232, the right contacts of key 238, conductor 233 and thence as traced through the windings of impulse relays 715, 716 and 724 to 24-volt battery. Due to the connection of 48-volt battery through a low resistance all these impulse relays respond. Relay 724 upon operating connects ground at its contact over conductor 822, inner lower back contacts of transfer relays 803, 813, and 823, conductor 833, inner lower front contact of transfer relay 903, conductor 911, inner left front contact of class relay 707 which was assumed to be operated, conductor 624 to battery through the winding of relay 625. Relay 625 operates and locks through the winding of relay 612, front contact of relay 625 to ground on conductor 704, but relay 612 being shunted as long as relay 724 remains operated does not operate at this time. Relay 716 upon operating closes a circuit extending from ground at its contact over conductor 722, upper front contact of transfer relay 904 to battery through the upper winding of register relay 908. Relay 908 operates and locks over its lower winding and lower contact to ground on conductor 900. Relay 715 upon operating closes a circuit extending from ground at its contact over conductor 723, inner upper front contact of relay 904 to battery through the upper winding of relay 907 and in parallel through the winding of relay 729 to battery. Relay 907 operates and locks over its lower winding and lower contact to ground on conductor 900. Relay 729 also operates but is ineffective at this time.

Key 238 also closes a circuit from ground through low resistance 239, high resistance 242, left contacts of key 238, conductor 234, thence as traced to 24-volt battery through the windings of impulse relays 705, 706 and 714 but due to the direction and strength of the current flowing only relay 714 operates duplicating the function of impulse relay 724 already described.

When the operator releases the depressed key 238, impulse relays 714, 715, 716 and 724 release, relays 714 and 724 opening the shunt around the winding of relay 612, whereupon relay 612 operates in the locking circuit of relay 625, disconnecting ground from conductor 812 at its inner upper back contact thereby releasing transfer relays 903 and 904. Transfer relay 904 upon releasing disconnects the operating circuits of register relays 905 and 908, inclusive, from contacts of the impulse relays. Relay 612 upon operating disconnects the windings of impulse relays 705, 706 and 714 at its lower back contact from the impulse path previously traced to conductor 233 at the keyset circuit and extends the impulse path over its lower front contact, conductor 626, right back contact of relay 725, inner left back contact of

relay 726 to 48-volt battery through the right winding of relay 727, and disconnects the windings of impulse relays 715, 716 and 724 at its upper back contact from the impulse path previously traced to conductor 234 at the keyset circuit and extends this impulse path over its upper front contact, conductor 627, inner left back contact of relay 725, outer left back contact of relay 726 to 48-volt battery through the left winding of relay 728.

At the keyset conductor 233 extends through the winding of polarized relay 243 to 24-volt battery and conductor 234 extends through the winding of polarized relay 244 to 24-volt battery. Relays 243 and 244 both operate but relays 727 and 728 being marginally wound do not operate at this time. With relays 243 and 244 both operated an obvious circuit is closed for relay 245 which locks to ground at the upper contact of relay 221 and connects ground over its upper contacts to conductor 234 whereby marginal relay 727 in the sender operates and locks in a circuit extending from battery through the winding of relay 726, left winding and contact of relay 727, to ground on conductor 704. Relay 726 upon operating disconnects the operating windings of relays 727 and 728 from the circuits previously traced through the windings of polarized relays 243 and 244 at the keyset circuit, relay 243 now releasing but relay 244 being held operated over the upper contacts of relay 245. Relay 243 upon releasing closes a circuit from ground at its back contact, lower contact of relay 245, winding of relay 219 to battery. Relay 219 operates and opens the circuit of relay 218 which upon releasing in turn releases relay 221. Relay 221 upon releasing in turn releases relays 245, 244, 219, 225 and 227 and extinguishes lamps 222 and 230. Relay 221 upon releasing also releases relay 123 in the cord circuit. The operator's keyset circuit is now in normal condition.

If the operator disregards the pilot lamp 230 and starts keying a designation before the sender is attached and relay 227 has been operated from the sender, a circuit will be closed for relay 229 from battery through its winding, inner lower back contact of relay 227, conductor 234 to ground on conductor 223 through contacts of any operated key of the keyset 224. Relay 229 upon operating locks over the left contact of key 216, upper front contacts of relay 229 to ground at the upper contact of relay 221 and at its lower front contact connects lamp 230 in a flashing circuit with interrupter 246. To prepare the keyset for use the operator must press key 216 to release relay 229.

#### *Transmission of impulses to selector switches*

Returning to a consideration of the sender it will be recalled that relay 611 operated

when the sender was seized. Upon its operation a circuit was established for operating impulse generating relays 730 and 731 extending from ground at its inner upper front contact, conductors 628, 629 and 630, resistances 732 and 733, resistance 735 to battery and in parallel over the lower contacts of jack 734, left windings of polarized relays 730 and 731, upper contacts of jack 734, resistance 736 to battery in preparation for impulsing, relays 730 and 731 both operating. At this time, the impulsing loop to the first selector previously traced through the windings of relays 618 and 619 is now closed at the sender through the contacts of relay 730 and back contacts of relay 711 in parallel until relay 711 operates at the end of the synchronizing impulse as will be described. Relay 611 also at its lower front contact switches the condenser 631 and resistance 632 across the impulsing conductors 531 and 538 extending from the sender to the first selector 300. At this time condenser 742 associated with the impulse generating relays 730 and 731 is also charged in a circuit extending from ground through condenser 742, upper normal contacts of jack 741, right windings of relays 730 and 731, lower normal contacts of jack 741 to battery through resistance 736.

It will be assumed that the sender is arranged to start the transmission of the first series of impulses as soon as the first digit has been registered on calls of classes A and C having a fixed number of digits and to delay the transmission of the first series of impulses until after the first two digits have been registered on calls of classes B and D having a variable number of digits. For this purpose, straps 651 to 663, inclusive, of Fig. 6 straps 862 to 865 of Fig. 8 and straps 955 and 956 of Fig. 9 are connected as shown. As soon as the first digit has been registered on the relays of groups 805 to 808, inclusive, and transfer relay 803 has released as previously described, a circuit for transfer relay 809 is established extending from battery through the winding of relay 809, upper back contact of transfer relay 810, lower back contact of relay 803, straps 651 and 652, conductor 681, outer right back contact of relay 737, relay 737 not being energized since the class assumed is the fixed four-digit class, conductor 738, straps 653 and 654, conductor 835, inner left front contact of relay 703, conductor 740, left back contact of relay 836, conductor 633, to ground at the inner lower front contact of relay 616.

Relay 809 upon operating locks through the upper winding of relay 810, lower front contact of relay 809, conductor 852, right back contact of counting relay 842, conductor 634 to ground at the middle lower front contact of relay 606, but relay 810 being shunted does not operate at this time. Re-

lay 809 upon operating closes a circuit from ground on conductor 630, inner lower front contact of relay 809, conductor 635, upper back contact of relay 636, back contact of relay 637, upper back contact of relay 638, inner lower back contact of relay 604, conductor 639, front contact of relay 731, upper contacts of jack 734, left windings of relays 731 and 730, lower contacts of jack 734, to battery through resistance 735 and in parallel with the left windings of relays 731 and 730 to battery through resistance 736. The current flowing through the left windings of relays 730 and 731 now decreases since the left windings of these relays are now connected in a circuit from ground on conductor 630, through resistances 732 and 733 to ground and condenser 742 which was normally charged now discharges to ground on conductor 630, creating a flux in the cores of relays 731 and 730 which gradually builds up as the condenser 742 approaches full discharge in opposition to the flux created by the left windings of these relays until a point is reached when the relays 730 and 731 both release differentially.

When relay 731 opens its front contact the charging path for condenser 742 through the right windings of relays 730 and 731 previously traced is again effective, current now flowing through the right windings in the reverse direction and these relays continuing to release and to remain normal until condenser 742 approaches full charge condition and the current in the initial energizing circuit through the left windings of these relays has reached operating strength, when relays 730 and 731 will again operate. This pulsing action continues until ground is removed from the armature of relay 731 by the release of transfer relay 809, following the transmission of impulses for the first digit, by the release of transfer relay 819, following the transmission of impulses for the second digit, by the release of transfer relay 829 following the transmission of impulses for the third digit, the release of transfer relay 909 following the transmission of impulses for the fourth or last digit and the timing for trunk hunting between the transmission of digits has been allowed.

Upon the first release of relay 731 a circuit is established from ground on conductor 639, back contact of relay 731, conductor 743, right back contact of counting relay 836, right back contact of counting relay 838, back contact of counting relay 854, to battery through the winding of counting relay 853. Relay 853 upon operating locks through the winding of relay 854, front contact of relay 853, left back contact of relay 838 to ground on conductor 634, but relay 854 being shunted does not operate until relay 731 again operates. Relay 854 upon operating extends ground from conductor 634, over the left

back contact of relay 838, inner left contact of relay 854, to the armatures of the Nos. 6 and 7 counting relays 849 and 851 for affording locking ground for these relays, over the back contact of relay 851 to the armatures of the Nos. 3 to 5 counting relays 843, 845 and 847 for locking these relays when operated, and at its outer left contact connects ground from conductor 634, over conductor 640 to battery through the winding of pulse-help relay 711. Relay 711 upon operating closes a shunt around the windings of relays 618 and 619, extending from conductor 620, right front contact of relay 711 to conductor 641 thus removing these relays from the impulsing circuit extending from the sender to the selector switches and at its left contact opens one point in the impulsing circuit thus placing the impulsing circuit under the control of relay 730. The first impulse generated by the release of relay 730 is thus absorbed by relays 853 and 854, succeeding impulses transmitted by the successive operation and release of relay 730 being effective to cause the vertical stepping of the first selector 300 in the well known manner as long as relay 711 remains operated.

It has been assumed that the first digit registered in the sender on the relays of the group 805 to 808 was 1 and that register relay 805 was therefore operated. When relays 730 and 731 again release, relay 730 opens the impulsing circuit extending to the first selector 300 and relay 731 at its back contact connects ground over conductor 743, right back contact of relay 836, right back contact of counting relay 838, right front contact of relay 854, left back contact of counting relay 850, back contact of counting relay 846, middle upper contact of transfer relay 809, back contacts of register relays 807 and 806, upper front contact of register relay 805, upper front contact of transfer relay 809, upper back contact of register relay 808, inner right back contact of relay 855, winding of counting relay 839 to battery. Relay 839 operates and locks through the winding of relay 838, front contact of relay 839, inner left back contact of relay 836 to ground on conductor 634, but relay 838 does not operate in this locking circuit being shunted by ground over the back contact of relay 731. When relay 731 again operates this shunt is removed and relay 838 operates opening the locking circuits of relays 853 and 854 which now release in turn releasing relay 711. When relay 711 releases, the winding of relays 618 and 619 are again connected into the impulsing loop and the further operation of relays 730 and 731 is ineffective to transmit impulses to the first selector, since the impulsing contacts of relay 730 are now shunted by the left normal contacts of relay 711. A single impulse has

thus been transmitted to step the first selector one step vertically. The impulses generated by the operation of relay 731 are still effective and upon the next release of relay 731 a circuit is established from ground over the back contact of relay 731, conductor 743, right back contact of counting relay 836, right front contact of counting relay 838 to battery through the winding of counting relay 837. Relay 837 operates and locks through the winding of relay 836, front contact of relay 837, inner lower front contact of transfer relay 809 to ground on conductor 630. Relay 836 operates in this locking circuit upon the next energization of relay 731 opening at its outer left back contact the shunt around transfer relay 810 which operates in the locking circuit of transfer relay 809. The operation of relays 836 and 837 begins the timing interval to permit the first selector switch to hunt for an idle trunk in the first level of its bank to which its brushes have been moved.

Upon the next release of relay 731 ground is extended over its back contact, conductor 743, right front contact of relay 836, conductor 856, lower back contacts of transfer relays 950, 940, 930, 920, 910, 830, 820, strap 857, conductor 922, left back contact of counting relay 848, to battery through the winding of counting relay 849. Relay 849 operates and locks through the winding of relay 848, front contact of relay 849, inner left front contact of counting relay 836 to ground on conductor 634 and on the next energization of relay 731, relay 848 operates in this locking circuit. With relay 848 operated upon the next deenergization of relay 731 the operating circuit previously traced to the left armature of relay 848 is extended over the left front contact of relay 848, left back contact of counting relay 846, to battery through the winding of counting relay 847. Relay 847 now operates locking through the winding of relay 846 and its own front contact over the back contact of counting relay 851 and inner left front contact of relay 836 to ground on conductor 634. On the next energization of relay 731 relay 846 operates in this locking circuit. On the next deenergization of relay 731 the circuit over which relay 847 was operated is extended over the left front contact of relay 846, left back contact of counting relay 844, to battery through the winding of counting relay 845 which operates and locks through the winding of relay 844 and its own front contact, back contact of relay 851 and inner left front contact of relay 836 to ground on conductor 634. On the next energization of relay 731, relay 844 operates in this locking circuit and at its right back contact opens the locking circuit of counting relays 839 and 838 which release. On the next deenergization of relay 731 the circuit

over which relay 845 was operated is extended over the left front contact of relay 844, left back contact of counting relay 842, to battery through the winding of counting relay 843 which operates and locks through the winding of relay 842 and its own front contact, back contact of relay 851 and inner left front contact of relay 836 to ground on conductor 634. On the next energization of relay 731 relay 842 operates in the locking circuit of relay 843 and at its right back contact opens the locking circuit of transfer relay 809 which releases, relay 810 being held energized over its lower winding and inner lower front contact to ground on conductor 800. Relay 809 upon releasing opens the locking circuits of relays 836 and 837 which now release opening the locking circuit of counting relays 842 to 849, inclusive, which release. Relay 809 upon releasing also disconnects the contacts of register relays 805 to 808, inclusive, from the counting relays thereby rendering these register relays further ineffective.

If the second digit has now been registered on the relays of group 815 to 818 and transfer relay 813 has become deenergized with transfer relay 810 operated, a circuit is closed for transfer relay 819 extending from battery, winding of relay 819, upper back contact of relay 820, inner upper front contact of relay 810, strap 863, conductor 870, straps 661 and 660, conductor 642, inner right back contact of relay 737, conductor 643, strap 656, conductor 871, strap 862, back contact of transfer relay 813, straps 657 and 658, conductor 835, inner left front contact of relay 703, conductor 740, outer left back contact of relay 836, to ground on conductor 633. Relay 819 operates and locks through the upper winding of relay 820, lower front contact of relay 819, conductor 852, right back contact of relay 842, to ground on conductor 634. When relay 731 next closes its back contact a circuit is closed from ground on conductor 630, inner lower front contact of relay 819, conductor 635, thence as previously traced over the back contact of relay 731, conductor 743, back contacts of relays 836, 838 and 854 to battery through the winding of relay 853. Relay 853 operates and locks through the winding of relay 854, front contact of relay 853, left back contact of relay 838 to ground on conductor 634, relay 854 operating on the next energization of relay 731 in this locking circuit and again causing the operation of relay 711 which as before described shunts the windings of relays 618 and 619 and opens the shunt around the impulsing contacts of relay 730. This terminates the 0.6 timing interval following the transmission of the first digit series.

It was assumed that the second digit registered in the sender on the relays of group

815 to 818 was 3 and that register relays 815 and 816 have therefore been operated. With relay 854 operated, on the next release of relays 730 and 731 the impulsing loop to the second selector 310 is opened at the contacts of relay 730, since relay 711 is operated, and the circuit from ground over the back contact of relay 731 is extended over conductor 743, back contacts of relays 836 and 838, right front contact of relay 854, left back contact of relay 850, back contact of relay 840, middle upper contact of transfer relay 819, back contact of register relay 817, front contact of register relay 816, lower front contact of register relay 815, back contact of counting relay 842, to battery through the winding of counting relay 843. Relay 843 operates and locks through the winding of relay 842, its own front contact, back contact of relay 851, inner left front contact of relay 854, left back contact of relay 838 to ground on conductor 634 but relay 842 being shunted at the back contact of relay 731 does not operate at this time. On the next energization of relays 730 and 731 the impulsing loop to the second selector is closed at the contact of relay 730 and the shunt of counting relay 842 is opened at the back contact of relay 731, and relay 842 operates in the locking circuit of 843. Relay 842 at its right back contact opens the locking circuit of transfer relay 819 but relay 819 is maintained operated over its initial operating circuit previously traced. On the next deenergization of relays 730 and 731 the impulsing loop is again opened and the previously traced circuit from ground over the back contact of relay 731 is now extended over the front contact of relay 842, right back contact of relay 850 to battery through the winding of counting relay 841. Relay 841 operates and locks through the winding of relay 840, its own front contact, inner left back contact of relay 836 to ground on conductor 634 but relay 840 being shunted at the back contact of relay 731 does not operate. On the next energization of relays 730 and 731 the impulsing loop to the second selector is again closed and the shunt of counting relay 840 is opened whereupon it energizes. On the next deenergization of relays 730 and 731 the impulsing loop is again opened and the previously traced circuit from ground over the back contact of relay 731 is now extended over the front contact of relay 840, upper front contact of transfer relay 819, upper back contact of register relay 818, inner right back contact of relay 855 to battery through the winding of counting relay 839. Relay 839 operates and locks through the winding of relay 838, its own front contact, back contact of relay 836 to ground on conductor 634 but being shunted at the back contact of relay 731 relay 838 does not operate. On the next energization of relays 730 and 731 the impulsing loop is again closed and the shunt is re-



moved at the back contact of relay 731 from the winding of relay 838 which now operates opening the locking circuit of relays 853 and 854 which release, in turn releasing relay 711 and releasing counting relays 842 and 843, relay 842 again restoring the locking circuit of transfer relay 819. When relay 711 releases, the windings of relays 618 and 619 are again connected into the impulsing loop and the further operation of relays 730 and 731 is ineffective to transmit impulses to the second selector since the contacts of relay 730 are now shunted by the normal contacts of relay 711. The second selector 310 has now been stepped three steps vertically.

On the next deenergization of relays 730 and 731 the circuit from ground over the back contact of relay 731 is extended as traced over conductor 743, right back contact of relay 736, right front contact of relay 838 to battery through the winding of relay 837. Relay 837 operates and locks through the winding of relay 836 and its own front contact, inner lower front contact of transfer relay 819 to ground on conductor 630 and relay 836 operates in this locking circuit upon the next energization of relay 731, opening at its outer left back contact the shunt around the winding of transfer relay 820, which operates in the locking circuit of relay 819 and opening the locking circuit of counting relays 838 to 841 inclusive at its inner left back contact. The operation of relays 836 and 837 begins the timing interval of 0.6 seconds to permit the second selector to trunk hunt.

Upon the next release of relay 731 ground is extended over its back contact, conductor 743, right front contact of relay 836, conductor 856, lower back contacts of transfer relays 950, 940, 930, 920, 910, 830, straps 858 and 857, conductor 922, left back contact of counting relay 848 to battery through the winding of counting relay 849. In the manner previously described upon the continued release and operation of relay 731 counting relays 849, 848, 847, 846, 845, 844, 843 and 842 operate in succession. Relay 842 upon operating opens at its right back contact the locking circuit of transfer relay 819. Relay 819 thereupon releases but relay 820 remains locked over its lower winding and inner lower front contact to ground on conductor 801. Relay 819 upon releasing opens the locking circuit of relays 836 and 837 which now release opening the locking circuits of counting relays 842 to 849, inclusive, which release. Relay 819 upon releasing also disconnects the contacts of register relays 815 to 818, inclusive, from the counting relays.

If the third digit has now been registered on the relays of group 825 to 828 and transfer relay 823 has become deenergized with transfer relay 820 operated, a circuit is closed for

transfer relay 829 extending from battery, winding of relay 829, upper back contact of relay 830, inner upper front contact of relay 820, straps 864 and 865, back contact of transfer relay 823, straps 662 and 663, conductor 835, inner left front contact of relay 703, conductor 740, outer left back contact of relay 836 to ground on conductor 633. Relay 829 operates and locks through the upper winding of relay 830, lower front contact of relay 829, conductor 852, right back contact of relay 842 to ground on conductor 634. When relay 731 next closes its back contact a circuit is closed from ground on conductor 630, inner lower front contact of relay 829, conductor 635, thence as traced over the back contact of relay 731, conductor 743, back contacts of relays 836, 838 and 854 to battery through the winding of relay 853. Relay 853 operates and locks through the winding of relay 854, front contact of relay 853, left back contact of relay 838 to ground on conductor 634, relay 854 operating on the next energization of relay 731 in this locking circuit and again causing the operation of relay 711. Relay 711 as before described shunts the windings of relays 618 and 619 and opens the shunt around the impulsing contacts of relay 730. This terminates the 0.6 timing interval following the transmission of the second series of digit impulses.

It was assumed that the third digit registered in the sender on the relays of the group 825 to 828 was 7 and that register relays 826 and 828 have therefore been operated. With relay 854 operated, on the next release of relays 730 and 731 the impulsing loop to the connector 320 is opened at the contacts of relay 730 since relay 711 is operated and the circuit from ground over the back contact of relay 731 is extended over conductor 743, back contacts of relays 836 and 838, right front contact of relay 854, left back contact of relay 850, back contact of relay 840, middle upper contact of transfer relay 829, back contact of register relay 827, upper front contact of register relay 826, lower back contact of register relay 825, winding of counting relay 841 to battery. Relay 841 operates and locks through the winding of relay 840, front contact of relay 841, inner left back contact of relay 836, to ground on conductor 634 but relay 840 being shunted does not operate. On the next energization of relays 730 and 731 the impulsing loop to the connector is closed at the contacts of relay 730 and the shunt of relay 840 is opened at the back contact of relay 731 and relay 840 operates.

On the next deenergization of relays 730 and 731, the impulsing loop is again opened and the previously traced circuit from ground over the back contact of relay 731 is now extended over the left front contact of relay 840, upper contact of transfer relay

829, upper front contact of register relay 828, outer right back contact of relay 855, to battery through the winding of counting relay 851. Relay 851 operates and locks through  
 5 the winding of relay 850, its own front contact, inner left front contact of relay 854, left back contact of relay 838 to ground on conductor 634 but being shunted relay 850 does not operate. On the next energization  
 10 of relays 730 and 731, the impulsing loop is again closed and the shunt around relay 850 is opened whereupon it operates. On the next deenergization of relays 730 and 731 the impulsing loop is again opened and the previously traced circuit from ground over the  
 15 back contact of relay 731 is now extended over the left front contact of relay 850, left back contact of relay 848 to battery through the winding of relay 849. Relay 849 operates and locks through the winding of relay 848,  
 20 its own front contact, inner left front contact of relay 854, left back contact of relay 838 to ground on conductor 634, but being shunted relay 848 does not operate. On the next energization of relays 730 and 731 the impulsing loop is again closed and the shunt  
 25 around relay 848 is opened whereupon it operates. On the next deenergization of relays 730 and 731 the impulsing loop is again opened and the previously traced circuit from ground over the back contact of relay 731 is now extended over the left front contact of  
 30 relay 848, left back contact of relay 846 to battery through the winding of relay 847. Relay 847 operates and locks through the winding of relay 846, its own front contact, the right front contact of relay 848, the inner left front contact of relay 854, left back contact  
 35 of relay 838 to ground on conductor 634 but being shunted relay 846 does not operate. On the next energization of relays 730 and 731 the impulsing loop is again closed and the shunt around relay 846 is opened whereupon it operates. On the next deenergization  
 40 of relays 730 and 731 the impulsing loop is again opened and the previously traced circuit from ground over the back contact of relay 731 is now extended over the left front contact of relay 846, the left back contact of relay 844 to battery through the winding  
 45 of relay 845. In a similar manner upon successive deenergizations and energizations of relays 730 and 731, relays 845, 844, 843 and 842 operate and the impulsing loop is opened and closed twice more. On the next deenergization of relays 730 and 731 the impulsing  
 50 loop is again opened and ground on the back contact of relay 731 is extended as traced to the left armature of relay 842, thence over the right front contact of relay 850 to battery through the winding of relay 839. Relay 839 operates and locks through the winding  
 55 of relay 838, its own front contact, the inner left back contact of relay 836 to ground on conductor 634 but relay 838 being shunted

does not operate. On the next energization of relays 730 and 731 the impulse loop is again closed and the shunt is removed at the back contact of relay 731 from the winding  
 70 of relay 838 which now operates, opening the locking circuits of relays 853 and 854 which release in turn releasing relay 711 and counting relays 842 to 851, inclusive. Seven impulses have now been sent to step the connector switch 320 seven steps vertically.  
 75 When relay 711 releases the windings of relays 618 and 619 are again connected into the impulsing loop and the further operation of relays 730 and 731 is ineffective to transmit impulses to the connector switch  
 80 since the contacts of relay 730 are now shunted by the normal contacts of relay 711. When counting relay 842 operated it opened the locking circuit of transfer relay 829 but relay 829 was maintained operated over its initial operating circuit. Upon the release  
 85 of relay 842 the locking circuit is re-established.

On the next deenergization of relay 731 the circuit from ground over its back contact is extended over conductor 743, right back contact of relay 836, right front contact of relay  
 90 838, to battery through the winding of relay 837. Relay 837 operates and locks through the winding of relay 836 and its own front contact, inner lower front contact of transfer relay 829 to ground on conductor 630 and relay 836 operates in this locking circuit upon the next energization of relay 731, opening  
 95 at its outer left back contact the shunt around the winding of transfer relay 830 which now operates in the locking circuit of relay 829 and locks over its lower winding and inner lower front contact to ground on conductor 802. Relay 836 also opens at its inner left  
 100 back contact the locking circuits of counting relays 838 to 841, inclusive. The operation of relays 836 and 837 begins the timing interval which in this case will be 0.4 seconds before the final series of impulses is transmitted to the connector switch 320.  
 105

It will be recalled that the call under consideration is a class A call for which a shortened interval is necessary between the last two digits to be transmitted by the sender  
 110 and that class relay 707 is operated. Therefore, with counting relays 836 and 837 operated, when relay 731 again releases ground is extended over its back contact, conductor 743, right front contact of relay 836, conductor  
 115 856, lower back contacts of transfer relays 950, 940, 930, 920 and 910, lower front contact of transfer relay 830, conductor 859, outer left front contact of class relay 707, conductor 744, left back contact of counting relay 844 to battery through the winding of counting relay 845. In the manner previously described upon the continued release and operation  
 120 of relay 731 counting relays 845, 844, 843 and 842 operate in succession. Relay 842  
 125  
 130



- upon operating opens at its right back contact the locking circuit of transfer relay 829 which releases opening the locking circuit of relays 836 and 837 which now release, and disconnects the contacts of register relays 825 to 828, inclusive, from the counting relays. Relay 836 upon releasing opens the locking circuit of counting relays 842 to 845, inclusive, which also release.
- If the fourth digit has now been registered on the relays of group 905 to 908 and transfer relay 903 has become deenergized, with transfer relay 830 operated, a circuit is closed for transfer relay 909 extending from battery, winding of relay 909, upper back contact of transfer relay 910, upper inner front contact of relay 830, straps 955 and 956, lower back contact of relay 903, conductor 835, inner left front contact of relay 703, conductor 740, outer left back contact of relay 836, to ground on conductor 633. Relay 909 operates and locks through the upper winding of relay 910, lower front contact of relay 909, conductor 852, right back contact of relay 842, to ground on conductor 634. When relay 731 again closes its back contact, a circuit is closed from ground on conductor 630, inner lower front contact of relay 909, conductor 635, thence as traced over the back contact of relay 731, conductor 743, back contacts of relays 836, 838 and 854 to battery through the winding of relay 853. Relay 853 operates and locks through the winding of relay 854, front contact of relay 853, left back contact of relay 838, to ground on conductor 634. Relay 854 operates on the next energization of relay 731 in this locking circuit and again causes the operation of relay 711. Relay 711 as before described shunts the windings of relays 618 and 619 and opens the shunt around the impulsing contacts of relay 730. This terminates the 0.4 timing interval following the transmission of the third digit series of impulses.
- It was assumed that the fourth digit registered in the sender on the relays of the group 905 to 908 was 9 and that register relays 907 and 908 have therefore been operated. With relay 854 operated, on the next release of relays 730 and 731 the impulsing loop to the connector 320 is opened at the contact of relay 730 since relay 711 is operated, and the circuit from ground over the back contact of relay 731 is extended over conductor 743 back contacts of relays 836 and 838, right front contact of relay 854, left back contact of relay 850, back contact of relay 840, middle upper contact of transfer relay 909, upper front contact of register relay 907, left back contact of counting relay 844 to battery through the winding of counting relay 845. Relay 845 operates and locks through the winding of relay 844, front contact of relay 845, back contact of relay 851, inner left front contact of relay 854, left back contact of relay 838 to ground on conductor 634 but relay 844 being shunted does not operate. On the next energization of relays 730 and 731 the impulsing loop to the connector is closed at the contacts of relay 730 and the shunt of relay 844 is opened at the back contact of relay 731 and relay 844 operates. In the manner previously described upon the next deenergization and energization of relays 730 and 731, relays 843 and 842 operate and the impulsing loop is opened and closed again. Relay 842 upon operating extends ground from the back contact of relay 731, over the left front contact of relay 842, right back contact of relay 850, to battery through the winding of relay 841 so that upon the next deenergization and energization of relays 730 and 731 the impulsing loop is opened and closed again and counting relays 841 and 840 operate and lock. Relay 842 upon operating also opens the locking circuit of transfer relay 909 but this relay remains operated over its initial operating circuit. With counting relay 840 operated ground on the back contact of relay 731 is extended as traced to the left back contact of relay 850, thence over the left front contact of relay 840, upper contact of transfer relay 909, upper front contact of register relay 908, outer right back contact of relay 855, winding of counting relay 851 to battery so that upon the next deenergization and energization of relays 730 and 731 the impulsing loop is again opened and closed and counting relays 851 and 850 operate and lock. Relay 851 upon operating opens the locking circuits of counting relays 842 to 845, inclusive at its back contact and these relays release. In the manner previously described upon successive deenergizations and energizations of relays 730 and 731 additional impulses are transmitted over the impulsing loop to the connector 320 and counting relays 849, 848, 847, 846, 845, 844, 843, 842, 839 and 838 operate and lock in the order named. Relay 838 upon operating opens the locking circuit of relays 853 and 854 which release in turn releasing relay 711 and counting relays 842 to 851, inclusive. Nine impulses have now been transmitted to step the connector in a rotary direction to the terminals of the wanted line 360. When relay 711 releases the windings of relays 618 and 619 are again connected into the impulsing loop and the further operation of relays 730 and 731 is ineffective to transmit impulses to the connector since the contacts of relay 730 are now shunted by the normal contacts of relay 711.
- Since, as assumed, immediate ringing from the sender may be necessary as indicated by the operated condition of class relay 707 and the arrangement of strapping at its contacts, counting relay 838 upon operating establishes a circuit from ground on conductor 634 over the left front contact of relay 838,

the inner upper front contact of transfer relay 909, conductor 912, inner right front contact of class relay 707, strap 745, conductor 746 to battery through the winding of relay 638. Relay 638 operates and at its upper back contact removes ground from the armature of relay 731 causing relays 730 and 731 to remain operated. When reversed battery is received from the selector 310, which may be of the well known toll transmission type, as an indication that the subscriber's line 360 has been seized, relay 618 operates over the impulsing loop in turn closing a circuit from battery through the winding of relay 636, lower front contact of relay 616, contact of relay 618, to ground on conductor 704. Relay 636 locks over its inner lower front contact to ground on conductor 704 and closes a circuit extending from battery, windings of counting relays 837 and 836 in series, conductor 754, upper front contact of relay 636, conductor 635, inner lower front contact of transfer relay 909, conductors 630, 629 and 628 to ground at the inner upper front contact of relay 611. Since the locking circuit of relays 909 and 910 is now restored at the right back contact of relay 842, and the shunt around the winding of relay 910 is removed at the outer left back contact of relay 836, relay 910 now operates in this locking circuit locking itself independently of relay 909 over its lower winding and inner lower front contact to ground on conductor 900. Relay 836 also opens at its inner left back contact the locking circuits of counting relays 840 and 841.

Relays 612, 625, 726 and 727 operated as previously described indicating that keying had been completed. The operation of relays 726 and 727 indicates to the sender that the call either originated over an "A" operator's position or over an outward toll operator's position and that therefore immediate ringing from the sender is not necessary. In this case with relay 638, operated a circuit is established for relay 605 extending from battery through the winding of relay 605, conductor 749, outer right front contact of relay 726, inner lower front contact of relay 638 to ground at the inner upper front contact of relay 606. Relay 605 locks over its lower contact to ground on conductor 634 and removes a shunt from the right high resistance winding of relay 603 extending from ground at the inner upper back contact of relay 605, upper normal contacts of relay 604, to ground through the right winding of relay 603. The current now flowing through the windings of relay 603, over conductor 527, brush 526, upper contact of relay 512 to battery through the windings of relays 524 and 525 at the link circuit, is reduced to such an extent that relay 525 releases in turn releasing relays 511

and 536. Relay 511 releases relay 503 and relay 536 releases relay 512.

With relays 503 and 512 released a circuit is now closed for release magnet 421 of 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 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 upon energizing releases 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. All operated apparatus of the link circuit, with the exception of sender finder 550, has now been restored to normal. Sender finder 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. Upon the release of relay 512 the circuit previously traced through the windings of relay 603 at the sender is opened and relay 603 releases in turn releasing relays 606, 600, 701 and 611. With these relays released off-normal ground is removed at the sender and all other operated relays release and restore the sender circuit to normal.

When relay 525 of the link circuit releases, it opens the previously traced holding circuit for relay 321 of the trunk circuit which, upon releasing closes a circuit for the cut-through relay 316 extending from battery, winding of relay 316, upper front contact of relay 317, back contact of relay 321, to ground at the inner upper front contact of relay 315. With relay 316 operated a connection is extended from the tip conductor of the toll selector 310 over the tip brush of selector 300, inner upper front contact of relay 316, rings of jack 314 and plug 122, lower normal contacts of relay 123, inner lower front contact of relay 124, lower right winding of repeating coil 113, lower back contact of relay 128, winding of polarized relay 135, upper front contact of relay 124, upper back contact of relay 128, upper right winding of repeating coil 113, inner upper front contact of relay 124, upper normal contacts of relay 123, the tips of plug 122 and jack 314, lower front contact of relay 316, ring brush of selector 300 to the ring conductor of the toll selector 310, the toll selector and connector being held over this circuit after the impulsing loop of the sender is opened at back contacts of relay 316. When the toll connector 320 cut through to the subscriber's line 360 upon the response of the called subscriber, ringing current applied to the called line from the connector is cut off and a circuit is established from the first selector 300 through the winding of relay 324, strap 325 to ground at the inner upper front contact of relay 315 and re-

lay 324 operates to close a shunt from ground over strap 326 around the lower high resistance winding of relay 315 thereby increasing the current flowing through the windings of sleeve relays 127 and 128 of the cord circuit to such an extent that marginal relay 128 now operates. With relay 128 operated the dry bridge through the winding of relay 135 is disconnected and a battery bridge through the windings of relay 136 is connected into the circuit extending over the brushes of selectors 300 and 310 and connector 320 for supplying talking battery to the called line. Relay 136 operates and closes an obvious circuit for relay 131 which opens the circuit of supervisory lamp 130.

Relay 131 also closes a circuit for relay 140 extending from battery through the winding of relay 140, lower back contact of relay 141 to ground at the upper front contact of relay 131. Relay 140 operates and on the next closure of interrupter contacts 142 closes the circuit of relay 143 which in turn closes a circuit from ground over its contact, the lower normal contacts and winding of relay 144 to battery. Relay 144 operates, opening its own operating circuit, locking to ground over its lower alternate contacts and closing a circuit from ground at the lower back contact of relay 145, over the upper front contact of relay 144, upper normal contacts of relay 141, lower front contact of relay 131, winding of relay 141, lower back contact of relay 103 to battery at the lower contact of relay 102, relay 141 upon operating locking to ground at its upper alternate contacts. On the next opening of the interrupter contacts relay 143 releases opening a shunt around the winding of relay 145 which now operates in a circuit from battery, winding of relay 145, lower alternate contacts of relay 144 to ground. As long as either relay 144 or 145 remain operated, relay 140 is held operated. On the next closure of the interrupter contacts relay 143 again operates shunting the winding of relay 144 over the upper front contact of relay 145 and relay 144 releases, relay 145 now being held operated as long as relay 143 remains operated in a circuit from battery through its winding, lower normal contacts of relay 144, to ground at the front contact of relay 143. On the next opening of the interrupter contacts relay 143 releases in turn releasing relay 145 which now releases relay 140 and closes a circuit from ground over its lower back contact, the upper back contact of relay 144, the lower front contact of relay 141, upper normal contacts and winding of relay 109, lower back contact of relay 103 to battery at the lower contact of relay 102.

Relay 109 upon operating locks directly to ground on its upper alternate contacts, disconnects battery through resistances 138 and 139 from the circuit previously traced through the windings of the back-bridge re-

lay of the connector which seized trunk jack 100, and establishes a loop circuit extending from the upper back contact of relay 103, lower winding of relay 108, inner lower front contact of relay 131, lower front contact of relay 109 to the inner lower back contact of relay 103. Relay 108 and the back-bridge relay of the connector operate in this circuit, relay 108 opening the circuit of supervisory lamp 105 and the back-bridge relay of the connector establishing the usual supervisory condition indicating a response of the called subscriber.

When the calling subscriber hangs up, the connection established to jack 100 is released thereby releasing relay 108 which re-establishes the circuit of lamp 105 as a disconnect signal. When the called subscriber hangs up, relay 136 releases in turn releasing relay 131 which recloses the circuit of lamp 130. Seeing both lamps lighted, the operator removes the plugs 101 and 122 of her cord circuit from jacks 100 and 314 thereby restoring all cord circuit relays. The removal of plug 122 also releases trunk relay 315 which in turn releases all other operated relays of the trunk circuit and initiates the release of switches 300, 310 and 320.

If the call had been intercepted from a selector level in which case relays 102 and 103 would both be operated with plug 101 in jack 100, then talking battery would be connected to the calling line through the windings of battery feed relay 107 of the cord circuit and relays 141, 109 and 108 would not be operated under the control of the interrupter contacts 142 as previously described following the operation of relay 131 when the called subscriber answers. In this case the answering supervisory lamp 105 is under the direct control of relay 107 to give a disconnect signal when the called subscriber hangs up.

Had the call originated over an inward toll operator's position it would be established in the manner previously described except that upon the completion of keying and the establishment of the previously traced circuit through the windings of relays 727 and 728 and the windings of polarized relays of the toll position keyset circuit corresponding to relays 243 and 244, direct ground would be returned to the sender in such a manner as to operate relays 728 and 725 rather than relays 727 and 726 indicating to the sender that immediate ringing should be applied from the sender. With relay 725 operated a circuit is now completed from battery, winding of ringing relay 617, lower back contact of relay 645, conductor 646, outer right front contact of relay 725, conductor 747, lower front contact of relay 638, lower front contact of relay 636 to ground on conductor 704. Relay 617 upon operating bridges the source of ringing current 647

across the impulsing loop extending to the toll selector, disconnects the windings of relays 618 and 619 from the impulsing loop and connects ground on conductor 635 over its inner lower front contact and conductor 639, to the armature of relay 731, thereby rendering relays 730 and 731 again effective to successively deenergize and energize. With relays 836 and 837 now operated upon the first deenergization of relay 731 ground on its armature is extended over its back contact, conductor 743, right front contact of relay 836, conductor 856, lower back contacts of transfer relays 950, 940, 930, 920, lower front contact of transfer relay 910, conductor 921, outer left back contact of class relay 709, conductor 748, conductor 922, left back contact of relay 848 to battery through the winding of counting relay 849. Relay 849 operates and locks through the winding of relay 848 and upon the energization of relay 731 relay 848 operates in this locking circuit. As previously described, counting relays 847, 846, 845 and 844 operate in succession as relay 731 continues to deenergize and energize. Relay 844 upon operating opens the locking circuit of relays 839 and 838 which release and in turn cause the release of relays 638 and 617. Relay 617 now disconnects the source of ringing current, connects the windings of relays 618 and 619 to the impulsing loop and disconnects ground from the armature of relay 731 whereupon relays 730 and 731 remain operated.

Relay 638 upon releasing closes a circuit from ground on conductor 704, lower front contact of relay 636, lower back contact of relay 638, conductor 648, outer left front contact of relay 725, conductor 749 to battery through the winding of relay 605. With relay 605 operated the sender and link circuit are now released and the talking circuit is cut through at the trunk circuit in the manner previously described.

*Call to a subscriber's line requiring the keying and transmission of five digits without immediate ringing from the sender*

It will now be assumed that the operator answers a call over a trunk incoming to her position from a first selector bank, the calling subscriber having dialed the operator for assistance in completing a connection. When the operator answers the call the cord circuit functions in the manner previously described in connection with the answering of a call incoming on a trunk from an intercepting terminal of a selector bank, the operator's telephone set being connected into a telephone connection with the calling line immediately without waiting to trip ringing. In this case both answering sleeve relays 102 and 103 of the cord circuit operate and battery feed relay 107 is connected in

a loop circuit with the calling line and operates to efface the calling supervisory lamp 105. It will also be assumed that the information concerning the desired connection received by the operator from the calling subscriber is such that the operator in order to complete the connection must plug the calling plug of her cord circuit into the jack of a trunk of the group over which three selector switches and a connector switch may be set. The trunks of this group will be similar to the trunk of Fig. 3 with the exception that straps 325, 326 and 327 will be omitted, straps 301 to 304 will be connected in the manner shown in Fig. 3—C and the trunks will terminate in first selectors of the well known Strowger type.

When the operator plugs into a trunk of this group it becomes associated with the sender in the manner previously described and a registration of the class to which the trunk group belongs is established in the sender. With the strapping as shown in Fig. 3—C relays 614 and 618 operate, relay 618 in turn closing a circuit from ground on conductor 704, over its front contact, the lower back contact of relay 616 to battery through the winding of relay 615 which operates and locks over its upper contact to ground on conductor 704. With relays 614 and 615 operated the class relay 709 is operated indicating that a five-digit number is to be keyed. In the manner previously described the operator is given a signal by the lighting of lamp 230 when the sender is ready to register the digits of the wanted line number and the operator then proceeds to key the digits which in this case will be assumed to be 24560, by depressing keys 247, 248, 249, 250 and 251 in the order named. Transfer relays 803 and 804 are operated as previously described immediately following the seizure of the sender. When the operator depresses key 247 for the first digit 2, 48-volt battery is connected through high resistance 240, contacts of key 247, conductor 234, thence as traced through the windings of impulse relays 705, 706 and 714 to 24-volt battery. Due to the inclusion of high resistance 240, sensitive relay 714 operates but marginal relay 706 does not receive sufficient current to operate and polarized relay 705 also operates. Relay 714, as previously described, causes the operation of transfer relay 813 which locks through the winding of transfer relay 814, but relay 814 being shunted does not operate as long as relay 714 remains operated. Relay 705 upon operating closes a circuit from ground at its contact over conductor 721, lower front contact of transfer relay 804, to battery through the upper winding of register relay 806. Relay 806 operates and locks over its lower winding and lower contact to ground on conductor 800. Upon the release of the de-

pressed key relays 705 and 714 release and transfer relay 814 operates unlocking transfer relays 803 and 804.

When the operator depresses key 248 for the second digit 4, ground through low resistance 239 and high resistance 242 is connected over the left contacts of key 248 to conductor 234, causing the operation of impulse relay 714, the strength and direction of the current not being sufficient to cause the operation of relays 705 and 706, and 48-volt battery through high resistance 240 is connected over the right contacts of key 248 to conductor 233, causing the operation of relay 724 and polarized relay 715, marginal relay 716 not receiving sufficient current to cause its operation. Relays 714 and 724 cause the operation of transfer relay 823 in the manner described and relay 715 closes a circuit over conductor 723 and the inner upper front contact of transfer relay 824 for operating register relay 817 of the second register which locks over its lower winding and contact to ground on conductor 801. Upon the release of key 248, relays 714, 715 and 724 release and transfer relay 824 operates releasing transfer relays 813 and 814.

When the operator depresses key 249 for the third digit 5 ground through low resistance 239 and high resistance 242 is connected over the left contacts of key 249 to conductor 234, causing the operation of relay 714, relays 705 and 706 not operating and ground through low resistance 241 is connected over the right contacts of key 249 to conductor 233 causing the operation of relays 716 and 724. Relays 714 and 724 cause the operation of transfer relay 903 in the manner described and with relay 716 operated, a circuit is closed over conductor 722 and the upper contact of transfer relay 824 through the upper winding of relay 828 of the third register which operates and locks over its lower winding and contact to ground on conductor 802. Upon the release of key 249 relays 714, 716 and 724 release and transfer relay 904 operates releasing transfer relays 823 and 824.

When the operator depresses key 250 for the fourth digit 6 ground through low resistance 239 is connected over the left contacts of key 250 to conductor 234 causing the operation of relays 706 and 714, and ground through low resistance 241 is connected over the right contacts of key 250 to conductor 233 causing the operation of relays 716 and 724. Relays 714 and 724 cause the operation of transfer relay 913 in a circuit which may be traced from ground over the contacts of relays 714 and 724, conductor 822, inner lower back contacts of transfer relays 803, 813 and 823, conductor 833, inner lower front contact of transfer relay 903, conductor 911, inner left back contact of class relay 707, conductor 750 to battery through the winding of relay

913. Relay 913 upon operating locks through the winding of transfer relay 914, intermediate upper contact of relay 913, upper back contact of transfer relay 924, to ground on conductor 812, but relay 914 being shunted as long as relays 714 and 724 remain operated does not operate at this time. With relays 706 and 716 operated circuits are closed over conductors 720 and 722 and the inner lower and upper front contacts of transfer relay 904 to battery through the operating windings of register relays 905 and 908 of the fourth register, these relays locking to ground on conductor 900. Upon the release of key 250 relays 706, 716, 714 and 724 release and transfer relay 914 operates opening the locking circuit of transfer relays 903 and 904.

When the operator depresses key 251 for the last digit 0 ground through low resistance 239 and high resistance 242 is connected over the contacts of key 251 to conductor 234 causing the operation of relay 714, relays 705 and 706 not operating. Since relays 705 and 706 are not operated no relays, 915 to 918 inclusive, of the fifth register are operated. Relay 714 connects ground over its contact, conductor 822, inner lower back contact of transfer relays 803, 813, 823, 903 and the inner lower front contact of transfer relay 913, conductor 751, inner left front contact of class relay 709, which has been assumed to be operated, conductor 624 to battery through the winding of relay 625. Relay 625 operates and locks through the winding of relay 612, front contact of relay 625 to ground on conductor 704 and relay 612 operates in this locking circuit upon the release of relay 714 following the release of the depressed key 251. From this point the sender functions to cause the release of the operator's keyset circuit and to prepare for the transmission of impulses in accordance with the set condition of the registers through the operation of relays 726 and 727 and the operation of relays 730 and 731 as previously described.

As soon as the first digit, assumed to be 2, has been registered by the operation of register relay 806, and transfer relay 803 has released, a circuit is closed for transfer relay 809 extending from battery through the winding of relay 809, upper back contact of relay 810, lower back contact of relay 803, straps 651 and 652, conductor 681, outer right back contact of relay 737, conductor 738, straps 653 and 654, conductor 835, inner left front contact of relay 703, conductor 740, outer left back contact of relay 836, conductor 633 to ground at the inner lower front contact of relay 615. Relay 809 locks through the winding of relay 810 over the circuit previously traced and causes the de-energization of relays 730 and 731. Upon the first release of relay 731, the previously

traced circuit for relay 853 is closed, relay 854 operating in the locking circuit of relay 853 upon the next energization of relays 730 and 731 and closing the circuit of relay 711.

5 When relays 730 and 731 again release, relay 730 opens the impulsing loop to the first selector switch in which the trunk seized by the operator terminates and relay 731 closes a circuit from ground over its back contact, conductor 743, right back contact of relay 836, right back contact of relay 838, right front contact of relay 854, left back contact of relay 850, back contact of relay 840, middle upper contact of transfer relay 809, back contact of register relay 807, upper front contact of register relay 806, lower back contact of register relay 805 to battery through the winding of counting relay 841. Relay 841 operates and locks through the winding of relay 840, front contact of relay 841, inner left back contact of relay 836 to ground on conductor 634, relay 840 operating in this locking circuit upon the next energization of relays 730 and 731. On the next deenergization of relay 731 ground over its back contact, conductor 743 and thence as traced over the left back contact of relay 850, is extended over the front contact of relay 840, upper front contact of transfer relay 809, upper back contact of register relay 808, inner back contact of relay 855, to battery through the winding of relay 839 and relay 839 operates and locks through the winding of relay 838 as previously described. On the next energization of relay 731, relay 838 operates unlocking relays 853 and 854, relay 854 in turn releasing relay 711. Two impulses have now been transmitted to the first selector through the operation of relay 730. In the manner previously described the counting relays are operated by the continued energization and deenergization of relay 731 to measure a 0.6 second interval following the transmission of the first series of impulses to the first selector, relay 810 being operated upon the operation of counting relay 836, counting relays 838 and 839 being released upon the operation of relay 844, and transfer relay 809 being released upon the operation of relay 842, relay 809 in turn releasing operated counting relays 836, 837, 842 to 849, inclusive.

When the second digit is registered and transfer relay 813 releases, transfer relay 819 is operated as previously described as soon as relay 810 operates, and relays 853 and 854 and 711 again operate terminating the timing cycle. It has been assumed that the second digit registered was 4 and that register relay 817 is operated. When therefore relay 731 again deenergizes with relay 854 operated, a circuit is closed from ground, back contact of relay 731, conductor 743, back contacts of relays 836 and 838, right front contact of relay 854, left back contact of relay 850, back con-

tact of relay 840, middle upper contact of transfer relay 819, front contact of register relay 817, left back contact of counting relay 844 to battery through the winding of counting relay 845. In the manner previously described, the successive deenergization and energization of relays 730 and 731 causes the operation of counting relays 845, 844, 843, 842, 841, 840, 839 and 838 in succession, relay 838 upon operating releasing relays 842 to 845, 853, 854 and 711. The repeated operation of relay 730 prior to the release of relay 711 has now transmitted four impulses to the second selector. As previously described the counting relays are then operated by the continued energization and deenergization of relay 731 to measure a 0.6 second interval following the transmission of the second series of impulses to the second selector, transfer relay 820 being operated upon the operation of relay 836, counting relays 838 to 841 being released upon the operation of relay 844 and transfer relay 819 being released upon the operation of relay 842, in turn releasing counting relays 836, 837 and 842 to 849, inclusive.

When the third digit is registered and transfer relay 823 releases, transfer relay 829 is operated as previously described as soon as relay 820 operates, and relays 853, 854 and 711 again operate terminating the timing cycle. It has been assumed that the third digit registered was 5 and that register relay 828 is operated. When therefore relay 731 again deenergizes with relay 854 operated, a circuit is closed from ground over the back contact of relay 731, conductor 743, back contacts of relays 836 and 838, right front contact of relay 854, left back contact of relay 850, back contact of relay 840, middle upper front contact of transfer relay 829, upper back contact of register relays 827, 826 and 825, left back contact of counting relay 846 to battery through the winding of counting relay 847. In the manner previously described, the successive deenergization and energization of relays 730 and 731 causes the operation of counting relays 847, 846, 845, 844, 843, 842, 841 and 840 in the order named. Relay 846 upon operating closes the circuit of relay 855 extending from battery through the winding of relay 855, right contact of relay 846, right back contact of relay 848, inner left front contact of relay 854, left back contact of relay 838, to ground on conductor 634. Relay 855 upon operating locks over its left contact and the right back contact of relay 848 to ground as traced. Relay 840 upon operating extends the operating ground from the back contact of relay 731 as traced to the left front contact of relay 840, upper contact of transfer relay 829, upper front contact of register relay 828, outer right front contact of relay 855 to battery through the winding of counting relay 839. On the next deenergiza-



tion and energization of relay 731, counting relays 839 and 838 operate, relay 838 releasing relays 842 to 847, 853, 854, 855 and 711. The repeated operation of relay 730 prior to the release of relay 711 has now transmitted five impulses to the third selector.

As previously described, relays 837 and 836 operate on the next deenergization and energization of relay 731 operating transfer relay 830. It will be recalled that the call being considered is a class "C" call and that class relay 707 is not operated but class relay 709 is operated, therefore with relay 836 operated when relay 731 again releases ground is extended over its back contact, conductor 743, right front contact of relay 836, conductor 856, lower back contacts of transfer relays 950, 940, 930, 920, 910, lower front contact of transfer relay 830, conductor 859, outer left back contact of class relay 707, conductor 748, conductor 922, left back contact of counting relay 848 to battery through the winding of counting relay 848 to battery through the winding of counting relay 849 and these counting relays followed by other counting relays operate in the manner previously described in response to the repeated deenergization and energization of relay 731 to measure a 0.6 second interval following the transmission of the third series of impulses to the third selector. Counting relays 838 to 841 are released upon the operation of relay 844 and transfer relay 829 is released upon the operation of relay 842. Relay 829 in turn releases counting relays 836, 837 and 842 to 849, inclusive.

When the fourth digit is registered and transfer relay 903 releases, transfer relay 909 is operated as previously described as soon as relay 830 operates, and relays 853, 854 and 711 again operate terminating the timing cycle. It has been assumed that the fourth digit registered was 6 and that register relays 905 and 908 are operated. When therefore relay 731 again deenergizes with relay 854 operated a circuit is closed from ground, back contact of relay 731, conductor 743, back contacts of relay 836 and 838, right front contact of relay 854, left back contact of relay 850, back contact of relay 840, middle upper contact of transfer relay 909, upper back contacts of register relays 907 and 906, upper front contact of register relay 905, upper contact of transfer relay 909, upper front contact of register relay 908, outer right back contact of relay 855 to battery through the winding of counting relay 851. Relay 851 operates and on the next energization of relay 731 relay 850 operates, relay 850 extending the ground on conductor 743 as traced to the left armature of relay 850, thence over the left back contact of relay 848 to battery through the winding of relay 849. Thus, on successive deenergization and energizations

of relay 721, counting relays 849, 848, 847, 846, 845, 844, 843, 842, 839 and 838 operate, relay 838 upon operating releasing relays 842 to 851, inclusive, and relays 853, 854 and 711. The repeated operation of relay 730 prior to the release of relay 711 has now transmitted six impulses to the connector.

As previously described, relays 837 and 836 operate on the next deenergization and energization of relay 731 causing the operation of transfer relay 910. When relay 731 again releases, ground is extended over its back contact, conductor 743, right front contact of relay 836, conductor 856, lower back contacts of transfer relays 950, 940, 930, 920, lower front contact of transfer relay 910, conductor 921, outer left front contact of class relay 709, conductor 744, left back contact of counting relay 844 to battery through the winding of relay 845 and counting relays 845, 844, 843, 842 operate in the manner described in response to the repeated deenergizations and energizations of relay 731 to measure a 0.4 second interval following the transmission of the fourth series of impulses to the connector. When counting relay 844 operates counting relays 838 and 839 are released, transfer relay 909 being released upon the operation of relay 842, relay 909 in turn releasing counting relays 836, 837 and 842 to 845, inclusive.

When the fifth digit is registered and transfer relay 913 releases, transfer relay 919, is operated over the circuit previously traced to the inner upper front contact of relay 910, thence over the upper back contact of relay 920 to battery through the winding of relay 919 and relays 853, 854 and 711 again operate terminating the timing cycle. It has been assumed that the fifth digit registered was 0, and that no register relays of the group 915 to 918 have been operated. When therefore relay 731 again deenergizes with relay 854 operated, a circuit is closed from ground, back contact of relay 731, conductor 743, back contacts of relays 836 and 838, right front contact of relay 854, left back contact of relay 850, back contact of relay 840, middle upper contact of transfer relay 919, upper back contacts of register relays 917, 916 and 915, left back contact of counting relay 846 to battery through the winding of relay 847. In the manner previously described, the successive deenergizations and energizations of relays 730 and 731 cause the operation of counting relays 847, 846, 845, 844, 843, 842, 841 and 840 in the order named, relay 846 upon operating causing relay 855 to operate and lock under the control of relay 848. With relay 855 operated, when relay 840 operates the operating ground from the back contact of relay 731 is extended as traced to the left front contact of relay 840, upper contact of transfer relay 919, upper back contact of register relay 918, inner right

front contact of relay 855 to battery through the winding of counting relay 851. On the next deenergization and energization of relay 731, relays 851 and 850 operate, relay 851 releasing counting relays 843 to 847, inclusive, and relay 850 extending the operating ground from the back contact of relay 731 as traced over the right front contact of relay 854, thence over the left front contact of relay 850 and the left back contact of relay 848 to battery through the winding of relay 849. Upon successive deenergizations and energizations of relay 731, counting relays 849, 848, 847, 846, 845, 844, 843, 842, 839 and 838 operate in the order named, relay 838 upon operating releasing relays 842 to 851, 853, 854 and 711. The repeated operation of relay 730 prior to the release of relay 711 has now transmitted ten impulses to the connector.

For a call of class "C" immediate ringing from the sender is not necessary and therefore when relay 838 operates at the time the last impulse is transmitted to the connector, a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper contact of transfer relay 919, conductor 931, intermediate right front contact of class relay 709, strap 752, inner right front contact of relay 726, conductor 749 to battery through the winding of relay 605. From this point the circuits function as described in connection with the call previously described, the link circuit releasing, the operated relays of the sender releasing and the cut-through relay 316 of the trunk circuit operating to cut a talking connection through from the jack 314 to the first selector.

#### *Extension of calls in variable class "D"*

It will first be assumed that the operator upon answering the call is informed by the calling subscriber that a connection is required which involves the setting of a single selector for its completion and that the operator therefore plugs the cord plug 122 into the jack of a trunk similar to Fig. 3 but with straps 325, 326, and 327 omitted and straps 301 to 304, inclusive, connected as shown in Fig. 3—D. When the trunk is seized an idle sender is associated therewith and with the strapping as shown in Fig. 3—D relays 613 and 618 operate, relay 618 in turn closing a circuit from ground on conductor 704, out over its contact, the lower back contact of relay 616, to battery through the winding of relay 615 which operates and locks over its upper front contact to ground on conductor 704. With relays 613 and 615 operated, the class relay 710 is operated indicating that the trunk seized by the operator belongs in a group over which calls requiring the setting of a variable number of selectors may be set and that immediate ringing may or may not be required. Class relay 710 upon operating

closes an operating circuit for relay 737 extending from battery through the winding of relay 737, to ground at the outer right front contact of relay 710. As previously described, the operator is given a signal by the lighting of lamp 230 when the sender is ready to register digits, transfer relays 803 and 804 being operated upon the seizure of the sender. The operator then proceeds to key the single digit which will be assumed to be 0 by depressing key 251. Transfer relays 803 and 804 being operated, the operation of key 251 controls the impulse relay 714 which in turn operates transfer relay 813 in the manner described. When the key is released transfer relay 814 operates in the locking circuit of relay 813 unlocking transfer relays 803 and 804.

Having keyed the single digit 0 the operator then depresses the start key 226 which at its left contacts connects 48-volt battery through high resistance 240, to conductor 233, thence as traced to conductor 307, strap 301, conductor 306, thence as traced over conductor 537, inner upper back contact of relay 614, lower front contact of relay 613, upper back contact of relay 612, conductor 623 to 24-volt battery through the windings of impulse relays 715, 716 and 724. The current flowing is in the proper direction and strength to operate polarized relay 715 and sensitive relay 724 but due to the inclusion of high resistance 240 marginal relay 716 does not operate. Relay 715 upon operating closes an obvious circuit for relay 729 which operates. At its right contacts key 236 closes a circuit from ground through low resistance 241, over conductor 234, thence as traced to conductor 305, strap 302, conductor 308, thence as traced to conductor 529, upper front contact of relay 613, lower back contact of relay 612, conductor 622 to 24-volt battery through the windings of impulse relays 705, 706 and 714. Relays 706 and 714 operate but relay 705 does not receive current in the proper direction to cause its operation. Relay 706 upon operating with relay 729 operated closes a circuit from ground at the contact of relay 706, front contact of relay 729 to battery through the winding of relay 753, relay 753 upon operating locking directly to ground on conductor 704. The operation of relays 714 and 724 as in the manner previously described cause the operation of transfer relay 823 which locks in series with relay 824. When the start key 226 is released and relays 715, 724, 706 and 714 release, transfer relay 824 operates in the locking circuit of relay 823 releasing transfer relays 813 and 814. The release of relay 715 also releases relay 729 and with relay 753 operated a circuit is closed from ground on the front contact of relay 753, back contact of relay 729 to battery through the winding of relay 755 which operates.



Relay 755 upon operating closes a circuit in series through the windings of relays 612 and 625, conductor 649, outer right contact of relay 755 to ground on conductor 704.

5 From this point the sender functions to cause the release of the operator's keyset and to prepare for the transmission of impulses in accordance with the set condition of the registers through the operation of relays 726 and

10 727 from the keyset in the manner previously described. Since, however, relay 737 is operated, the operation of relay 612 does not release the last pair of transfer relays 823 and 824 which were operated, these relays

15 being held locked in a circuit extending through their windings in series, the middle upper front contact of relay 823, conductor 831, the upper back contact of transfer relay 904, conductor 812, the outer left contact of

20 relay 737 to ground on conductor 704.

As soon as the single digit 0 and the start combination have been keyed and transfer relays 803 and 813 have released, transfer relay 809 is operated in the circuit extending

25 from battery through its winding, the upper back contact of transfer relay 810, lower back contact of relay 803, straps 651 and 652, conductor 681, outer right front contact of relay 737, conductor 767, straps 655 and 656,

30 conductor 871, strap 862, lower back contact of transfer relay 813, straps 657 and 658, conductor 835, inner left front contact of relay 703, conductor 740, outer left back contact of relay 836, to ground on conductor 633. Re-

35 lay 809 locks and the sender then proceeds to transmit ten impulses to the first selector in the manner previously described. It will thus be seen that the transmission of the series of impulses is delayed until one digit

40 and the start combination have been registered. This is for the purpose of permitting the location of calls through tandem points over automatic listening straightforward trunks as it is necessary to delay impulsing

45 until after the start key has been depressed in order to allow time for the sender to release the keyset and be ready to cut the trunk circuit through to the operator immediately after the last digit has been trans-

50 mitted to insure that the operator may hear the order tone from the tandem point.

When counting relay 838 operates at the time the last impulse of the single digit series is transmitted, counting relays 842 to 851,

55 853, 854 and 711 are released and a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper front contact of transfer relay 809, upper front

60 contact of transfer relay 823, which is in this case strapped to conductor 860, inner right front contact of relay 755, strap 756, inner

65 right front contact of class relay 710, which has been assumed to be operated, strap 757, inner right front contact of relay 726, con-

70 ductor 749, to battery through the winding

of relay 605. Relay 605 then operates to cause the trunk to cut the talking connection through immediately without waiting for the application of ringing current from the sender, the link and sender being restored in the manner previously described.

It will now be assumed that the operator keys two digits instead of one and then depresses the start key 226. In this case transfer relays 803 and 804 operate as before upon

75 the seizure of the sender. Transfer relays 813 and 814 operate upon the keying of the first digit, relay 814 upon operating releasing relays 803 and 804. Transfer relays 823 and 824 operate upon the keying of the second

80 digit, relay 824 upon operating releasing relays 813 and 814, and transfer relays 903 and 904 and relays 612 and 625 operate upon the operation and release of the start key 226 as just described. The operation of relay 612

85 does not in this case release the last pair of operated transfer relays 903 and 904 as they are held operated in a local circuit extending through the windings of these relays, the

90 middle upper front contact of relay 903, the upper back contact of transfer relay 914, conductor 812, the outer left contact of relay 737 to ground on conductor 704. The operator's keyset circuit is now released and the sender is prepared to transmit impulses as

95 previously described.

As soon as the two digits keyed have been registered and transfer relays 803 and 813 have released the transfer relay 809 operates

100 over the circuit last traced and thereupon the sender proceeds to transmit the first series of impulses. Following the transmission of the first series of impulses the timing interval is measured as previously described and transfer relay 810 is operated and locked and

105 transfer relay 809 is released. When relay 809 releases relays 836 and 837 release and if the start combination has been keyed and relay 823 has released, a circuit is established for transfer relay 819 extending from battery,

110 winding of relay 819, upper back contact of relay 820, inner upper front contact of relay 810, strap 863, conductor 870, straps 661 and 660, conductor 642, inner right front contact

115 of relay 737, conductor 758, straps 659, 864 and 865, lower back contact of transfer relay 823, straps 662 and 663, conductor 835, inner left front contact of relay 703, conductor 740,

120 outer left back contact of relay 836 to ground on conductor 633. It is thus seen that the second digit series is not transmitted until after the second digit and the start combination have been keyed. When counting relay

125 838 operates at the time the last impulse of the second digit series is transmitted a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper front contact of transfer relay 819, upper

130 front contact of transfer relay 903 which is in this case strapped to conductor 860, inner

right front contact of relay 755, strap 756, inner right front contact of class relay 710, strap 757, inner right front contact of relay 726, conductor 749 to battery through the winding of relay 605. Relay 605 then operates to cause the trunk to cut the talking circuit through immediately without waiting for the application of ringing current from the sender, the link and sender being restored in the manner previously described.

Should the operator key a six-digit number with class relay 710 operated and then depress start key 226, transfer relays 803, 804, 813, 814, 823, 824, 903, 904, 913, 914, 923, 924, 933, 934 will be operated and released in succession, and transfer relays 943 and 944 will be operated and held operated when relays 612 and 625 operate following the release of the start key since relay 737 is operated. The operator's keyset circuit is then released and the sender then proceeds to transmit impulses as soon as the first two digits keyed have been registered in the same manner as for the two-digit call just described, a 0.6 timing interval being measured after each of the first four digits have been transmitted. Preparatory to the transmission of the third digit series, transfer relay 829 must be operated and this occurs after transfer relay 823 releases following the registration of the third digit keyed, in a circuit extending from battery, winding of relay 829, upper back contact of relay 830, inner lower front contact of relay 820, straps 864 and 865, lower back contact of relay 823, straps 662 and 663, conductor 835 and thence as traced to ground. Preparatory to the transmission of the fourth series of impulses transfer relay 909 must be operated and this occurs after transfer relay 903 releases following the registration of the fourth digit keyed, in a circuit extending from battery, winding of relay 909, upper back contact of relay 910, inner upper front contact of relay 830, straps 955 and 956, lower back contact of relay 903, conductor 835, thence to ground as traced. When counting relay 838 operates at the time the last impulse of the sixth digit series is transmitted, a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper front contact of transfer relay 929, upper front contact of transfer relay 943 which is in this case strapped to conductor 860, inner right front contact of relay 755, strap 756, inner right front contact of class relay 710, strap 757, inner right front contact of relay 726, conductor 749 to battery through the winding of relay 605. Relay 605 then operates to cause the trunk to cut the talking circuit through immediately without waiting for the application of ringing current from the sender, the link and sender being released in the manner previously described.

Should the operator key a seven-digit number with class relay 710 operated and

then depress start key 226, transfer relays 803, 804, 813, 814, 823, 824, 903, 904, 913, 914, 923, 924, 933, 934, 943, 944 will operate and release in succession, relays 953 and 954 will be operated and held operated when relays 612 and 625 operate following the release of the start key since relay 737 is operated. The operator's keyset circuit is then released and the sender proceeds to transmit impulses as soon as the first two digits keyed have been registered as described in connection with the two-digit call. A 0.6 second interval is measured after the transmission of each of the first six digits. When relay 838 operates at the time the last impulse of the seventh digit is transmitted a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper front contact of transfer relay 939, lower front contact of relay 953, strapped in this case to conductor 860, inner right front contact of relay 755, strap 756, inner right front contact of class relay 710, strap 757, inner right front contact of relay 726, conductor 749 to battery through the winding of relay 605. Relay 605 then operates to cause the trunk to cut the talking circuit through immediately without waiting for the application of ringing current from the sender, the link and sender being released in the manner previously described.

Should the operator key an eight-digit number, the maximum which the sender is arranged to register, transfer relays 803, 804, 813, 814, 823, 824, 903, 904, 913, 914, 923, 924, 933, 934, 943, 944 and relays 953 and 954 will operate and release in succession relays 953 and 954 operating upon the depression and release of the key corresponding to the station designation of the desired number. It is not necessary for the operator in this case to depress the start key 226 since relays 612 and 625 are now operated in series as soon as relay 954 operates, in a circuit extending through the windings of relays 612 and 625, conductor 649, conductor 759, front contact of relay 954 to ground on conductor 704. When relay 612 operates the locking circuit of relays 953 and 954 is opened, the operator's keyset circuit is released and the sender proceeds to transmit impulses. As soon as the first two digits have been registered as described in connection with the preceding call, a 0.6 second interval is measured after the transmission of each of the first six digits and following the transmission of the seventh digit with transfer relay 940 operated a 0.4 second interval is measured, counting relay 845 being first operated rather than the counting relay 849 following the operation of counting relay 836, in a circuit extending from ground at the back contact of relay 731, conductor 743, right front contact of relay 836, conductor 856, lower back contact of transfer relay 950, lower front contact of transfer relay 940, conductor 941, outer left

back contact of class relay 708, outer left front contact of class relay 710, conductor 744, left back contact of counting relay 844 to battery through the winding of relay 845.

5 When relay 838 operates at the time the last impulse of the eighth digit series is transmitted, a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper front contact of transfer relay 949, conductor 932, strap 756, inner right front contact of class relay 710, strap 757, inner right front contact of relay 726, conductor 749, to battery through the winding of relay 605. Relay 605 operates to cause the trunk

10 to cut the talking circuit through immediately without waiting for the application of ringing current from the sender, the link and sender being restored in the manner previously described.

20 Should an inward toll operator plug into the trunk circuit and key a three-digit number with class relay 710 operated and then depress the start key 226, transfer relays 803, 804, 813, 814, 823, 824, 903, 904 will be operated and released in succession, and relays 913 and 914 will be operated and held operated when relays 612 and 625 operate following the release of start key 226 since relay 737 is operated. The operator's keyset circuit is then released and in this case relays 725 and 728 are operated to indicate to the sender that the call has come from an inward toll operator's position. As soon as the first two digits keyed have been registered the sender proceeds to transmit impulses. A 0.6 second interval is measured after the transmission of the first two digit series and when counting relay 838 operates at the time the last impulse of the third digit is transmitted a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper front contact of transfer relay 829, conductor 861, upper front contact of transfer relay 913, strapped in this case to conductor 872, inner left front contact of relay 755, strap 760, middle right front contact of class relay 710, strap 761, conductor 746 to battery through the winding of relay 638. From this point the sender functions to transmit current from the ringing source 647, to measure off a predetermined interval during which ringing current is applied, after which relay 605 operates to cause the talking connection to be cut through at the trunk circuit and to cause the release of the link and sender circuits as previously described in connection with the first call discussed.

60 Should the toll operator key a four-digit number and then depress the start key 226, transfer relays 803, 804, 813, 814, 823, 824, 903, 904, 913, 914 will be operated and released in succession, and relays 923 and 924

65 will be operated and held operated when

relays 612 and 625 operate following the release of the start key. The operator's keyset circuit is then released and as soon as the first two digits keyed have been registered, the sender proceeds to transmit impulses as previously described. A 0.6 second interval is measured after the transmission of the first three digit series except that after the transmission of the third digit series, class relay 707 not in this case being operated, the counting relay 849 is operated at the start of the timing interval in a circuit extending from ground on conductor 634, left front contact of relay 836, conductor 856, lower back contacts of relays 950, 940, 930, 920, 910, lower front contact of relay 830, conductor 859, outer left back contact of relay 707, conductors 748 and 922, left back contact of counting relay 848 to battery through the winding of relay 849. When relay 838 operates at the time the last impulse of the fourth digit series is transmitted a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper front contact of transfer relay 909, conductor 912, upper front contact of transfer relay 923, strapped to conductor 872, inner left front contact of relay 755, strap 760, middle right front contact of class relay 710, strap 761, conductor 746 to battery through the winding of relay 638. From this point the sender functions to transmit ringing current from the source 647, to measure off a predetermined interval during which ringing current is applied, after which relay 605 operates to cause the talking connection to be cut through at the trunk circuit and to cause the release of the link and sender circuits as previously described in connection with the call first discussed.

#### *Establishment of connections in variable Class B*

Class B calls are similar to class D calls except that no calls of this class require immediate ringing from the sender. For completing a call of this class the operator plugs into a trunk similar to that of Fig. 3 but with straps 325, 326 and 327 omitted and straps 301 to 304, inclusive, connected as shown in Fig. 3—B. When a trunk is seized an idle sender is associated therewith and relays 613 and 619 operate, relay 619 in turn closing a circuit from ground on conductor 704 over its front contact, the lower back contact of relay 615 to battery through the winding of relay 616 which operates and locks over its upper front contact to ground on conductor 704. With relays 613 and 616 operated the class relay 708 is operated indicating that the trunk seized by the operator belongs in a group over which a variable number of selectors may be set and that immediate ringing from the sender is not required. Class relay 708 upon operating closes an operating circuit

for relay 737 extending from battery, winding of relay 737, to ground at the outer right front contact of relay 708. As previously described the operator is given a signal by the lighting of lamp 230, when the sender is ready to register digits, the transfer relays 803 and 804 having operated upon the seizure of the sender. The setting of the sender registers and the control of impulsing to the selector switches in response to the keying of one to eight digits as the desired call may require then proceeds as previously described in connection with class D calls except that straps 764 and 765 associated with class relay 708 are so connected that regardless of the number of digits keyed relay 605 operates following the transmission of the last impulse of the last digit series registered to cause the trunk circuit to cut the talking connection through and to cause the release of the link and sender circuits without waiting for the sender to apply ringing current.

Recapitulating, it will be seen that by changing the strapping associated with the armature contacts of any one of the class relays 707 to 710, inclusive, the class relay may be made to determine first if the class indicates whether the operator will key a single fixed number of digits not requiring the operation of start key 226 or whether she may key any number of digits within the registering capacity of the sender with the operation of the start key, and second, whether or not immediate ringing is required from the sender. Further, the strapping from the upper front contacts of transfer relay 803, 813, 823, 903, 913, 923, 933, 943 and from the lower front contact of relay 953 to conductors 860 and 872 determines in accordance with the number of digits keyed whether immediate ringing is necessary or is not necessary. It is thus possible by a simple change in strapping to make any class a fixed or variable digit class and to determine for any variable digit class just how the sender shall function following the completion of keying and the transmission of the last digit registered.

#### *Delaying the transmission of digits*

In the preceding description it was assumed that straps 651 to 663, 862 to 865 and 955 and 956 were closed for the purpose of delaying the transmission of the first series of impulses on variable digit calls of classes B and D until after the first two digits or the first digit and start combination had been keyed and to delay the transmission of the second series of impulses until after the second and third digits keyed or the second digit and start combination had been keyed. It may be desirable in certain cases to permit the transmission of the first series of impulses as soon as the first digit keyed has been registered, to delay the transmission of the sec-

ond series of impulses until after the second and third digits or second digit and start combination keyed have been registered and to delay the transmission of the third series of impulses until after the third and fourth digits or third digit and start combination keyed have been registered. This may be accomplished by closing straps 655, 660, 662 to 672, 866 to 869, 955 and 956 and by opening straps 651 to 654, 656 to 659, 661 and 862 to 865 which were closed in the case just discussed where transmission was delayed until after the first two digits had been registered. With the strapping as indicated and variable class relay 737 operated, transfer relay 809 may be operated to start the transmission of the first series of impulses after the first digit keyed has been registered and transfer relay 803 has released, in a circuit which may be traced from battery through its winding, upper back contact of relay 810, lower back contact of relay 803, straps 670 and 671, conductor 835 and as traced to ground. Before the second series of impulses can be transmitted transfer relay 819 must be operated and this cannot occur until after the second and third digits keyed have been registered. The circuit of relay 819 extends in this case from battery through its winding, upper back contact of relay 820, inner upper front contact of relay 810, straps 869 and 868, lower back contact of relay 813, straps 665 and 664, conductor 681, outer right front contact of relay 737, conductor 767, straps 655 and 668, conductor 768, strap 866, lower back contact of transfer relay 823, straps 662 and 663, conductor 835, thence as traced to ground. Before the third series of impulses can be transmitted, transfer relay 829 must be operated, the circuit therefore extending from battery through its winding, the upper back contact of relay 830, the inner upper front contact of relay 820, straps 867, 667 and 660, conductor 642, inner right front contact of relay 737, conductor 758, straps 669, 955 and 956, lower back contact of transfer relay 903, conductor 835, thence as traced to ground. Before the fourth series of impulses can be transmitted, transfer relay 909 must be operated, the circuit therefor being closed following the registration of the fourth digit keyed and the release of transfer relay 903, from battery through the winding of relay 909, upper back contact of relay 910, inner upper front contact of relay 830, straps 955 and 956, lower back contact of relay 903, conductor 835 and thence as traced to ground.

On fixed digit calls of classes A and C with relay 737 not energized, transfer relay 809 operates as soon as relay 803 releases following the registration of the first digit keyed, in a circuit extending from battery through its winding, upper back contact of relay 810, lower back contact of relay 803, straps 670 and 671, conductor 835 to ground as traced.

Transfer relay 819 operates to start the transmission of the second digit series after the second digit keyed has been registered and transfer relay 813 has released, in a circuit  
 5 from battery through its winding, upper back contact of relay 820, inner upper front contact of relay 810, straps 869 and 868, lower back contact of transfer relay 813, straps 665 and 664, conductor 681, outer right back contact of relay 737, conductor 738, straps 666 and 672, conductor 835 to ground as traced. Transfer relay 829 operates to start the transmission of the third digit series after the third digit keyed has been registered and transfer relay 823 has released, in a circuit from battery through the winding of transfer relay 829, upper back contact of relay 830, inner upper front contact of relay 820, straps 867, 667 and 660, conductor 642, inner right back  
 10 contact of relay 737, conductor 643, strap 668, conductor 768, strap 866, lower back contact of transfer relay 823, straps 662 and 663, conductor 835 and thence as traced to ground. Transfer relay 909 operates to start the transmission of the fourth series of impulses after the fourth digit keyed has been registered and transfer relay 903 has released, in a circuit extending from battery through the winding of relay 909, upper back  
 15 contact of relay 910, inner upper front contact of relay 830, straps 955 and 956, lower back contact of relay 903, conductor 835 and thence as traced to ground.

In some cases it may be desirable to delay the transmission of the first digit series and the transmission of the third digit series. For this purpose straps 651, 652, 657, 658, 661, 673 to 680, 684, 862 to 865, 957 and 958 are closed and straps 653 to 656, 662 to 672, 866 to 869, 955 and 956 are opened. With this strapping and variable class relay 737 operated, transfer relay 809, which must operate before the first digit series can be transmitted, will not operate until the first digit and the start combination or the first two digits have been registered. The circuit of relay 809 may then be completed from battery through its winding, the upper back contact of relay 810, the lower back contact of transfer relay 803, which releases as soon as the first digit has been registered, straps 651 and 652, conductor 681, outer right front contact of relay 737, conductor 767, straps 673, 677, conductor 871, strap 862, back contact of transfer relay 813, straps 657 and 658, conductor 835 to ground as traced. If the call is a two-digit call the first digit will be delayed as just described until after the first two digits have been registered and the transmission of the second digit will be started without delay through the operation of transfer relay 819 in a circuit extending from battery, winding of relay 819, upper back contact of relay 820, inner upper front contact of relay 810, strap 863, conductor 870, straps 661 and 677, con-  
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ductor 871, strap 862, back contact of transfer relay 813, straps 657 and 658, conductor 835 to ground as traced. If the call comprises three or more digits, the transmission of the first digit will be delayed as described and the transmission of the third digit will be delayed until after the third digit and start combination or the third and fourth digits have been registered and transfer relays 823 and 903 have released, the transmission being started through the operation of transfer relay 829 in a circuit from battery through its winding, the upper back contact of relay 830, the inner upper front contact of relay 820, straps 864 and 865, the lower back contact of relay 823, straps 678 and 684, conductor 642, the inner right front contact of relay 737, conductor 758, strap 676, strap 957, the lower back contact of transfer relay 903, conductor 835 to ground as traced. For a call comprising four or more digits the transmission of the first and third digits will be delayed as described and the transmission of the fourth digit will start immediately after the timing interval following the transmission of the third digit through the operation of transfer relay 909 in a circuit extending from battery, winding of relay 909, upper back contact of relay 910, inner upper front contact of relay 830, straps 958 and 957, lower back contact of transfer relay 903, conductor 835 to ground as traced.

With the strapping as indicated on fixed digit calls of classes A and C with relay 737 not operated, transfer relay 809 operates to start the transmission of the first digit series as soon as relay 803 releases following the registration of the first digit keyed, in a circuit extending from battery through its winding, upper back contact of relay 810, lower back contact of relay 803, straps 651 and 652, conductor 681, outer right back contact of relay 737, conductor 738, straps 674, 680, 657 and 658, conductor 835 to ground as traced. Transfer relay 819 operates to start the transmission of the second digit series following the timing interval if the second digit keyed has been registered and transfer relay 813 has released, in a circuit from battery, winding of relay 819, upper back contact of relay 820, inner upper front contact of relay 810, strap 863, conductor 870, straps 661, 677, conductor 871, strap 862, back contact of relay 813, straps 657 and 658, conductor 835 to ground as traced. Transfer relay 829 operates to start the transmission of the third digit series following the timing interval if the third digit has been registered and transfer relay 823 has released, in a circuit from battery, winding of relay 829, upper back contact of relay 830, inner upper front contact of relay 820, straps 864 and 865, back contact of transfer relay 823, straps 678 and 684, conductor 642, inner right back contact of relay 737, conductor 643, straps 675 and  
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679, conductor 835 to ground as traced. Transfer relay 909 operates to start the transmission of the fourth digit series following the timing interval if the fourth digit keyed has been registered and transfer relay 903 has released, in a circuit from battery, winding of relay 909, upper back contact of relay 910, inner upper front contact of relay 830, straps 958 and 957, back contact of relay 903, conductor 835 to ground.

the back contact of transfer relay 903, conductor 835 and thence as traced to ground.

#### *Sender times out*

In the consideration of delayed impulsing previously discussed, it was assumed that the transmission of the first two, second two, and first and third digits might be delayed as required on variable class calls. It is also possible, for example, to delay the transmission of any particular single digit series until after the corresponding and following digit has been keyed, or the corresponding digit and start combination have been keyed. For the purpose of illustrating this alternative arrangement it will be assumed that on class B and D calls it is desired to delay the transmission of the first digit series until after the first two digits have been registered. In this case straps 651 to 658, 662, 663, 862, 864, 865, 868, 869, 955 and 956 are closed and straps 659 to 661, 664 to 681, 863, 866, 867, 957 and 958 are opened. With this strapping and variable class relay 737 operated, transfer relay 809, which must operate before the first digit series can be transmitted will not operate until the first digit and start combination or first two digits have been keyed and registered and transfer relays 803 and 813 have released. The circuit of relay 809 may then be traced from battery, winding of relay 809, upper back contact of relay 810, lower back contact of relay 803, straps 651 and 652, conductor 681, outer right front contact of relay 737, conductor 767, straps 655 and 656, conductor 871, strap 862, back contact of relay 813, straps 657 and 658, conductor 835 and thence to ground. After the timing interval following the transmission of the first digit series, transfer relay 819 may operate over a circuit from battery, winding of relay 819, upper back contact of relay 820, inner upper front contact of relay 810, straps 869 and 868, back contact of transfer relay 813, straps 657 and 658, conductor 835 and thence to ground. After the timing interval following the transmission of the second digit series transfer relay 829 may operate in a circuit from battery through its winding, the upper back contact of relay 830, the inner upper front contact of relay 820, straps 864 and 865, the back contact of transfer relay 823, straps 662 and 663, conductor 835 and thence to ground. After the timing interval following the transmission of the third digit series, transfer relay 909 may operate in the circuit from battery through its winding, the upper back contact of relay 910, the inner upper front contact of relay 830, straps 955 and 956,

At the time the sender was seized it will be recalled that the operation of relay 600 connected ground to conductor 607 extending to the time alarm circuit, not shown, to start timing on the selector sender. The timing circuit may be of the type disclosed in the Patent 1,577,076 granted to A. C. Powell, March 16, 1926. Thereupon ground is connected at the timing circuit to conductor 608, thence over the inner left front contact of relay 600, conductor 682, to battery through the right winding of timing relay 700. Relay 700 operates and locks over its left winding and left contact to ground on conductor 704 and connects the right winding of timing relay 770 over its right contacts to the timing lead 769. After an interval measured by the operation of the timing circuit, if the operator has failed to complete the registration of all digits, or if the sender has failed to pulse out all of the registered digits within the time required by the timing circuit to function, ground will be applied at the timing circuit to timing lead 769, thereby operating timing relay 770. Relay 770 at its outer right front contact closes a circuit over conductor 771, right back contact of relay 601 to alarm lead 683 extending to the timing circuit and closes a circuit from ground on conductor 704 over its outer left front contact, conductor 650, to battery through the winding of relay 604.

Relay 604 upon operating opens the impulsing loop to the selector switches to release all operated switches, disconnects ground from the armature of pulsing relay 731, thereby causing relays 730 and 731 to remain operated, and closes a shunt around the right and middle windings of relay 603, extending over the inner lower back contact of relay 645, upper alternate contacts of relay 604 to ground at the upper back contact of relay 605. This increases the current flowing over the circuit traced through the windings of relay 603 and to battery in parallel through the windings of relays 524 and 525 at the link circuit. Marginal relay 524 now operates closing a circuit from ground at its front contact over the next to upper front contact of relay 512, conductor 534, brush 423, conductor 424, winding of relay 322 at the trunk circuit to battery. Relay 322 operates and locks over its outer right front contact to ground at the inner upper front contact of sleeve relay 315, closes a holding circuit for relay 321 extending from battery, winding and lower front contact of relay 321, intermediate left front contact of relay 322 to ground through resistance 332 to prevent the cut-through relay 316 from operating, and



establishes a circuit from battery, winding of relay 328, outer left front contact of relay 322, to ground through the contacts of interrupter 329. Relay 328 now operates 5 intermittently. When relay 322 operates and prior to the operation of relay 328, a battery through resistances 334 and 335 is connected over the inner front contacts of relay 322, back contacts of relay 328, over the back con- 10 tacts of relay 316, thence to the keyset circuit if it has not been released and relay 123 is still energized, causing the release of the keyset circuit through the operation of polarized relays 244 and 243 in the same manner as 15 when released from the sender. Upon the energization of relay 328 a circuit is closed from battery, resistance 331, upper front contact of relay 328, upper back contact of relay 316, rings of jack 314 and plug 122, lower 20 normal contacts of relay 123, which releases upon the release of the keyset circuit, inner lower front contact of relay 124, lower right winding of repeating coil 113, lower back contact of relay 128, winding of polarized 25 relay 135, upper front contact of relay 124, upper back contact of relay 128, upper right winding of repeating coil 113, inner upper front contact of relay 124, upper normal con- 30 tacts of relay 123, tips of plug 122 and jack 314, lower back contact of relay 316, lower front contact of relay 328 to ground through resistance 333. Relay 135 operates in this circuit extinguishing the calling supervisory lamp 130. On the next deenergization of re- 35 lay 328, relay 135 releases again lighting lamp 130. Thus as relay 328 continues to operate and release the lamp 130 is flashed as a reorder signal.

Relay 322 upon operating also opens the 40 circuit of relay 511 in the link circuit which in turn releases relay 503. With relay 503 released ground is connected through resistance 535 over the upper back contact of relay 503, lower front contact of relay 512, up- 45 per back contact of relay 501, brush 518, conductor 519, right front contact of relay 600, outer front contact of relay 703 lower winding of relay 609 to battery. Relay 609 operates closing a circuit for relay 645 from bat- 50 tery, winding of relay 645, upper back contact of relay 605 to ground at the front contact of relay 609. Relay 645 operates and locks through its winding and inner upper front contact to ground on conductor 634 and 55 causes relay 605 to operate and lock to ground on conductor 634. Relay 605 also opens the shunt around the middle and right windings of relay 603 whereby relays 524 and 525 do not receive sufficient current to remain oper- 60 ated and release. Relay 525 upon releasing also releases relay 536 which in turn releases relay 512. With relays 503 and 512 released the link circuit is restored to normal condi- 65 tion as previously described and relay 603 in the sender is released causing the release

of all operated relays in the sender. When the operator withdraws plug 122 from jack 314 in response to the flashing or reorder signal all operated relays of the trunk circuit re- 70 lease.

#### *Preliminary disconnect*

If for any reason relay 609 of the sender momentarily operates and in turn operates 75 and locks relay 645, ground from the back contact of relay 609 when relay 609 again releases over the inner lower front contact of relay 645 will shunt the middle and right windings of relay 603 causing the operation 80 of marginal relay 525 of the link circuit whereupon the operator will be given a reorder signal as previously described.

#### *Erroneous operation of the start key*

Should the start key 226 be operated erro- 85 neously on a fixed digit call of classes A and C before the required number of digits have been keyed relays 729 and 753 will be operated as previously described and since on a call of classes A and C the variable class re- 90 lay 737 is not operated, a circuit will be closed as soon as the start key is released and relay 729 releases, from ground on conductor 704, front contact of relay 753, back contact of relay 729, left back contact of relay 737, 95 conductor 650, winding of relay 604 to battery and an immediate reorder signal will be given to the operator as previously described. The impulsing loop will be opened at the con- 100 tacts of relay 604 to release any operated selector switches and ground will be removed from the armature of pulsing relay 731 at the inner back contact of relay 604 to hold relays 730 and 731 operated. The operator then re- 105 moves the plug 122 from jack 314 and the operated circuits are restored to normal as previously described. If the start key is depressed after the required number of digits have been keyed no reorder signal is given.

Should the operator key a five-digit call 110 in variable class D with class relay 710 operated, which it will be assumed cannot be completed, the operator will be given a reorder signal. In response to keying five 115 digits followed by the depression of the start key 226, transfer relays 803, 804, 813, 814, 823, 824, 903, 904, 913, 914, 923, 924, are operated and released in succession and re- 120 lays 933 and 934 are operated and held operated when relays 612 and 625 operate fol- 125 lowing the release of start key 226. The operator's keyset circuit is then released and the sender proceeds as described to transmit series of impulses in accordance with the five registered digits. When relay 838 operates 130 at the time the last impulse of the last digit series is being transmitted, a circuit is closed from ground on conductor 634, left front contact of relay 838, inner upper front con- 135 tact of transfer relay 919, conductor 931, up-



per front contact of transfer relay 933, strapped in this case to conductor 873, outer left front contact of relay 755, conductor 650 to battery through the winding of relay 604. 5 Relay 604 upon operating opens the impulsing loop to the selector switches causing them to release and disconnects ground from the armature of pulsing relay 731, thereby causing relays 730 and 731 to remain operated. 10 Relay 604 also causes the transmission of a reorder signal to the operator and the link circuit and sender are released in the manner previously described. Should any other transfer relay have its upper front contact 15 or relay 953 have its lower front contact strapped to conductor 863 in the same manner as transfer relay 933 as just described and be operated in response to the operation of start key 226, the circuit of relay 604 will be closed as just described when relay 838 operates at the time the last impulse of the last digit series is being transmitted and the operator will be given a reorder signal. It is 20 thus possible to use strapping to conductor 873 when it is not desirable to complete a connection through the keying of any particular number of digits in a variable class and to give the operator a reorder signal that the connection cannot be completed as 30 keyed.

What is claimed is:

1. In a telephone exchange system, a first group of trunk circuits, each trunk circuit 35 having access to a train of selector switches responsive to a fixed number of impulse series for completing connections, a second group of trunk circuits, each trunk circuit having access to trains of selector switches 40 responsive to a variable number of impulse series for completing connections, a plurality of senders for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith, and 45 means in said sender controlled from the trunk circuit associated therewith for recording a class registration indicative of the group to which the trunk circuit taken for use belongs. 50

2. In a telephone exchange system, a first group of trunk circuits, each trunk circuit having access to a train of selector switches, responsive to a fixed number of impulse 55 series for completing connections to called lines, means associated with one of said selector switches for automatically applying ringing current to the called line upon connection with said line, a second group of 60 trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections to called lines, means associated with one of said latter selector 65 switches responsive to ringing current ap-

plied thereto for applying ringing current to the called line, a plurality of senders for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith, means in said sender for recording a class registration indicative of whether the trunk circuit taken for use belongs to the first or to the second group, 70 and means in said sender operative only when the class registration indicates that the trunk circuit belongs to the second group for applying ringing current from said sender to operate the ringing current responsive means of the selector switch of the train accessible over the trunk circuit of said second group. 75

3. In a telephone exchange system, a first group of trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections to called lines, means associated with one of said selector switches for automatically applying ringing current to the called line upon connection with said line, a second group of trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections to called lines, means associated with one of said latter selector switches responsive to ringing current applied thereto for applying ringing current to the called line, each of said trunk circuits having means for closing a talking circuit thereover, a plurality of senders for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith, means in said sender for recording a class registration indicative of whether the trunk circuit taken for use belongs to the first or to the second group, and means in said sender operative when the class registration indicates that the trunk circuit belongs to the second group for applying ringing current from said sender to operate the ringing current responsive means of the selector switch of the train accessible over the trunk circuit of said second group and for then causing said trunk circuit to close said talking circuit, and operative when the class registration indicates that the trunk circuit belongs to the first group for causing said trunk circuit to close said talking circuit without waiting for the application of ringing current from said sender. 100 105 110 115 120

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 connections 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 125 130

with a trunk circuit to associate an idle sender with said trunk circuit, means at said operator's position for setting the registers of the associated sender, a source of ringing current in said sender, said trunk circuits being divided into groups in accordance with whether or not ringing current is to be applied from said sender, and means in said sender controlled from the trunk circuit associated therewith for recording a class registration indicative of whether the trunk circuit used is or is not in a group requiring the application of ringing current from the sender.

5. In a telephone exchange system, a group of trunk circuits, each trunk circuit having access to trains of selector switches for establishing different types of connections, a plurality of senders for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith, means in the associated sender for registering the designation of any desired connection, a source of ringing current in said sender, and means in said sender operative in accordance with the designation registered for determining whether ringing current shall or shall not be applied from said sender over the connected trunk circuit and the train of selector switches set thereover.

6. In a telephone exchange system, a first group of trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections to called lines and for automatically initiating the application of ringing current thereto, a second group of trunk circuits, each trunk circuit having access to trains of selector switches responsive to a variable number of impulse series for completing connections to called lines and on certain calls only for automatically initiating the application of ringing current to the called line, a plurality of senders for controlling said selector switches, means operative upon the seizure of any one of said trunk circuits for associating an idle sender therewith, means in said sender for recording a class registration indicative of whether the trunk circuit taken for use belongs to the first or to the second group, means in said sender for registering the designation of any desired connection, a source of ringing current in said sender, and means in said sender operative in accordance with said class registration and in accordance with the designation registered for determining whether ringing current shall or shall not be applied from said sender over the connected trunk circuit and the train of selector switches set thereover.

7. In a telephone exchange system, a first group of trunk circuits, each trunk circuit having access to a train of selector switches

responsive to a fixed number of impulse series for completing connections to called lines and for automatically initiating the application of ringing current thereto, a second group of trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections to called lines without automatically initiating the application of ringing current thereto, a third group of trunk circuits, each trunk circuit having access to trains of selector switches responsive to a variable number of impulse series for completing connections to called lines and on certain calls only automatically initiating the application of ringing current to the called line, a plurality of senders for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith, means in said sender for recording a class registration indicative of the group to which the associated trunk circuit belongs, means in said sender for registering the designation of any desired connection, a source of ringing current in said sender, and means in said sender operative in accordance with said class registration and in accordance with the designation registered for determining whether ringing current shall or shall not be applied from said sender over the connected trunk circuit and the train of selector switches set thereover.

8. In a telephone exchange system, a first group of trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections to called lines and for automatically initiating the application of ringing current thereto, a second group of trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections to called lines without automatically initiating the application of ringing current thereto, a third group of trunk circuits, each trunk circuit having access to trains of selector switches responsive to a variable number of impulse series for completing connections to called lines and on certain calls only automatically initiating the application of ringing current to the called line, a fourth group of trunk circuits, each trunk circuit having access to trains of selector switches responsive to a variable number of impulse series for completing connections to called lines and for automatically initiating the application of ringing current thereto, a plurality of senders for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith, means in said sender for recording a class registration indicative of the group to which the associated trunk circuit belongs,

means in said sender for registering the designation of any desired connection, a source of ringing current in said sender, and means in said sender operative in accordance with said class registration and in accordance with the designation registered for determining whether ringing current shall or shall not be applied from said sender over the connected trunk circuit and the train of selector switches set thereover.

9. In a telephone exchange system, a plurality of trunk circuits having access to trains of selector switches, a plurality of register senders, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith, a group of counting relays in said sender, impulsing means for transmitting series of impulses for successively setting the switches of said trains and for successively operating said counting relays during the transmission of each series of impulses in accordance with the setting of the registers of said sender, means in said sender operative when a connection is completed to a called subscriber's line for applying ringing current thereto, and means controlled by said impulsing means for successively operating certain of said counting relays to discontinue the application of said ringing current after a predetermined interval.

10. In a telephone exchange system, a plurality of trunk circuits having access to trains of selector switches, said trunk circuits being divided into groups in accordance with the character of the connections to be established thereover, a plurality of senders for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith over four control conductors, means in said senders for recording a registration indicative of the group to which the trunk circuit taken for use belongs, and means in said trunk circuit for selectively applying potential to said conductors in accordance with the grouping of said trunk circuits for selectively operating said recording means.

11. In a telephone exchange system, an operator's position having a cord circuit, a key set at said operator's position associable with said cord circuit, trunk circuits and selector switches for extending connections from said operator's position, said trunk circuits being divided into groups in accordance with the character of the connections to be established thereover, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith to establish a two-conductor in-pulsing path from said key set to said sender and a two-conductor out-pulsing path from

said sender to said selector switches, means in said sender for recording a registration indicative of the group to which the trunk circuit taken for use belongs, and means in said trunk circuits for selectively applying potential to said conductors in accordance with the grouping of said trunk circuits for operating said recording means.

12. In a telephone exchange system, an operator's position having a cord circuit, a key set at said operator's position associable with said cord circuit, trunk circuits and selector switches for extending connections from said operator's position, said trunk circuits being divided into groups in accordance with the character of the connections to be established thereover, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith to establish a two-conductor in-pulsing path from said key set to said sender and a two-conductor out-pulsing path from said sender to said selector switches, means in said trunk circuits for selectively applying potential to said conductors in accordance with the grouping of said trunk circuits, a group of relays in said sender selectively operable over said conductors, and class relays selectively operable by said group of relays.

13. In a telephone exchange system, an operator's position having a cord circuit, a key set at said operator's position associable with said cord circuit, trunk circuits and selector switches for extending connections from said operator's position, said trunk circuits being divided into groups in accordance with the character of the connections to be established thereover, a plurality of register senders common to said trunk circuits for controlling said selector switches, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith to establish a two-conductor in-pulsing path from said key set to said sender and a two-conductor out-pulsing path from said sender to said selector switches, means in said trunk circuits for selectively connecting battery potential from said key set to either one of the conductors of the in-pulsing path and for connecting battery potential to one of said out-pulsing conductors and ground to the other of said out-pulsing conductors or reversely, in accordance with the grouping of said trunk circuits, a pair of registering relays in said sender operable respectively from battery potential applied to said in-pulsing conductors, a pair of polarized relays in said sender, each operable respectively over said out-pulsing conductors in accordance with the direction of current flowing thereover, a second pair of registering relays in said sender

operable respectively by said polarized relays, and a group of class relays selectively operable in accordance with the operated condition of said two pairs of registering relays.

14. In a telephone exchange system, a first group of trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections, a second group of trunk circuits, each trunk circuit having access to trains of selector switches responsive to a variable number of impulse series for completing connections, a plurality of register senders for controlling said selector switches, cord circuits for connection to said trunk circuits, means operable upon the connection of a cord circuit with a trunk circuit for associating an idle one of said senders with said trunk circuit, a key set circuit comprising digit keys and a start key associable with any one of said cord circuits for setting the registers of said sender, means in said sender controlled from the trunk circuit associated therewith for recording a class registration indicative of whether the trunk circuit taken for use belongs to the first or to the second group, and means controlled in accordance with said class registration for disassociating said key set circuit from said sender immediately following the registration of the last digit keyed if the trunk circuit seized is of the first group and following the operation and release of said start key if the trunk circuit seized is of the second group.

15. In a telephone exchange system, a first group of trunk circuits, each trunk circuit having access to a train of selector switches responsive to a fixed number of impulse series for completing connections, a second group of trunk circuits, each trunk circuit having access to trains of selector switches responsive to a variable number of impulse series for completing connections, a plurality of register senders for controlling said selector switches, cord circuits for connection to said trunk circuits, means operative upon the connection of a cord circuit with a trunk circuit for associating an idle one of said senders with said trunk circuit, a key set circuit comprising digit keys and a start key associable with any one of said cord circuits for setting the registers of said sender, means in said sender controlled from the trunk circuit associated therewith for recording a class registration indicative of whether the trunk circuit taken for use belongs to the first or to the second group, means controlled in accordance with said class registration for disassociating said key

set circuit from said sender immediately following the registration of the last digit keyed if the trunk circuit seized is of the first group and following the operation and release of said start key if the trunk circuit seized is of the second group, and means for transmitting a reorder signal to said cord circuit if the start key is erroneously operated when the cord circuit is connected to a trunk circuit of said first group.

16. In a telephone exchange system, an operator's position having a cord circuit, a key set circuit comprising digit keys and a start key associable therewith, a plurality of trunk circuits of different character accessible to said cord circuit, connection extending means operable over said trunk circuit, a plurality of senders for controlling said connection extending means, means operable upon the connection of said cord circuit to any one of said trunk circuits for associating an idle one of said senders therewith, means controlled by said key set circuit for registering in the associated sender the designation of a desired connection, the designations of connections to be established over certain of said trunk circuits being registered in said sender by the operation of said digit keys without the operation of said start key and the designations of connections to be established over certain other of said trunk circuits being registered in said sender by the operation of said digit keys followed by the operation of said start key, and means controlled by said sender for signaling said operator and for disassociating said key set circuit from said cord circuit if the operator erroneously operates said start key.

17. In a telephone exchange system, a plurality of trunk circuits having access to trains of selector switches, a plurality of register senders, means operable upon the seizure of any one of said trunk circuits for associating an idle one of said senders therewith, a group of counting relays in said sender controlled in accordance with the setting of the registers thereof for counting the number of impulses in each series to be transmitted to said switches, a condenser, and a pair of polarized relays intermittently operated and released through the charging and discharging of said condenser for transmitting selector switch setting impulses and for transmitting impulses to successively operate said counting relays.

In witness whereof, I hereunto subscribe my name this 22 day of August, 1932.

ISRAEL H. HENRY.